# ENERGY SECURITY, POVERTY AND SOVEREIGNTY IN MOUNTAIN COMMUNITIES OF TAJIKISTAN

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# ENERGY SECURITY, POVERTY AND SOVEREIGNTY IN MOUNTAIN COMMUNITIES OF TAJIKISTAN

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## ABSTRACT

This dissertation research examines the vulnerabilities of energy systems in Tajikistan at the national scale, assesses the energy needs and resources of rural mountain communities at the local scale, and recommends energy solutions to improve the security of energy systems and livelihood opportunities of local communities. It advances the concepts of *energy security*, *energy poverty* and *energy sovereignty* from national and community perspectives. Using mixed-method research design and employing survey research, and in-depth interviews, in addition to literature review and secondary data analysis, this research identifies the energy needs at the household level, and sheds light onto national energy system vulnerabilities.

Based on the analysis of available data, this research highlights key vulnerabilities of the energy system including insufficient energy production capacity, unreliable and expensive energy imports, dwindling power infrastructure causing technical and economic losses, inadequate transparency in the power sector, lack of regional cooperation in energy and water resource sharing, and inadequate financial resources to address all of the above. This research finds that energy poverty reflects the current condition of access to energy services at the level of the community and

household in rural villages of the southeastern part of Khatlon region, Tajikistan. Rural communities continue to rely on solid biomass (wood, straw, animal dung) to meet their thermal energy needs, and many households are not connected to the electrical grid. For those connected to the grid, access to electricity is neither reliable nor affordable. This research recommends a potential intermediate solution to local energy access that entails proliferation of small-scale technologies such as solar home systems, micro-hydro units, biogas digesters, improved cookstoves, residential wind turbines and thermal insulation of homes. These technologies may be optimal to rural areas as they are smartly deployed, easily maintained and configurable to needs, plus cost-effective and environmentally sustainable in the long-term. Businesses, together with governments and civil society organizations can take advantage of technologies to lead the transition from energy poverty to security. Ultimately, the policymakers, energy planners and providers should prioritize the role of households and their communities in addressing their energy challenges.

## BIOGRAPHICAL SKETCH

Murodbek Laldjebaev was born in Kazideh village of Ishkashim District, Gorno-Badakhshan Autonomous Oblast, Tajikistan. After completion of his primary and secondary education in School #26 in his home village, he studied at Khorog State University and obtained a Bachelor's degree in English Language in 2003. He then worked for the Institute for Professional Development of teachers in Khorog until 2008, after which he traveled to Singapore for further studies. In 2010 he obtained a Master's in Public Policy degree from the Lee Kuan Yew School of Public Policy, National University of Singapore. Then he worked as a senior specialist for a year for the Ministry of Economic Development and Trade in Dushanbe, Tajikistan. In 2011 he embarked on his doctoral studies at the Department of Natural Resources, Cornell University, and graduated in 2017. In addition to his degrees, Murodbek has also completed non-degree courses on education at the University of Saint Thomas, Harvard Graduate School of Education, and Upper Canada College, and consulted the World Bank on pre-service education.

In loving memory of

my grandparents Laljeba and Sadafmo,

my brother Rauf,

and

my dearest friend Maruf.

**ACKNOWLEDGEMENTS**

I would not have been where I am today had it not been for the interest that the late Dr. Mark Bain took in my research proposal when I applied for Ph.D. studies through the Open Society Foundations (OSF). Therefore, I am indebted to Dr. Bain for supporting my candidacy to pursue my studies at the Department of Natural Resources (DNR), Cornell University. I was fortunate to work with him for over a semester in the early stages, and I wish we could continue to work together. However, it was not meant to be. May his soul rest in eternal peace!

My deepest gratitude goes to my major advisor, Dr. Karim-Aly Kassam, whose guidance and support on both professional and personal levels has been instrumental to my development as an aspiring scholar. I have been very fortunate to have known Dr. Kassam a few years before applying for OSF scholarship. Our acquaintance, and his close familiarity with Tajikistan, where he has been conducting field research since 2006, served as a solid foundation to our working relationship and my subsequent progress towards my degree. Through his guidance and mentorship I underwent a complete transformation in my worldview. He showed me the way back to my roots through a renewed appreciation of local and indigenous ways of knowing. Given our shared interest in research in the Central Asian region it is my hope that we will continue to collaborate well beyond my doctorate studies. Dr. Kassam has also been a tremendous source of support for my family, especially during the difficult times when my wife fell ill. We are thankful for all his help.

I am thankful to my three committee members – Dr. Stephen Morreale, Dr. Shorna Allred and Dr. Benjamin Sovacool – for their thoughtful guidance and critical and constructive feedback throughout my research work at Cornell. It has always been a pleasure to work with Steve. His door is always open and I would stop by his office with a quick question and just like that he would generously spend the next hour or two helping me think through not only that question but also engage in deep discussion of what my research entailed for the rural households in Tajikistan. I am delighted that Shorna agreed to serve on my committee at a later stage when I was desperately looking for an expert to guide me on survey research. She provided valuable guidance on the methodology and more specifically on the draft of my questionnaire that had hundreds of questions to begin with! The only aspect that I had challenge with at Cornell University was lack of coursework on social science perspective on energy systems. Fortunately, I was able to fill this gap by working with Benjamin who I met during my master's studies at the Lee Kuan Yew School of Public Policy in Singapore. We worked remotely and I truly appreciate his prompt response to my emails and multiple requests, even when he was traveling. His contribution to our co-authored book chapter with Dr. Kassam laid a solid foundation to my scholarly writing.

The members of Kassam Research Group – Morgan Ruelle, Michelle Baumflek, Chuan Liao, Nicole Wilson, Rajeev Goyal, Michael Dunaway, and Michael Lieberman – have been a source of inspiration and support at different stages of my studies. From meticulous edits to multiple drafts of my writing to rehearsing my presentations to long conversations outside the meetings, they helped me polish my work and enrich my thinking. I spent many hours with Morgan in our shared office, over “mandatory” lunches, walks through the Plantations, and many other occasions outside Ithaca, including a trip to New York City and visiting with his family in Vermont. I learned a lot from him and I cherish his friendship.

I am thankful to DNR faculty, staff and fellow students who have all been very supportive in helping me progress towards obtaining my degree. My special thanks go to Dr. Patrick Sullivan for his guidance on matters of statistics, and to Dr. Steven Wolf and Dr. Joseph Yavitt for granting me opportunities to assist with teaching sections in their courses. I thank Ms. Christie Sayre for helping me navigate the system to get my paperwork in order. I learned many things about ecology, conservation, and natural resources from my fellow graduate students through their talks at the DNR seminars, the GSA symposium and during informal conversations, and I thank them all for sharing their knowledge.

During our *Klinik* meetings with Jeffrey Wall, Darragh Hare, and Ritwick Gosh, I received constructive feedback on my writing and later on, job applications and talks, which helped me prepare for the next step. I am immensely grateful for the contribution of these fellow students. Countless hours spent in the company of Jeff and Darragh in our shared office and elsewhere helped nurture a strong friendship bond that I will cherish for years to come. They were equally supportive of me and my family outside work that I deeply appreciate as well.

I would also like to acknowledge the support of fellow graduate students Manuel Berrio, Jaime Ortiz, Bob Beazley, Annise Dobson and Samar Deen. The early

Sunday mornings with Manuel, as he was teaching me how to drive, were also occasions for great conversations about current affairs. Jaime gave us rides when we needed one. With his wealth of experience, Bob was always great to talk to just about anything. I enjoyed sharing an office with Annise and having conversations about ecology, deer and earthworms, and other interesting topics. Samar is a good friend and a caring neighbor who is always there when we need help – be it looking after our daughter or talking through the challenges of life.

Throughout my time at Cornell, I lived with my family at the Hasbrouck Apartments among a community of international students and scholars and their families and children. I am thankful of the support that this community had provided over the years that made our stay there safe and enjoyable.

I would also like to express immense gratitude to Yasmin Kassam for her care, love and support for my family during our time in Ithaca. She took great care of my wife during her illness and helped look after our daughter as well. We deeply thank her and pray for her and her family's happiness, health and prosperity.

My Ph.D. studies and research were made possible through financial support of many organizations and I am truly grateful for their generosity. The Open Society Foundations (OSF) and Cornell University granted me scholarships and assistantships to cover my tuition and other expenses for the entire duration of my studies. At OSF, I would like to especially acknowledge Ms. Zoe Brogden's efforts. She had been responsive to every question and attentive to every need on a timely manner. She would resolve every conceivably difficult issue so seamlessly. I appreciate all her prompt and continuous support over the years. I would like to acknowledge the University of Central Asia (UCA) for granting me an individual fellowship to complete my studies. In this process, Dr. Bohdan Krawchenko and Dr. Nasreen Dhanani of UCA were instrumental.

Funding research in the context of Central Asia is hard to come by. Therefore, I am thankful to the UCA's Central Asia and Afghanistan Research Fellowship made available through the Mountain Societies Research Institute that covered the bulk of the expenses associated with my field research. The rest of the field research was sponsored through grants from the Einaudi Center for International Studies, Richard Bradfield Research Award and Graduate School Research Travel Grant of Cornell University.

When in the field, the Ministry of Economic Development and Trade of Tajikistan and particularly, first deputy minister Dr. Saidrahmon Nazriev provided letters of support that opened many doors. The Physics-Technical Institute named after S.U. Umarov of the Academy of Sciences of Tajikistan, and particularly, Dr. Hikmat Muminov and Dr. Qurbonjon Kabutov provided additional letters of support to facilitate access to stakeholders. The Mountain Societies Development Support Program (MSDSP) of the Aga Khan Foundation (AKF) facilitated access to research sites. I thank the MSDSP staff, namely, Muhammad Bodurbekov and Bakhtovarsho Alidodov for their on the ground assistance with implementation of the research. The branch of the UCA in Dushanbe provided office space and organizational assistance. I am thankful to Khairisho Shonusairiev, Dr. Pulat Shozimov and Abdurahmon

Davronov of UCA Dushanbe for their assistance. I would also like to acknowledge Muso Mamadmusoev for his IT support.

Two research assistants and four enumerators were instrumental in data collection in Khatlon region through their commitment, diligence and perseverance. I would like to acknowledge the role of my research assistants – Khonim Ahrorova and Barfiya Palavonshanbieva – who demonstrated a keen interest in the project in the field and were very effective in keeping detailed notes of the interviews and measurements. More importantly, their presence was instrumental in conducting interviews with female household members, which otherwise would not have been possible due to established cultural norms. In every step of the way they kept up with me – traveling to remote villages at the heat of the summer, treading through snow in winter, getting stuck in mud in the spring, crossing a narrow hanging bridge that swayed to sides over a fast flowing mountain river, or climbing a steep slope to get to a village with no electricity. Though legitimately very concerned about our safety, yet understanding the necessity of travel, at one point we hopped on an old Russian jeep – our only option to get to a remote village – that carried four diesel fuel tanks plus a 40 kg gas tank inside the car and half a dozen sacks of potatoes in the trunk – smelling and bumping every meter of the two hours journey into the mountains in the company of another four passengers. We made it safely to our destination this time, and many other times like this. I deeply appreciate Khonim and Barfiya’s efforts in this project, and I am forever indebted to their assistance.

With assistance from the MSDSP, I recruited four local residents from Khatlon region to help me conduct the survey research in the villages. They conducted the survey in the most difficult time of the year, which is winter, and they had to endure many hardships: traveling on bumpy dirt roads, walking up and down steep mountain slopes, crossing icy rivers on foot, traveling on heavy-duty trucks where their jeep could not go, dealing with sensitive local authorities concerned about interference in the process of voting for parliamentary elections, and likely many other troubles that they did not share with me because they would just brave it. I could hardly do good justice to their commitment, diligence and perseverance to complete the survey as best as they could because no words could impart their efforts effectively. Without their assistance I would not have been able to gather as much data as they helped gather. I am truly deeply thankful to these four courageous men – Qurbomad Sharipov, Mirzomurod Qurbonov, Shuhrat Safaraliev, and Sherdil Jumaev – for all their hard work!

Residents of Khatlon region generously shared their time, knowledge and hospitality with the research team. I wholeheartedly thank each and every household member who we spent time with over the course of my research. These interactions have left a deep mark on me. It is my hope that through this dissertation and subsequent publications I will attract the attention of a larger society to the challenges of rural communities in Tajikistan as a first step towards their resolution.

When doing research in Khatlon region I stayed with Hokim in Darai Mukhtor, Jabbor in Devdor, Mirzo in Chorbogh, and Odina and another family that wished to remain anonymous in Jirk. I deeply thank my hosts and their families for their hospitality and most importantly, their acceptance, kindness, and patience when I asked numerous questions about life in their locality. They helped me understand the culture and nuances of life that would not have been possible otherwise. For that and for everything they shared, I am very grateful of my hosts.

In Dushanbe city, I interviewed experts in public, private, and non-governmental organizations as well as independent analysts on the topic of energy security in Tajikistan. I thank these professionals, who wished to stay anonymous, for sharing their insights on the complexity of challenges as well as potential avenues to address them.

During my stay in Dushanbe, my aunt Obidamo and uncle Tohir truly made me feel at home. I cannot thank them enough for their hospitality, care and love. At some point I also stayed with my cousins Gulbarg and Payrav who I thank for their hospitality as well, and particularly for bearing with me as I would spread my survey questionnaires around the living room for days on end. I would like to specially thank my cousin Kishvar for tremendous support he provided over the years through putting me up at his place, running errands, topping up my phone balance and countless other little things that made my life so much easier. My very special thanks also go to my dear friend Hurmat for standing by my side at times of hardship and sharing in the joyous moments. His friendship, sense of humor and promptness to respond to my numerous requests for help were a great source of support. I would also like to thank my friend Firdavs for his encouragement and support over the years, particularly urging me with his nagging question “So, when are you going to finish your studies?” Now, I can respond without resorting to a long explanation: “I am done, my friend!” I truly appreciate all the support I received from these friends and family members.

I owe my biggest debt of gratitude to my family. My late grandfather Laljeba would shower his blessings every time we spoke either in person or over the phone. His stories continue to serve as inspiration. I wish he were alive to see his grandson graduate with a Ph.D.. I am thankful to my father Mirshams and my mother Anorbegim for their blessings, love and encouragement. My brothers Sodiq and Orzu took the brunt of supporting our parents and this allowed me to pursue further studies. I thank them for this support and hope to reciprocate soon. I miss our late brother Rauf, especially at this point, and send him my prayers for the peace of his soul.

I cannot convey the amount of gratitude I owe my beloved Barfiya. We have been together through thick and thin, and she had gone through many more on her own, when I was away doing fieldwork, at conferences or other places. Our daughter Vasila has been very kind and patient especially as I would be away or had to attend to urgent work, thus missing the opportunities to attend her school performances or going out for fun. I will try my best to make it up to both of them for my long absences and putting in my share of housework and contributing to fun. The arrival of our younger daughter Farahruz is a true blessing for all of us in the family. She multiplies our joy day after day and I am happy that she will not have to put up with her student-dad anymore as her older sister had.

At the end, I would like to thank everyone who directly or indirectly has lent their hand in helping me complete my research and studies. Your support has been monumental and it means a lot to me. I sincerely wish that all the kindness that you showered on me returns to you a thousand-fold!

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ABD – Asian Development Bank

AKF – Aga Khan Foundation

AVG – Average

CAPS – Central Asian Power System

CASA – Central Asia South Asia

CD – Compact Disc

CHP – Combined Heat and Power (plant)

CIA – Central Intelligence Agency

CIP – Critical Infrastructure Protection

df – degree of freedom

DNR – Department of Natural Resources

DVD – Digital Video Disc

EDB – Eurasian Development Bank

EEMP – Energy Efficiency Master Plan

FAO – Food and Agriculture Association

FoEI – Friends of the Earth International

GBAO – Gorno-Badakhshan Autonomous Oblast

GDP – Gross Domestic Product

GERES – Group for the Environment, Renewable Energy and Solidarity

GIZ – Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (German Corporation for International Cooperation)

GSA – Graduate Students Association

GWh – Gigawatt hour

HPP – Hydropower Plant

IDA – International Development Association

IEA – International Energy Agency

IRB - Institutional Review Board for Human Participants

IRD – Integrated Rural Development

IT – Information Technology

kg – kilogram

kgoe – kilogram of oil equivalent

km – kilometer

ktoe – kiloton of oil equivalent

kW – kilowatt

kWh – kilowatt hour

LPG – Liquefied Petroleum Gas

Max – Maximum

Min – Minimum

MSDSP – Mountain Societies Development Support Program

MSEs – Micro and small-scale enterprises

Mtoe – Million tons of oil equivalent

MW – Megawatt

NA – Not Applicable (also N.A.)

NGO – Non-governmental Organization

OECD – Organization for Economic Cooperation and Development

OKVED – Russian Classification of Economic Activities)

OSF – Open Society Foundations

PPEO – Poor People's Energy Outlook

PPS – Probability Proportionate to Size

PV – Photovoltaic

RES – Renewable Energy Sources

RRS – Regions of Republican Subordination (administrative unit in Tajikistan)

SE – Standard Error

SHPPs – Small-scale Hydropower Plants

STC – Solar Thermal Collector

T&D – Transmission and Distribution

TALCO – Tajik Aluminum Company

TJS – Tajik Somoni (currency code of Tajikistan)

toe – ton of oil equivalent

TPES – Total Primary Energy Supply

TPP – Thermal Power Plant

TTU – Tajik Technological University

TV – television

UCA – University of Central Asia

UN – United Nations

UNDP – United Nations Development Program

UNGA – United Nations General Assembly

USD – United States Dollar (currency code of the United States of America)

VAT – value-added tax

WB – World Bank

WHO – World Health Organization

WTP – Willingness To Pay

## INTRODUCTION

The yearly arrival of the cold season and a gradual reduction in the flow of the rivers in the early fall ushers in a period of shortage in electricity provision in Tajikistan. Rationing of electricity by the national government to the rural population begins with occasional power cuts, then is progressively reduced to providing three to five hours a day at best, and eventually culminates in total blackouts, sometimes for several days. Cities and other larger administrative centers in Tajikistan also experience some rationing, albeit less severe than in rural areas. The situation improves only with the arrival of the warmer season that brings with it increased hydroelectricity generation due to higher flows in the rivers as a result of snowmelt and relief from warmer temperatures. While provision of energy access during the Soviet Union was not uniform and fully reliable in all parts of Tajikistan, this cycle of shortage in the winter followed by electricity surplus in the summer has gained a constant pattern since the early 1990s, when Tajikistan gained independence after the disintegration of the Soviet Union. Breaking out of this entrenched cycle and achieving energy security is, therefore, a key strategic direction for the country's development[1]. The path to energy security is envisaged through harnessing of the country's large water resources to produce additional hydropower. Along with the prospect of economic benefits, the construction of large hydropower facilities is also accompanied by significant geo-political, sociocultural and environmental impacts. Therefore, a rethinking of the options for sustainable energy provision is needed.

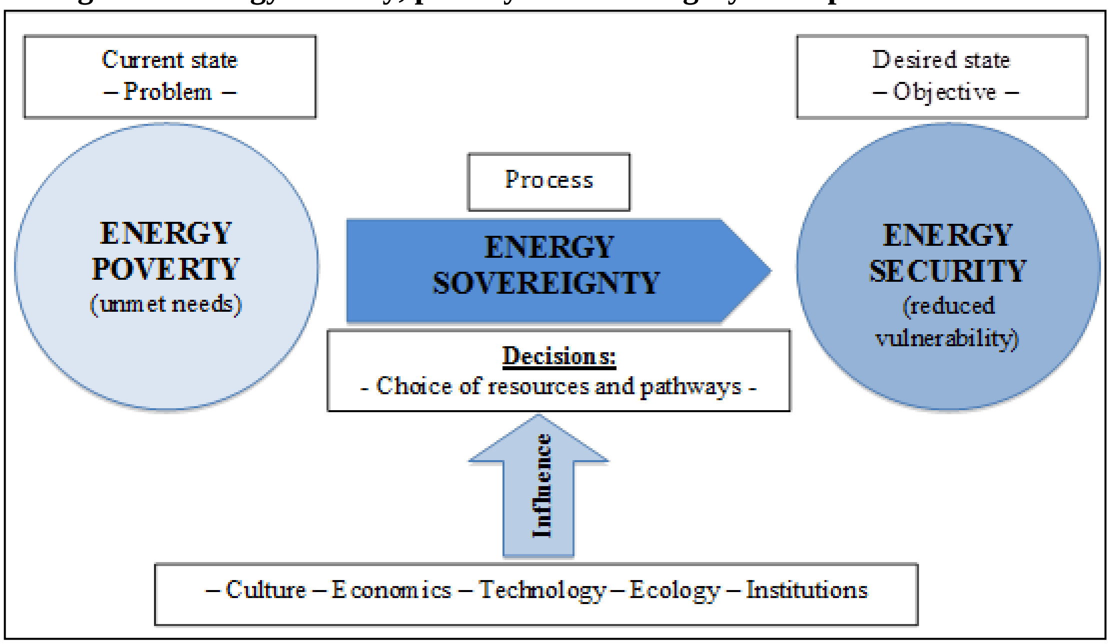
[1] Three strategic directions are: "withdrawal of the country from communication isolation and ensuring energy and food security." Statement of the President of Tajikistan E. Rahmon at UNGA September 23rd, 2010, New York (Rahmon, 2010).

This dissertation takes the first step in that direction. It examines the vulnerabilities of energy systems in Tajikistan at the national level, assesses the energy needs and resources of rural mountain communities at the local level, and recommends viable, sustainable energy solutions to improve the security of energy systems and livelihood opportunities of local communities. By exploring the overlapping concepts of *energy security*, *poverty*, and *sovereignty*, it explains how these concepts interact, and what their interactions mean for scholars and practitioners seeking to address energy problems. *Energy security* is conceptualized as low vulnerability of vital energy systems and sustained provision of modern energy services (Cherp & Jewell, 2014). *Energy poverty* is traditionally framed as lack of access to electricity networks and dependence on solid fuels for cooking (IEA, 2012). *Energy sovereignty* is concerned with household decision-making and their ability to access energy options in ways that meet their needs. Furthermore, energy sovereignty emphasizes the role of local people in determining their energy systems in ways that are culturally relevant and ecologically sustainable (Friends of the Earth International 2006; Moreno & Mittal 2008; Paradis et al. 2009). These concepts are explained in greater detail in the book chapter entitled "Energy security, poverty, and sovereignty: Complex interlinkages and compelling implications" (Laldjebaev, Sovacool & Kassam, 2015), and further expanded upon in Chapters 1, 2 and 3 of this dissertation.

### *1. Conceptual framework for the research*

The concepts of *energy security, energy poverty,* and *energy sovereignty* are integrated into a conceptual framework for the research (see Figure 1). The meaning of *energy* *security* is context-dependent, and therefore, this research clarifies the meaning of *energy security* in the context of rural mountain communities in Tajikistan. The concept of *energy poverty* explains the lack of access that these communities have to energy services, such as cooking, heating and lighting. On the other hand, *energy sovereignty* is a relatively new term that requires further articulation. Articulation of these concepts and testing their relevance at the rural household level in Tajikistan will be key contributions of this research to the discourse on energy policy.

**Figure 1: Energy security, poverty and sovereignty conceptual framework**




As the above framework suggests, *energy security* is treated as a *goal* – a desired state of being, in which energy services are provided to a satisfactory level and the vulnerabilities of the energy systems are reduced. For example, security in the electricity sector would mean that large-scale dams are physically safe, the grid is upgraded, and small-scale technologies are installed to service remote communities.

At the local level, adequate provision of these services would result in energy security, while failure to do so – in energy poverty.

*Energy poverty* reflects the current condition of access to energy services at the level of the community and household – this constitutes the *problem*. Rural communities in Tajikistan continue to rely on solid biomass (wood, straw, and animal dung) to meet their thermal energy needs, and many households are not connected to the electrical grid. Those connected to the grid do not have a reliable or even affordable access to electricity. During the winter season, when energy needs are particularly acute, households experience daily blackouts. To assess the level of energy poverty is to take account of energy needs, such as cooking, heating, and lighting, and the extent to which they are met. In other words, the fundamental need of a household is expressed through its specific energy need. Thus, energy poverty must be assessed starting at the level of the household and community.

*Energy sovereignty* is a *process* to reach the goal of *energy security*. The key question is: *How* are energy needs met? This is a process of complex decision-making that is influenced by many factors including cultural values, available resources, financial wherewithal, technological capability, and ecological foundation of households. An interplay of these factors leads to decisions and choices about the use of certain energy resources and pathways.

## *2. Research questions*

The primary research question for this dissertation is:

– In what ways are the concepts of *energy security*, *energy poverty*, and *energy sovereignty* relevant to understanding and alleviating energy problems in rural communities of Tajikistan?

The empirical questions that will answer this overarching question are:

– What are the impacts of current energy use and energy shortages, and what vulnerabilities exist at the national scale in Tajikistan (*energy security*)

– For what purposes is energy used, and how much and in what forms is energy needed at the household scale? (*energy poverty* )

– How do rural households make decisions about their use of different energy sources for different needs? (*energy sovereignty*)

– What options can this research suggest to improve access to energy services and reduce vulnerabilities of the energy system in Tajikistan? (*policy recommendations)*

## *3. Research methods*

Evaluation of the *energy security* situation requires understanding of what vulnerabilities exist in the energy system of Tajikistan. To assess the level of *energy poverty*, it is important to know the energy needs (e.g. lighting, cooking, heating) of households and the energy sources (e.g. grid electricity, firewood, animal dung) used to meet those needs. The level of *energy sovereignty* can be measured by how households make decisions about their use of different sources for different needs.

This study employed mixed methods, particularly the *sequential design* (Teddlie and Tashakkori, 2009). Initially, qualitative interviews were conducted at a smaller scale to get a sense of energy use patterns. Semi-structured interviews were used to reveal the energy use patterns of selected households. In particular, households were asked about the sources of energy (e.g. firewood, animal dung, electricity, solar and wind power, and biogas) used to satisfy their energy needs (e.g. lighting, cooking, heating and entertainment). Due to differences in seasonal use of energy, the interviews were conducted in summer of 2013 (warm season) and in winter of 2015 (cold season) with the same households. During the summer season interviews, which constituted the preliminary phase of the research, households were also asked to recall their energy use in the previous winter season. This information was used to formulate questions about energy use during the subsequent phase of the research in winter season. Furthermore, in the winter season questions were asked about energy use in the previous summer. This iterative engagement allowed for corroboration of the responses and assessment of the reliability of recall.

The study took place in rural mountain villages of Khatlon region, Tajikistan (see Figure 2). Six villages were selected and a total of 111 households were interviewed in the summer of 2013, and a total of 51 of those households were interviewed again in the winter of 2015.

Next, significance of insights emerging from the interviews was tested at a larger scale using a quantitative survey. The sample for the survey was taken from a study that was conducted by a local NGO – the Mountain Societies Development Support

Program (MSDSP) – in 2012 that included the districts of Baljuvon, Khovaling and Shurobod. A team of four enumerators was trained to conduct the survey in the winter of 2015. In the MSDSP study 20 clusters were selected with 7 households in each cluster, for a total of 140 households in each district. For all three districts, the sample comprised 420 households.

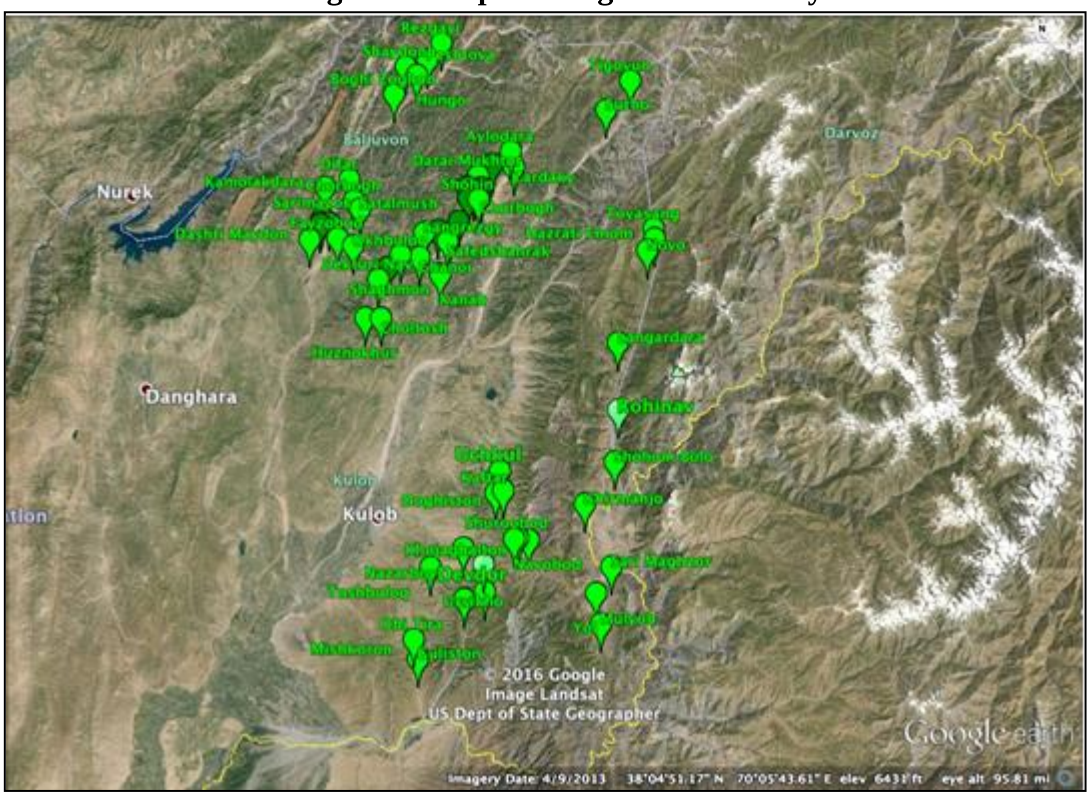
**Figure 2: Map of Tajikistan showing the research area in Khatlon region**


Source: Nations Online Project (http://www.nationsonline.org/oneworld/map/tajikistan-political-map.htm). Green box indicates research area.

However, due to three households choosing to drop out of the study, the counts for districts were 139 households for Baljuvon, 138 for Khovaling and 140 for Shurobod, which were targeted with the survey. During the survey, some households on the list could not be found in the villages. It is likely that some errors might have occurred in the data entry for MSDSP study. Furthermore, some households could not participate, because no adult household member was present at the time of the visit. Due to these reasons the number of households surveyed dropped to 124 in Baljuvon, 129 in Khovaling and 133 in Shurobod, comprising 386 households located in 59 villages (see Figure 3).

In this dissertation, the results of the survey are reported because the initial phase of the research consisting of interviews served as a springboard for a quantitative study.

**Figure 3: Map of villages in the survey**




Source: Google Earth. Note: Pins indicate villages in the survey.

In addition to household interviews and the survey, further interviews were conducted with experts in the public, private and non-governmental organizations in order to understand the energy security situation at the national level. Expert views were solicited on energy problems and potential options to achieving energy security goal as well as resolving challenges to regional stability. The analysis of expert opinions, however, is not included in the main part of the dissertation because only 6 out of 17 experts agreed to be interviewed. The difficulty of scheduling interviews is in part due to hesitation of expressing one's views on the contentious topic of energy security that could have undesirable consequences for the experts. Therefore, a summary of their views is provided in Appendix 2, without revealing experts' names.

### *4. Research significance*

This research project is relevant to impoverished rural communities in Tajikistan because it sets out to understand their energy situations and seeks real solutions to their energy challenges. While the focus of the study is Tajikistan, the findings may be important to understanding energy access and security in many other rural contexts. The project is of great benefit to the government and international development agencies working on issues of energy access, because they need field-tested tools and approaches to rapidly assess problems and to craft appropriate responses. Last, this research is important to the academic community, because it contributes to the discourse on *energy security*, *energy poverty*, and *energy sovereignty* conceptually, and demonstrates methodological instruments that can be applied in other contexts.

## *5. Overview of dissertation chapters*

Chapter 1. Energy Security: Understanding National Vulnerability in Energy Sector of Tajikistan

Energy security is treated as a *goal* – a state of being, in which energy services are accessible and the vulnerabilities of the energy systems are reduced. For example, security in the electricity sector would mean that large-scale dams are physically safe, the grid is upgraded, and small-scale technologies are installed to service remote communities. At the local level, adequate provision of these services would result in energy security while failure to do so would result in energy poverty.

The research uncovered key vulnerabilities of the energy system including insufficient energy production capacity, unreliable and expensive energy imports, dwindling power infrastructure causing technical and economic losses, inadequate transparency in the power sector, lack of regional cooperation in energy and water resource sharing, and inadequate financial resources to address all of the above. The Government of Tajikistan has taken steps to address these vulnerabilities. Plans and projects are under way to build small, medium and large hydropower plants to not only meet domestic demand, but also to sell power abroad. Existing thermal power plants are switching to coal; new ones are under construction, primarily aiming to provide for heating needs in the winter. To ensure sufficient supply, development of new coal mines is proposed. Discovery of potentially large resources of natural gas and oil is attracting attention to further exploration and seismic surveys. International players are involved, but the prospects of actual extraction remain uncertain. In the meantime, however, fuel imports are likely to remain as a primary option in powering the transportation and industry, while the domestic sector would remain dependent on local biomass (wood, dung).

More specifically, three major proposals are offered by the World Bank, the United Nations Development Program (UNDP) and the Government of Tajikistan to achieve energy security in Tajikistan. A rigorous evaluation of these options, however, shows that they fall short of achieving the objective. Another potential solution, currently underexplored, rests with taking the *energy services* approach developed by the Practical Action (2014). This approach is dealt with in more detail in Chapter 2 and complemented with the *energy sovereignty* concept, which is the subject of Chapter 3.

## Chapter 2. Understanding and Alleviating Energy Poverty in Tajikistan

Energy poverty reflects the current condition of access to energy services at the level of the community and household – this constitutes the *problem*. Rural communities in Tajikistan continue to rely on solid biomass (wood, straw, animal dung) to meet their thermal energy needs, and many households are not connected to the electrical grid. Being connected to the grid, however, does not mean access to electricity is reliable or affordable. During winter, when energy needs are particularly acute, households experience daily blackouts. Households use a variety of energy sources, including electricity, wood and dung to satisfy their various energy services, including lighting, cooking, heating, cooling, information and communication, and mobility. The main reason is that each fuel is used for a different purpose, such as cooking, cooling, information and communication, etc. Moreover, the use of fuel critically depends on the availability, affordability and reliability of energy sources. When either of these qualities is lacking, households adopt multiple energy sources to fulfill their needs.

The analysis of rural energy situation in Tajikistan shows that people there are enduring energy poverty. To improve access to energy, a mutually beneficial sharing of water and energy resources among Central Asian countries is a possibility that is much lauded; yet, it breeds more controversy than cooperation. Other proposals are also being considered that are discussed in detail in Chapter 2. A more practical and immediate way to start to address the challenge of energy access is through provision of small-scale technologies such as solar home systems, micro-hydro units, biogas digesters, improved cookstoves, residential wind turbines and thermal insulation of homes. Easily deployed, maintained and configurable to needs, plus cost-effective and environmentally sustainable in the long-term, these technologies can be optimal for rural areas. However, their dissemination requires service providers and supply chains that extend beyond national boundaries. Businesses, together with governments and civil society organizations, can take advantage of technologies to lead the transition from energy poverty to security.

## Chapter 3. Energy Sovereignty: Understanding Decision-making and Empowerment in Tajikistan

Energy sovereignty is a *process* to reach the goal of energy security. The key question is: *How* are energy needs met? This is a process of complex decision-making that is influenced by many factors including cultural values, available resources, financial wherewithal, technological capability, and ecological foundation of households. An interplay of these factors leads to decisions and choices about the use of certain energy resources and pathways. This chapter finds economic, technological, ecological, cultural and institutional factors to influence energy decisions the most relevant. The agro-pastoral system determines how energy is used at the household scale in rural areas. More importantly, the institutions of state, market and civil society are currently underperforming in their respective roles to improve access to energy for rural households.

This research reveals that energy use factors interact in myriad ways and their influence is hard to plan for and therefore, predict. Nevertheless, programs and projects aimed at eradicating energy poverty and improving energy security need to take these factors into account in order to be successful. Reliance only on technical and economic efficiency is clearly insufficient. Ecological, institutional and cultural characteristics of the target population should be well-studied and then incorporated into energy solutions. Local people should not only be involved in all stages of project conception through implementation but, in fact, they should drive such initiatives to improve their wellbeing through satisfying their energy needs. This is what energy sovereignty ultimately entails.

# CHAPTER 1: ENERGY SECURITY: UNDERSTANDING NATIONAL VULNERABILITY IN ENERGY SECTOR OF TAJIKISTAN

***Abstract***

Massive shortages of key energy inputs such as electricity and natural gas as well as transport fuels such as gasoline and diesel cripple efforts aimed at achieving greater prosperity in Tajikistan. This chapter conceptualizes *energy security* as *low vulnerability of vital energy systems and sustained provision of modern energy services*. Based on the analysis of government statistics, this chapter highlights key vulnerabilities including insufficient energy production capacity, unreliable and expensive energy imports, dwindling power infrastructure causing technical and economic losses, inadequate transparency in the power sector, lack of regional cooperation in energy and water resource sharing, and inadequate financial resources to address all of the above. This chapter reviews three major proposals presented by the World Bank, the United Nations Development Program, and the Government of Tajikistan to achieve energy security in Tajikistan. Evaluation of these options, however, shows that they fall far short of achieving the goal. This chapter points to leveraging small-scale technologies and business models as another solution to improving energy access in Tajikistan.

## *1. Introduction*

On the road to economic development and improving welfare of the people, the national government of Tajikistan is following three strategic directions: achieving energy security, ensuring food security and withdrawal of the country from communication isolation (Rahmon, 2010). The strategic importance of energy security arises from a precarious energy situation that cripples efforts aimed at achieving greater prosperity for the people of Tajikistan. This situation is characterized by massive shortages of key energy carriers such as electricity and natural gas as well as transport fuels such as gasoline and diesel. Alleviation of such energy shortages and providing of "reliable and high quality access to energy for the entire population, for industries and services, and to ensure the efficient use of energy in order to reduce poverty" are the main objectives of energy security in Tajikistan (Energy Charter Secretariat, 2013. p. 11).

In Tajikistan, there are at least three major proposals to achieve energy security. The World Bank proposal (Fields et al., 2013) emphasizes energy efficiency, investment preparation, trade promotion and energy policy as mechanisms to attain the energy security objective. The proposal by the United Nations Development Program (UNDP) takes a bottom-up approach, focusing on enhancing energy efficiency and developing renewable energy sources at the local level with the subsequent integration of primarily small-scale hydropower plants into the national electricity grid (Morjav et al., 2010a; Morvaj et al., 2010b; Bukarica et al., 2011). The third proposal put forth by the Government of Tajikistan is to complete the construction of the Rogun hydropower plant with the tallest dam in the world (Rogunges.tj; Energyprojects.tj).

All three proposals have elements that could potentially contribute to achieving energy security. However, a closer examination of proposals conducted in this chapter reveals critical shortcomings that can be detrimental to energy security, if not addressed adequately. The proposals overlook the complexity of energy needs and the role of local communities in addressing their energy priorities. As a way to remedy these shortcomings, this chapter then proposes an alternative approach to energy security, namely the *energy services* approach adapted from Practical Action (2014), and explored more fully in Chapter 2. The importance of engaging local people is detailed in Chapter 3.

The rest of the chapter is organized as follows. First, the methods of this research are explained. Second, before undertaking the analysis of the proposals, the concept of energy security is clarified. Third, energy security in terms of sources, production and consumption of energy in Tajikistan is assessed to provide the basis for evaluating the three proposals. Finally, an energy services approach is suggested as an alternative before concluding the chapter with recommendations arising from the analysis.

## ***2. Methods***

### *2.1 Review of literature and secondary data*

The topic of energy security has received a lot of attention, yet there is little consensus if any on the definition of the concept or the metrics used in its analysis. To better understand the state of the research, relevant literature including scholarly publications and other reports, was reviewed, and a summary of this review is presented in the next section. The analysis of the energy situation in Tajikistan drew on the energy database of the International Energy Agency and the Statistics Agency of the Republic of Tajikistan, in addition to scholarly literature and reports to obtain data on the sources, production and consumption of energy in Tajikistan. This assessment is provided after the literature review. Finally, evaluation of three energy security proposals were based on available reports by the World Bank and the UNDP, and the documents by the Government of Tajikistan.

### *2.2 Expert interviews*

In order to understand the energy security situation at the national level, interviews were conducted with experts working in energy-related issues in the public, private and non-governmental organizations. A partnership was built with the Ministry of Economic Development and Trade, which is a de-facto leading ministry, to provide access to other relevant governmental agencies. A total of 17 experts were contacted; however, only 6 experts agreed to be interviewed in the capital city of Dushanbe, Tajikistan in April-May, 2015.

Three questions were asked during the interviews, namely, about expert's understanding of the concept of energy security, the challenges facing the country in the energy security domain and the potential solutions they see to achieve the objective of energy security. The questions to and responses of experts are provided in Appendix 2, but are not integrated into this chapter because of the small number of experts interviewed.

Many reasons precipitated the low recruitment level: some experts lost the letter of support, some got the letter but delayed on the pretext of being busy, others were always away from their desk (and phone), still others would outright refuse to participate. This reluctance is understandable because the issue of energy security is highly contentious and people are afraid of the repercussions even though the researcher promised to guarantee absolute confidentiality of respondents. But this is a finding in itself that demonstrates the constraints on conducting research with expert participants. It is also an indication that there is some level of apprehension on the part of experts to express their views even under conditions of confidentiality that the research guarantees.

### *3. Evolution of the energy security soncept*

The concept of energy security is widely used in the literature. Before delving into the complexity of the issue, it is instructive to consider the meaning of the word "security". It is derived from 'secure', which comes from the Latin words "se" meaning "without, apart" and "cura" meaning "care" ("Secure," 1996); thus, security is understood as "freedom from care, anxiety or apprehension; absence of worry or anxiety; confidence in one's safety or well-being" ("Security", 2014). When it comes to the domain of energy, what is the "worry", "anxiety" or "apprehension"? What can bring about and sustain "confidence in one's safety or well-being"? The short answer is "vulnerabilities". In other words, the worry, energy security anxiety or apprehension stems from the vulnerabilities associated with our energy systems. In order to be confident in our safety and wellbeing, we need to make our energy systems secure by minimizing or eliminating those vulnerabilities.

In this chapter, such a vulnerabilities approach is adapted to discuss energy security, and this reveals the types of threats that energy systems are prone to, and identifies potential responses to those threats.

### *3.1 Dimensions of energy security*

Many analysts and experts have dealt with the challenge of addressing energy security issues (Hughes, 2009; Löschel, Moslener, & Rübbelke, 2010; Vivoda, 2010; Sovacool & Brown, 2010; Sovacool & Mukherjee, 2011; Sovacool, 2011), and these efforts contributed to the evolution of the concept. As a result, an approach emerged in the past decade that aims to parcel out energy security challenges into different "aspects" or "dimensions" (Cherp & Jewell, 2011).

To illustrate this approach several examples are presented here. The widely known 4 A's of energy security are: "availability" (elements relating to *geological* existence), "accessibility" (*geopolitical* elements), "affordability" (*economical* elements), and "acceptability" (*environmental* and societal elements) (Kruyt, van Vuuren, de Vries, & Groenenberg, 2009, emphasis in original). Similar to this classification, Sovacool & Brown (2010) suggest "availability" (independence and diversification), "affordability" (low and stable price, high quality fuel/service), "efficiency" (technical and economic efficiency of energy technologies/services, and conservation), and "environmental stewardship" (sustainable use of resources). An alternative classification developed by von Hippel et al. (2011) clusters the energy security challenges around six dimensions, namely, "energy supply, economic, technological, environmental, social/cultural, and military/security". In a similar vein, Alhajji (2010) classifies the challenges into six dimensions, with slight variation, but takes a further step to demonstrate the interrelationship among the dimensions in terms of "competition" and "interaction", discussed below.

Such attempts at making the concept of energy security comprehensive highlight its significance for policy relevance. However, the rationale and method for selecting and grouping certain aspects, but not others, are not always clear or systematic (Cherp & Jewell, 2011). Furthermore, the level of generalization can result in oversight of contextual importance (Cherp, 2012). In a survey of the literature, Lynne Chester (2010) contends that energy security is "commonly found embedded in discussion framed around a handful of notions which denote unimpeded access or no planned interruptions to sources of energy, not relying on a limited number of energy sources, not being tied to a particular geographic region for energy sources, abundant energy resources, an energy supply which can withstand external shocks, and/or some form of energy self-sufficiency" (p. 885). Recognizing the variety of interpretations, Chester suggests that the term is not well understood in the literature because energy security is "polysemic in nature, capable of holding multiple dimensions and taking on different specificities depending on the country (or continent), timeframe or energy source to which it is applied" (p. 886). Therefore, Chester discourages formulating a common standard definition or metric; rather, she emphasizes that the underlying assumptions be made explicit through providing definitions.

Considering the multiplicity of dimensions to energy security, Cherp & Jewell (2011) in their extensive review of literature, from early 1900 to the first decade of 2000, integrate various energy security concerns into three perspectives: "robustness", "sovereignty"[2] and "resilience" (see Table 1).

**Table 1: Three perspectives on energy security**

| **Perspective** | **Sovereignty** | **Robustness** | **Resilience** |
|---|---|---|---|
| **Historic roots** | War-time oil supplies and the 1970s oil crises | Large accidents, electricity blackouts, concerns about resource scarcity | Liberalization of energy systems |
| **Key risks for energy systems** | Intentional actions by malevolent agents | Predictable natural and technical factors | Diverse and partially unpredictable factors |
| **Primary protection mechanisms** | Control over energy systems. Institutional arrangements preventing disruptive actions | Upgrading infrastructure and switching to more abundant resources | Increasing the ability to withstand and recover from various disruptions |
| **Parent discipline** | Security studies, international relations, political science | Engineering, natural science | Economics, complex system analysis |

Source: Cherp, A., & Jewell, J. (2011).

Each perspective has emerged in the analysis of energy security from different academic disciplines, ranging from security studies to engineering to economics. The underlying concerns dealt with in the literature converge on the risks of disruptions to energy systems, and in particular, four risk factors: "natural (e.g., resource scarcity,

[2] This 'sovereignty' perspective is relevant at the nation state level, whereas the "energy sovereignty" concept formulated in Chapter 3 pertains to the sub-national, local level and deals with the factors influencing household decision making to provide for modern energy services.

extreme natural events), technical (e.g., aging of infrastructure, technological accidents), political (e.g., intentional restriction of supplies or technologies, sabotage and terrorism), and economic (e.g., high or volatile prices)" (Cherp et al., 2012, p. 330). Consequently, Cherp et al. (2012) define "a nation's energy security as protection from disruptions of energy systems that can jeopardize nationally vital energy services" (p. 329). The outcome of such "protection from risks" is "independence, reliability, resilience, availability, accessibility, affordability, or sustainability of energy systems" (p. 330) that constitute the key "dimensions" in the classification of energy security challenges as discussed above.

As their definition suggests, the security of energy systems is necessary for provision of "vital energy services", which Cherp et al. (2012) recognize as being different from country to county, but nonetheless include energy for transportation and buildings, and to varying degrees, energy for industry, and revenue from energy exports. An assessment of energy security, thus, involves gauging the "vulnerability of energy sources (such as oil, gas, coal, hydro, and nuclear energy) and infrastructure for energy conversion and transmission (such as power plants, fuel reservoirs, and pipelines)" as well as their interrelationships with energy demand (p. 331). This vulnerability approach to energy security assessment will be adopted in the analysis of Tajikistan's energy security situation in subsequent sections of this chapter. As will be explained in detail below, this approach is appropriate because it allows looking at system level risks as well as the provision of energy services.

### *3.2 Energy security vulnerabilities*

Energy systems are vulnerable to a suite of threats that over three decades ago Amory and Hunter Lovins (1982) meticulously demonstrated in their book *Brittle Power: Energy Strategy for National Security*. Assessing the electricity system in the United States, their central argument was that energy systems are inherently vulnerable as a result of "unintended side effect of *the nature and organization of highly centralized technologies*" (p. 2, emphasis in original). The way these systems are designed, operated and managed makes them vulnerable to threats and failure. Lovins & Lovins (1982) characterize four key threats, namely, "natural events, aggressive physical act (war, terrorism, and sabotage), failures of complex technical and economic systems, and failures of control mechanisms and devices".

Natural events can turn into disasters, for example, when hurricanes take a toll on human lives directly, as well as indirectly as they wash away offshore oil and gas platforms or destroy coastal energy infrastructure leading to shutdown of refineries and pipelines and power outages for consumers. Not only severe weather such as storms, drought or floods, but even "'normal' bad weather is also disruptive, with routine snowfalls, spring thaws, ice break-ups, and so forth snarling transportation and communication for days or weeks each year" (Lovins & Lovins, 1982, p. 11). Deliberate human action against energy systems can be aggressive, so as to cause harm (war, terrorism or sabotage), but it can also be carried out for other motives not necessarily intending to harm (strikes, judicial injunctions or permit suspensions) - either way resulting in disruption. Because of their elaborate design and complex construction, technical systems can fail when a small detail is overlooked. A misplaced minus sign in a computer program sent a NASA missile on a wrong path and it had to be destroyed in the air (Lovins & Lovins, 1982, p. 16). Another example is Space Shuttle Challenger disaster of 1986 that occurred due to a technical flaw and lower than required temperature on the launch day (Bergin, 2007). Finally, control mechanisms are arguably the most vulnerable part of any system, and especially of computerized ones, because "through computers, the ability to affect much by little becomes concentrated in one place, perhaps accessible electronically from many other places" (Lovins & Lovins, 1982, p. 16). This is more so evident in today's age of internet connectivity. Physical or even virtual presence is not required, as was demonstrated in the detonation of a Soviet natural gas pipeline in Siberia in 1982. It was caused by malfunctioning of a computer control software that the Soviets allegedly stole from Canada. As it turned out, it was a deliberate setup by the US Central Intelligence Agency that bugged the software and left it in Canada to be stolen by the Soviets (Sovacool, Sidortsov, & Jones, 2014, p. 160).

Although Lovins & Lovins' (1982) assessment was completed over three decades ago and their focus was on the USA, their findings remain valid today and are applicable to any energy system in the world, granted the nature and intensity of threats may differ depending on the context. In a more recent study, Farrel et al. (2004) further explore the vulnerability of energy systems with a particular attention to the concept of "critical infrastructure protection" or CIP. What can be considered as critical infrastructure varies depending on the context and time. However, the salient feature of such infrastructure is that its destruction would jeopardize national security, public safety or way of life. Critical infrastructure can range from transportation and communication to water and energy systems as well as pubic health and the environment. With respect to energy infrastructure Farrel and colleagues note some distinct vulnerabilities:

> "Breaches of security in nuclear plants can lead to large-scale environmental disasters—but the infrastructure is concentrated and relatively easy to guard. Oil and gas production, transportation, and refining infrastructures are often spatially concentrated, and disruptions can lead to shortages if supply is not restored before stockpiles are exhausted. Traditional electricity infrastructures suffer from the need for system-wide integrity to ensure supply reliability, having critical facilities spatially concentrated (substations), and insignificant storage capacity for emergency supply" (p. 421).

Farrel et al. (2004) go on to identify four approaches to CIP. Physical protection, which they dub as "guns, gates and guards", is meant to prevent unauthorized access to energy infrastructure through increased surveillance, training on counter-terrorism and improvement of physical security. Failing that, emergency response and restoration measures are meant to contain and reduce the damage by risk communication (to avoid panic), evacuation, medical treatment and long-term decontamination and repair. In either case, the role of institutions - both public and private - is paramount in providing intellectual and financial support to mitigate and respond to infrastructure failure. Finally, energy efficiency can potentially reduce the impact of failure because the burden on infrastructure is lower and therefore, the "system [could] continue to function and stored fuels would last longer during an emergency" (p. 459). In addition, decentralized local production through small-scale renewable technologies is more responsive to local demand and less dependent on vulnerable fuel supplies.

The security of energy systems, in general, and reliability of infrastructure, in particular, are likely to remain a longtime challenge because human ingenuity can work both ways, either to enhance or undermine security. One side might work toward reducing vulnerabilities whereas the other, in Lovins & Lovins's (1982) words, "deliberately seek out and exploit vulnerabilities so as to maximize damage and limit possible responses" (p. 14).

### *3.3 Complexity of energy security risks and responses*

The various threats to energy security are not always distinct and isolated. Quite the contrary, as Lovins & Lovins (1982) document, the threats can interact and result in compound effects. In the western USA, California experienced a drought period from 1975 to 1977. Due to low rainfall hydroelectric generation was reduced by about 40%, prompting electric utilities to burn more oil, thus raising operating costs. Moreover, water allotments for agriculture had to be reduced, which prompted more pumping of groundwater for irrigation, resulting in more electricity use. If coal slurry pipelines operated, which they did not, their use would be reduced sharply because of lack of water. In other words, two separate systems of hydro and coal electricity generation could fail at once. During the same period, in the eastern part of the United States cold temperatures hit the record low, necessitating burning of more oil. As a result of drought in the West and cold in the East, an additional 200 million barrels of oil was imported with a price tag of US$6 billion. The consequences would have been devastating and large-scale, had the cold temperature also affected Europe and Japan, which usually have the same characteristic weather pattern. It is not hard to imagine what a scramble this situation would have created if one considers that in this period the supply and cost of oil at the world marketplace were major concerns in the aftermath of the 1973 oil crisis.

Another interaction of threats that Lovins & Lovins (1982) mention is that bad weather can be the best time to cause disruption to energy systems. As a case in point, the 1972 and 1974 coal miners' strike in Britain took place in winter. According to Coalfield Web Materials project, which digitizes University of Wales's South Wales Coalfield Collection, the miners demanding higher pay went on strike on January 9, 1972 and subsequently picketed all power stations, and also steelworks, ports, coal depots and other major coal use locations. The resulting shortage of power led to a state of emergency and introduction of a three-day working week. The deal was reached and work resumed on the last day of winter – February 28. However, miners' wages plunged compared to other sectors, and two years later the miners came out on strike - again coinciding with winter. State of emergency and a three-day working week were re-introduced. This time, though, the incumbent government of Edward Heath did not budge, and called for a general election on February 28, 1974. But contrary to his expectations, his Conservative party lost, and the winning Labor Party reached a deal with the miners. As this case demonstrates, heavy reliance on coal made the British economy extremely vulnerable, particularly at a time when energy was most needed.

There is competition and interaction among the dimensions of energy security, as demonstrated in Alhajji's (2010) classification. Under the economic dimension, a higher price of energy resources could have a negative impact on the consuming country whose economy is energy intensive and dependent on energy imports. Conversely, it could reflect positively on the producing country bringing more revenues per unit of export. In the long-run, however, high prices may lead to reduction in economic growth in consuming nations resulting in lower demand for energy. This would in turn lead to reduction in prices and thus revenues for producing nations, resulting in subsequent reduction in their economic growth. Potential responses would be economic reorganization away from dependence on exports or imports by diversification of sources of income and reducing energy intensity through energy efficiency.

The environmental dimension, as Alhajji (2010) suggests, is concerned with negative environmental impacts, such as water contamination and emissions of carbon dioxide, associated with production and consumption of energy sources. To alleviate negative effects, energy efficiency is one response. Others include reducing energy use or increasing taxes on energy products. The latter, however, could impact the economic dimension in terms of dampening growth, or drive low-income families to shift to using coal, wood and dung - that could lead to other environmental impacts such as deforestation and pollution.

Next, Alhajji (2010) highlights the social dimension in the energy gap between the energy-rich and the energy-poor. In essence, “the larger the energy gap, the more insecure a country becomes; the larger the proportion of the poor who are not able to obtain energy resources, the more energy insecurity a country experiences” (p. 207).

This is a security issue as it may lead to political unrest or reduction in economic growth. As a response, subsidies and price controls could increase access to energy resources; however, such policies also result in unintended adverse environmental impacts, help the rich more than the poor, and encourage smuggling.

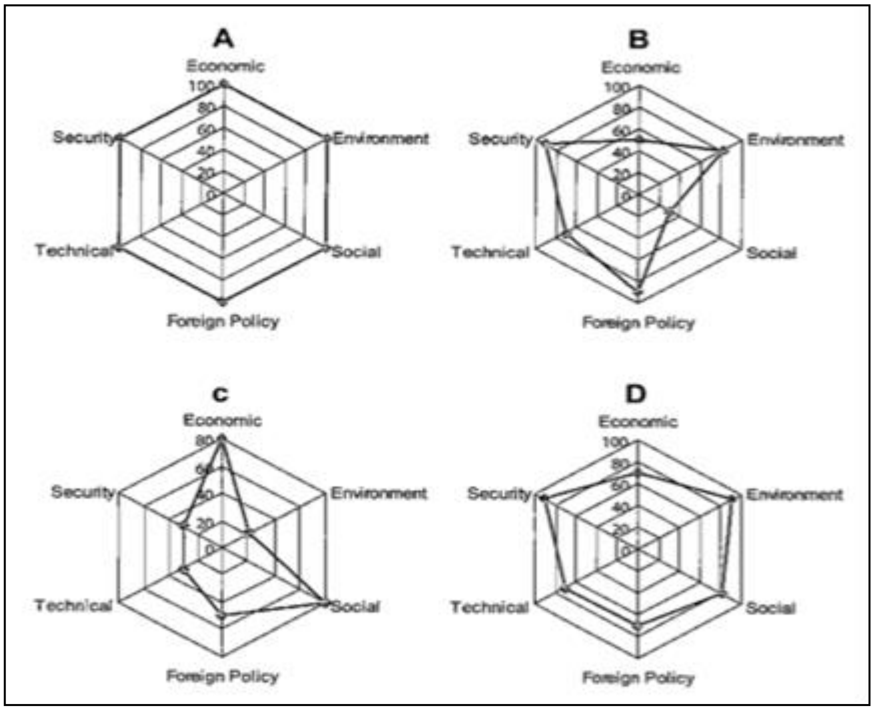
Another dimension that Alhajji (2010) points out concerns foreign policies directed at cajoling the countries on whose energy export or imports they depend, at the expense of other important issues such as human rights and environmental protection. Diversification of income and energy sources would be an appropriate response. Foreign policy objectives could also be incorporated into energy policy, for example, by increasing imports from those countries where human rights records improved. The latter, however, would have economic repercussions as noted in the economic dimension.

As for the technological dimension, Alhajji (2010) states the objective as making sure that “low prices for a certain energy resource - such as oil - and government regulations do not choke new technologies that improve energy efficiency, increase energy productivity, lower production costs, lower emissions, and bring new energy sources to the market place” (p. 210). Moreover, proliferation of technologies around the world is encouraged, but a check should be put on government support of such technologies that could adversely affect other dimensions of energy security. For example, in an effort to become more energy independent, a government might invest in a certain technology (e.g. fuel cells), the primary material for which (e.g. palladium) is concentrated in a few countries (e.g. Russia and South

Africa) that may have divergent foreign policy objectives. Apart from failure to achieve more energy independence, such investment would also compromise the foreign policy or the national security dimensions of energy security. This latter and final dimension echoes the threats and responses to the critical infrastructure protection (CIP) discussed above, and adds an emphasis on “availability of energy resources for the nation’s military and police forces, especially during wars, domestic violence or natural disasters” (p. 212).

It is important to accentuate, as Alhajji (2010) does, that these dimensions are competitive and interactive. Their competitive nature reveals that trade-offs are inherent with the risk of maximizing one dimension at the expense of another. Contrary to competition the property of interaction is that a positive change (say growth) in one dimension can lead to positive change (growth) in other dimensions - perhaps also resulting in some multiplier effect. Recognizing that it can be tricky for countries to make decisions that would lead to greater energy security, Alhajji (2010) proposes a measurement tool called “Energy Security Index” that is graphically illustrated as “Energy Security Star” (see Figure 4). Each dimension is calculated, given an index, and plotted on the hexagon ‘star’. The larger the area of the star, the greater is the energy security of a country. As Figure 4 illustrates, next to the ideal situation of country A, a hypothetical country D has greater energy security than countries B and C. This tool is conceptually appealing, however, practically very difficult to apply. It is data-intensive and therefore may be very costly for some countries. As with any index, assumptions must be made that may not reflect the reality and comprise complexity, especially as many energy security issues are context-dependent. Nonetheless, understanding competition and interaction among energy security dimensions at the conceptual level can aid better policy making by calling for a closer look at the interacting effects, as opposed to the narrow view of maximizing one dimension.

**Figure 4: Energy Security Stars for hypothetical countries**




Source: Adapted from Alhajji, A. F. (2010).

## *3.4 Application of energy security concept to Tajikistan*

As discussed above, many attempts are made at making the concept of energy security comprehensive. However, the question remains open regarding the extent to which its underlying assumptions can be made explicit, and thus, avoid the confusion of meaning different things to different people. In addressing this question, energy security in this chapter will be articulated based on the vulnerability approach. A working definition of energy security – *low vulnerability of vital energy systems and* *sustained provision of modern energy services* – is based on the work of the Global Energy Assessment (Cherp et al., 2012). This definition captures the various dimensions of risk factors discussed, while allowing space for necessary contextual adaptation. Using the vulnerability approach, threats and responses to Tajikistan's energy system will be assessed, along with the services that such a system provides.

## *4. Analysis of energy security situation in Tajikistan*

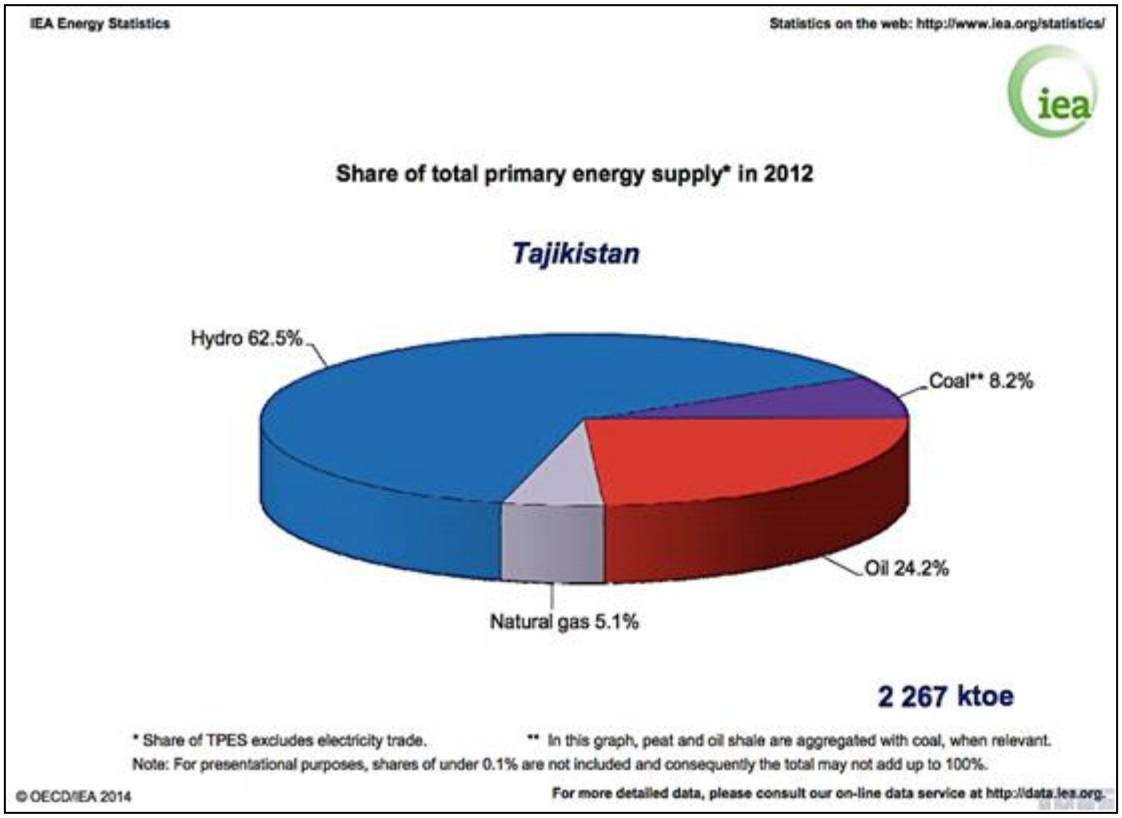
This section provides an overview of the energy situation in Tajikistan by taking stock of energy sources and analyzing energy production and consumption patterns. This analysis provides the necessary context, in which to place the subsequent evaluation of energy security options provided in the next section.

### *4.1 Sources of energy*

In order to understand the energy situation in Tajikistan a review of energy sources and use patterns provides a good starting point. The primary energy supply for the country is hydropower, followed by oil, coal and natural gas (see Figure 5). This pattern is essentially determined by the resource base of the country.

According to Musayeva et al. (2009), hydro resources in Tajikistan hold a substantial power generation potential that is estimated at 527 billion kilowatt-hours (kWh), but technical potential is 317 billion kWh, or 61% per year. This ranks Tajikistan eighth in the world, after China, Russia, the USA, Brazil, Zaire, India and Canada, in terms of absolute hydro resources (EDB, 2008). According to Fakirov (2012), with 87.8 thousand kWh of electricity per capita, Tajikistan ranks second worldwide, and with 3.62 million kWh per square kilometer it ranks first in its hydropower potential. These estimates imply that Tajikistan could be a leading producer of hydroelectricity, positioning itself as a potential energy exporter in the region. As the analysis below will demonstrate, such plans are in place, although their feasibility is questionable.

**Figure 5: Share of total primary energy supply in 2012**




Source: IEA Online Energy Statistics Database (2014).

As for hydrocarbons, the resource endowments for coal are estimated at about 4.452 billion tons, gas at 8.517 trillion cubic meters and oil at 117.6 million tons (also see Table 2). Recent reports of discovery of large reserves in Bokhtar region of Tajikistan purport as much as 114 trillion cubic feet of gas and 8.5 billion barrels of oil

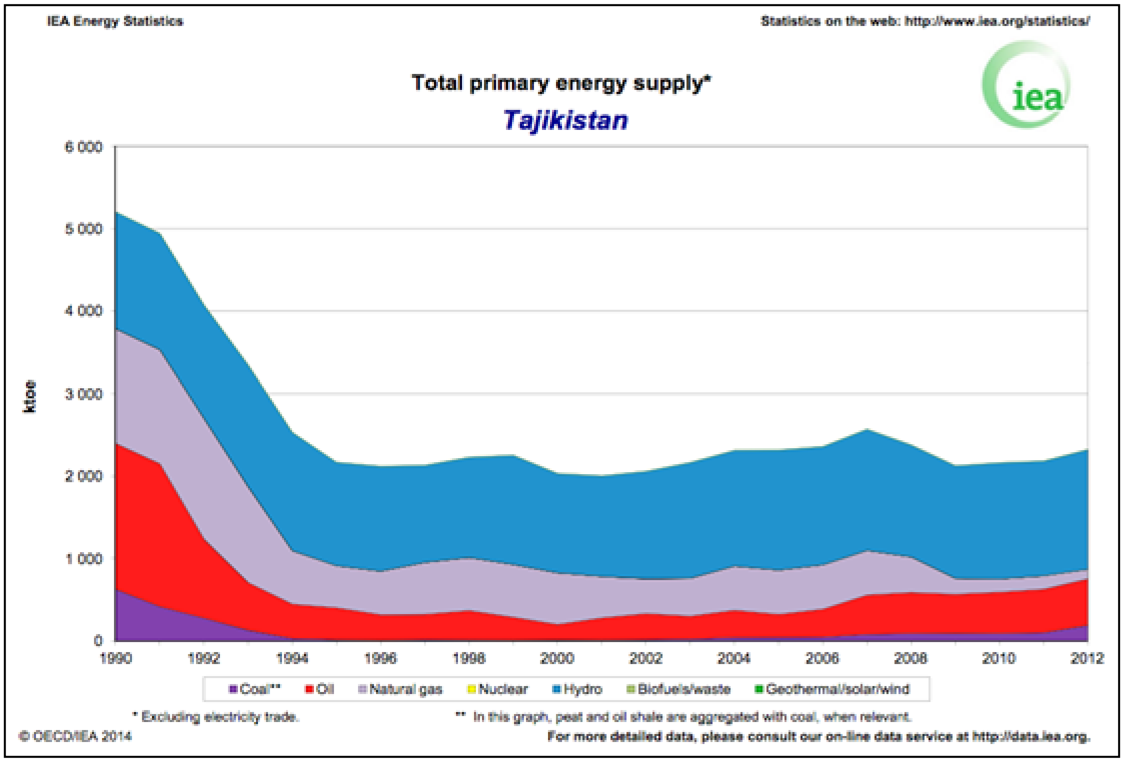
(Collins & White, 2013). According to another source, recoverable oil potential stands at 27 billion barrels (EurasiaNet, 2012).

**Table 2: Structure of energy resources**

| Resource name: | Mtoe | Source: |
|---|---|---|
| Hydro | 158.12 (a)<br>179.2 (b) | (a) Olimova et al. (2006); Musayeva et al. (2009)<br>(b) Fakirov (2012) |
| Coal | 13.35 | Olimova et al. (2006);<br>Musayeva et al. (2009);<br>Fakirov (2012) |
| Oil | 1.85 | |
| Natural gas | 0.75 | |
| Other sources, including solar, wind and biomass | 1.6 | Olimova et al. (2006) |

The historical record of energy supply, as depicted in Figure 6, shows that Tajikistan's energy supply was highest in pre-1990 period, when it was part of the Soviet Union, and a share of fuels in the supply was relatively balanced. A sharp decline occurred during the early 1990s, after the break-up of the Soviet Union and ensuing civil war in Tajikistan that devastated the economy in a matter of a few years. After signing of the peace and reconciliation act in 1997, in the latter part of the decade and continuing to 2012, overall supply levels appear to have stabilized around a little over 2 Mtoe (million tons of oil equivalent). The energy mix, however, has gradually shifted. Gas supply, once accounting for a larger share in the mix, decreased over time. Since 2008 piped supply from Uzbekistan has shrunk significantly, and it was motivated by overdue payments that Tajikistan owed (Khashim, 2009). The gas supply was subsequently stopped at the end of 2012 due to disagreement over its import price (Swinkels, 2014). Unlike gas, oil supply has shown a slight upward trend owing to increased number of private vehicles. The supply of coal has made a slow comeback due to demand for heating, and operation of combined heat and power (CHP) plants on coal. The share of hydropower supply has increased since mid-1990s to compensate for the reduction in the share of other fuels.

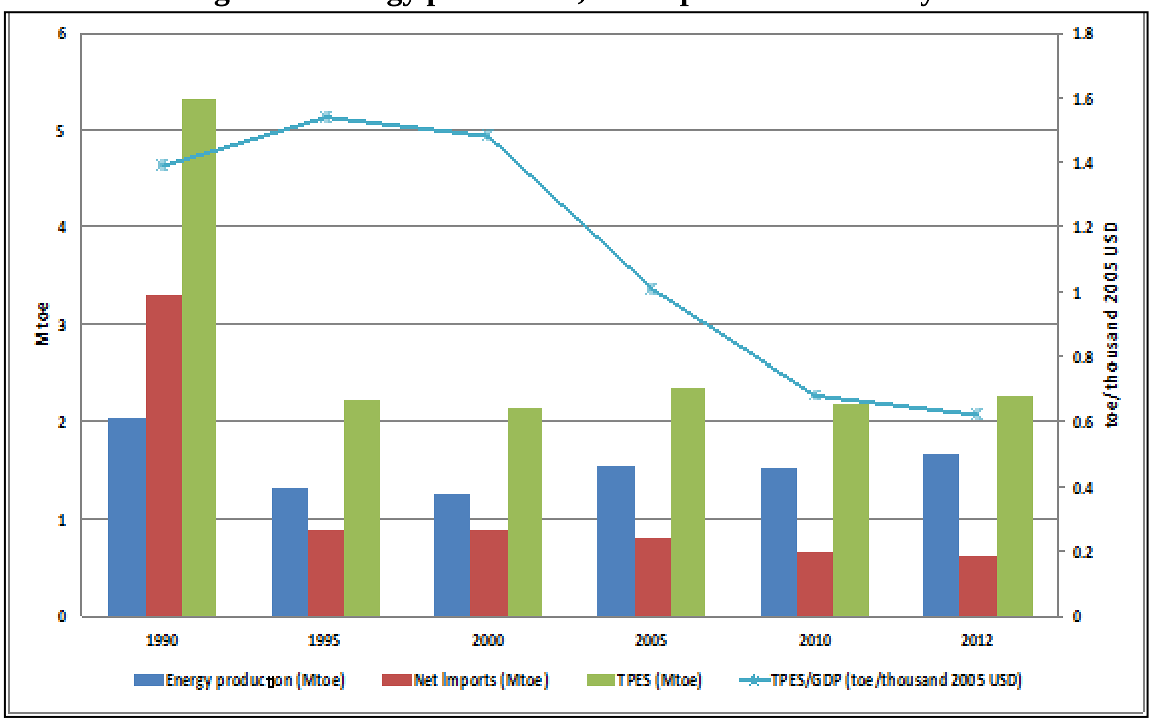
**Figure 6: Total primary energy supply, 1990-2012**




Source: IEA Online Energy Statistics Database (2014).

As a breakdown of energy supply reveals, Tajikistan produced about 40% and imported 60% of its energy in 1990 (see Figure 7). This pattern was due to a resource sharing mechanism that operated among Central Asian republics under the Soviet rule (see sub-section 4.6). Since the mid-1990s, domestic production gradually increased making up for the shortfall in energy trade, albeit the total supply shrank substantially. By 2010 the relative share of domestic production rose to 70%. This reversal took shape when the former Soviet Union republics began to shift in the political-economic domain away from centralized rule and command economy towards independence and market relations. In Tajikistan, a reduction in energy intensity of the economy, which is a proxy for energy efficiency, was observed as shown with a line in Figure 7. The reduction was due to faster increase in GDP (denominator) from $1.45 to 3.67 billion (constant 2005 prices) from 2000 to 2012, compared to marginal change in TPES (numerator) during the same period. Economic growth in the initial period was a result of end of civil war and post-conflict rehabilitation. In the later period, the growth was stimulated by consumption, which in turn was driven in greater part by inflow of remittances than by industrial activity.

**Figure 7: Energy production, net imports and intensity**




Source: IEA Online Energy Statistics Database (2014).

## *4.2 Production of energy*

In view of its resource endowments, energy production in Tajikistan is dominated by electricity, which is almost entirely generated by hydropower plants. As shown in Table 3, annual generation was around 16 billion kWh on average between 2005 and 2011. Extraction of hydrocarbons remained limited due to lack of adequate investment and technical expertise. Coal production, on the other hand, more than doubled in the same period. Oil production increased marginally, whereas gas production fluctuated in a downward trend.

**Table 3: Energy production by source**

| Energy source: | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|
| Coal (thousand metric tons) | 98.5 | 104.6 | 181.4 | 198.5 | 178.3 | 199.7 | 236.4 |
| Oil including gas condensate (thousand metric tons) | 21.7 | 23.7 | 25.9 | 25.8 | 26.2 | 27 | 28.3 |
| Gas (million cubic meters) | 29.4 | 20 | 17.4 | 16.1 | 19.9 | 22.8 | 18.5 |
| Electricity (billion kilowatt hours) | 17.1 | 16.9 | 17.5 | 16.1 | 16.1 | 16.4 | 16.2 |
| *Hydropower, billion kilowatt hours* | *17* | *16.7* | *17.1* | *15.8* | *15.9* | *16.4* | *16.2* |

Source: Regions of Tajikistan 2012 by the Statistical Agency of Tajikistan.

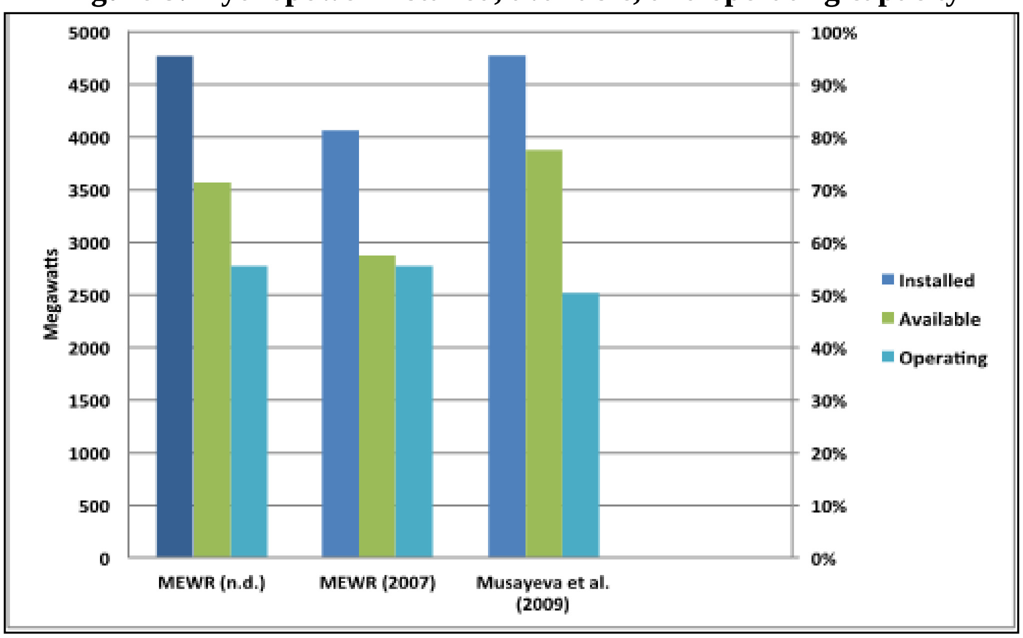
## *4.3 Hydropower plants in Tajikistan*

An overview of installed energy capacity in Tajikistan is provided in Table 4. Hydropower plants claim over 90% of the total installed electricity generation capacity in Tajikistan, with remaining capacity provided by thermal power plants. The Nurek Hydropower Plant (HPP) alone holds 3,000 MW or over 60% of all installed hydropower capacity, and therefore, is considered the backbone of the energy sector in

Tajikistan. Other significant plants include Sangtuda-1 HPP (670 MW) and Baipaza HPP (600 MW).

The installed capacities are not fully utilized because their availability depends on river flows and effective demand. According to different estimates shown in Figure 8, between 71 and 81% of the capacity is available, and only 53 to 68% is actually operating on average annually. Due to the seasonal nature of hydropower production the operating capacity is even lower in winter period given reduced river flows. Fields et al. (2013) estimate that total firm capacity[3] in wintertime falls to 2,250 MW or 47%, which is 1,250 MW short of peak load demand. Winter flows affect small hydropower plants even worse due to the absence of water storage facilities. The firm capacity of such plants drops down to 25% of installed capacity during the winter months.

**Figure 8: Hydropower installed, available, and operating capacity**




Source: Musayeva et al. (2009); Ministry of Energy and Industry, Tajikistan (no date; & 2007).

[3] "firm capacity is taken to be the available capacity in January—the month of peak demand, even though, from a purely hydrological point of view, available capacity is lowest in March, when flows are lowest" (Fields et al., 2013, p. 29).

## Table 4: Electricity generation capacity

| # | Generator name | Installed capacity, MW | | | | Available capacity, MW | | | Operating capacity, MW (average annual) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Hydropower plants (HPPs)** | | | | | | | | | |
| 1 | Nurek HPP | 3000 | 3000 | 3000 | 3015 | 2100 | 2100 | 2275 | 2035.3 | 2035.3 | 1853.6 |
| 2 | Sangtuda-1 HPP | 670 | | 670 | 670 | 670 | | 670 | | | |
| 3 | Baipaza HPP | 600 | 600 | 600 | 600 | 450 | 450 | 600 | 471.8 | 471.8 | 437.6 |
| 4 | Kayrakkum HPP | 126 | 126 | 126 | 126 | 126 | 126 | 96 | 68.3 | 68.3 | 55.52 |
| 5 | Vakhsh cascade | 285.05 | 285.05 | 285.05 | 249 | 162 | 162 | 205 | 160.9 | 160.9 | 139 |
| *5.1.* | *Golovnaya HPP* | *240* | | *240* | *210* | *140* | | *160* | *140* | | *119.8* |
| *5.2.* | *Perepadnaya HPP* | *29.95* | | *29.95* | *24* | *22* | | *15.1* | *20.5* | | *3.7* |
| *5.3.* | *Central HPP* | *15.1* | | *15.1* | *15* | | | *15.1* | | | *3.7* |
| 6 | Varzob cascade | 25.43 | 25.43 | 25.36 | 25.4 | 6.1 | 5.1 | 6 | 8.4 | 8.4 | 7.9 |
| *6.1.* | *HPP-1* | *7.15* | | *7.15* | *7.5* | *3.5* | | *3* | *4.783* | | *3.942* |
| *6.2.* | *HPP-2* | *14.76* | | *14.76* | *14.4* | *1.6* | | *2.5* | *3.6* | | *3.048* |
| *6.3.* | *HPP-3* | *3.52* | | *3.52* | *3.5* | | | *0.5* | *0.017* | | *0.526* |
| 7 | Pamir-1 HPP | 14 | | 36.7 | 14 | 14 | | | | | |
| 8 | Khorog HPP | 8.7 | | | 10 | 8.7 | | | | | |
| 9 | Kalaikhumb HPP | 0.208 | | | | 0.208 | | | | | |
| 10 | Vanj HPP | 1.2 | | | | 1.2 | | | | | |
| 11 | Namadgut HPP | 2.5 | | | | 2.5 | | | | | |
| 12 | Ak-Su HPP | 0.64 | | | | 0.64 | | | | | |
| 13 | Small scale HPP | 30.62 | 30.62 | 30.62 | | 26.825 | 26.82 | 26.825 | 22.33 | 22.33 | 22.33 |
| 14 | Varvarinskaya HPP | | | | 28 | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | (non-operational) | | | | | | | | | | |
| 15 | Central Tajik HPP (non-operational) | | | | 18 | | | | | | |
| | **Total HPPs** | **4764.348** | **4067.1** | **4773.73** | **4755.4** | **3568.173** | **2869.92** | **3878.825** | **2767.03** | **2767.03** | **2515.95** |
| | ***% of grand total*** | ***93%*** | ***92%*** | ***93%*** | ***92%*** | ***92%*** | ***90%*** | ***92%*** | ***99%*** | ***99%*** | ***99%*** |
| | | **Thermal power plants (TPPs)** | | | | | | | | | |
| 16 | Dushanbinsk TPP | 198 | 198 | 198 | 230 | 198 | 198 | 198 | 27.2 | 27.2 | 33.9 |
| 17 | Yavansk TPP | 120 | 120 | 120 | 180 | 98.63 | 98.63 | 120 | 8.4 | 8.4 | |
| 18 | Diesel power plant | 27.64 | 27.64 | 27.64 | | 22.441 | 22.44 | 22.441 | | | |
| 18.1. | Mobile | 9.1 | | 9.1 | | 7.5 | | 7.5 | | | |
| | **Total TPPs** | **345.64** | **345.64** | **345.64** | **410** | **319.071** | **319.07** | **340.441** | **35.6** | **35.6** | **33.9** |
| | ***% of grand total*** | ***7%*** | ***8%*** | ***7%*** | ***8%*** | ***8%*** | ***10%*** | ***8%*** | ***1%*** | ***1%*** | ***1%*** |
| **GRAND TOTAL** | | **5109.988** | **4412.74** | **5119.37** | **5165.4** | **3887.244** | **3188.99** | **4219.266** | **2802.63** | **2802.63** | **2549.85** |
| **Data sources:** | | **(a)** | **(b)** | **(c)** | **(d)** | **(a)** | **(b)** | **(c)** | **(a)** | **(b)** | **(c)** |

Sources: (a) Ministry of energy and water resources, Tajikistan (no date); (b) Ministry of energy and water resources, Tajikistan (2007); (c) Musayeva et al. (2009); (d) Energy Charter Secretariat (2013).

### *4.4 Discrepancies in the data on installed capacity*

The estimates of installed capacity shown in Table 4 are taken from different data sources, which vary among each other. To aid the analysis of discrepancy, the respective figures are put together in Table 5. Note that estimates provided by Fields et al. (2013) are also included in this table.

**Table 5: Differences in estimates of installed energy capacity**

| | Ministry of Energy and Industry, Tajikistan (n.d.) | Ministry of Energy and Industry, Tajikistan (2007) | Musayeva et al. (2009) | Energy Charter Secretariat (2013 | Fields et al. (2013) | Average of all estimates |
|---|---|---|---|---|---|---|
| Total installed capacity (MW) | 5,109.988 | 4,412.74 | 5,119.37 | 5,165.4 | 4,750 | 4,911.49 |
| *difference from average* | *4%* | *10%* | *4%* | *5%* | *3%* | *5%* |
| Hydropower capacity (MW) | 4,764.348 | 4,067.1 | 4,773.73 | 4,755.4 | 4,560 | 4,584.12 |
| *difference from average* | *4%* | *11%* | *4%* | *4%* | *1%* | *5%* |

The most recent report by the Energy Charter Secretariat (2013) estimates the total installed capacity at 5,165.4 MW, of which hydropower plants account for 4,755.4 MW. However, in the text of their report on page 37, the respective figures are stated as 5,244 MW and 5,211 MW, without any further clarification. It should be noted that they refer to the website of the Ministry of Energy and Industry of Tajikistan as the source of their data. A thorough search of the website, nonetheless, did not confirm the reported figures. Instead, the website contained an estimate only for hydropower at 4,050 MW – for the "current period", which is not specified anywhere on the webpage[4]. It is possible that the information was removed at a later date.

In a similar fashion Musayeva et al. (2009) estimate total installed capacity as 5,070 MW in the text of their report on page 5, which differs from the estimate of 5,119.37 MW as given in Table 5. The discrepancy in figures for hydropower installed capacity stands at 4,750 MW and 4,773.73 MW respectively.

[4] The webpage has information in Russian and can be accessed at: http://www.minenergoprom.tj/energetika.php

The Ministry of Energy and Industry of Tajikistan provides two sets of data for total capacities of plants (see Table 5). The difference between the two sources is in the number of plants reported. The source that did not specify a date added smaller hydropower plants to the list, which increased the total hydropower installed capacity to 4,764.3 MW, compared to the 2007 estimate of 4,067.1 MW.

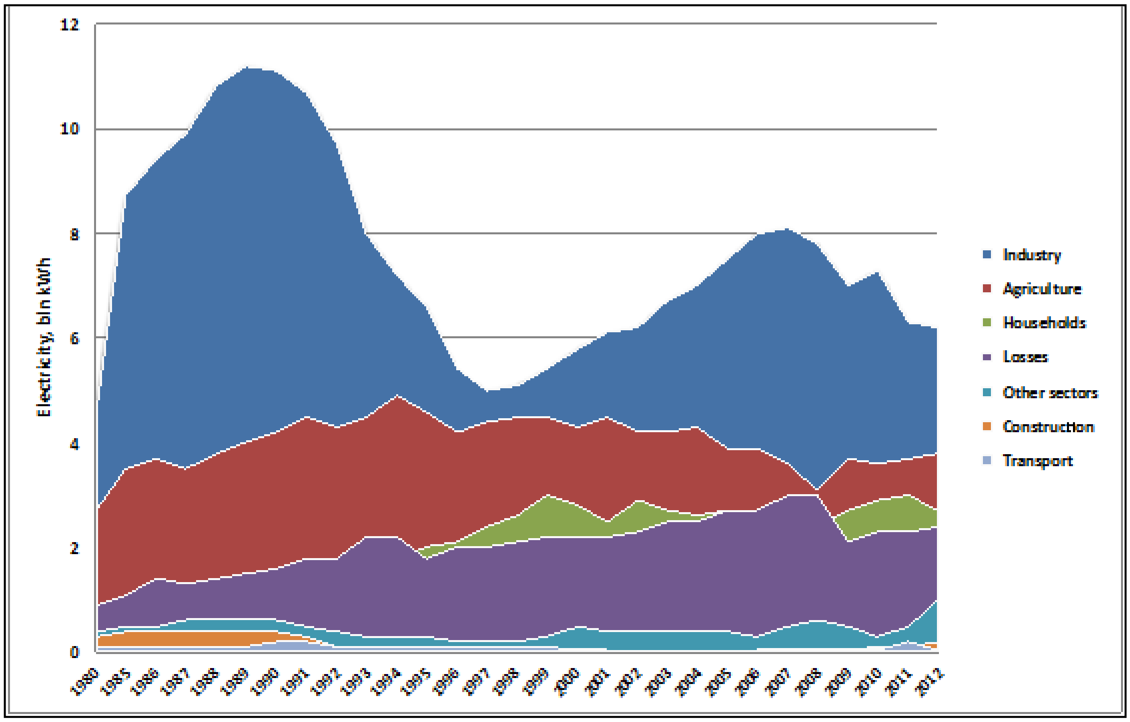
The discrepancy among the different reports is about 5% (Table 5), which is a relatively narrow margin. However, it is unclear which estimate is reliable? This will be very hard if not impossible to ascertain given the nature of data collection and handling by governmental agencies in Tajikistan. The issue of quality and reliability of data is partly due to lack of access to technology and advanced data management tools, as well as inadequate technical expertise of the staff (which in turn is due to lack of funding available for advanced learning, low salaries and poor motivation). The other part is due to lack of adequate transparency in reporting data that is related to the energy sector. The state owned company Barki Tojik in charge of generation, transmission and distribution of electricity is not transparent in reporting data on its operations (Kochnakyan et al., 2013). Another state owned company Tajik Aluminum company or TALCO –reportedly the single largest consumer, taking up 40% of all generated electricity – is also not forthcoming in making its operation reports publicly accessible (Fields et al., 2013). Furthermore, there are rumors that electricity is ‘syphoned off’ to neighboring countries in larger quantities than what is reported in official export-import statements. Therefore, the absolute numbers should be treated with caution.

### *4.5 Consumption of energy*

Historical record of electricity consumption in Tajikistan shows different patterns for different sectors of the economy (Figure 9). Industrial use of electricity more than doubled from 4.6 to 11.2 billion kWh in the decade of 1980s when Tajikistan was part of the Soviet Union. This increase was associated with the completion of the Nurek Hydropower Plant (HPP) with 3,000 MW installed capacity, along with rising demand from the aluminum smelting plant's (now known as Tajik Aluminum Company or TALCO) expanding production that reached its maximum of 457,000 metric tons in 1988 (TALCO website). Other large industrial projects including a nitric-fertilizer plant in Vakhsh town, a chemical plant in Yavan town, and a cement plant in Dushanbe city also contributed to the surge in electricity consumption (TALCO website). Following independence from the Soviet Union in 1991, and due to subsequent political turmoil evolving into civil war through the 1990s, industrial production collapsed and its share of electricity consumption plummeted from 60% to 35% (see Figure 9). Aluminum production dropped to its low of 180,000 metric tons in 1997 (TALCO website) – about 40% reduction from its peak. At the same time, electricity generation decreased from 18 billion kWh in 1990 to 14 billion kWh during 1995-1998 period due to (a) halting of Yavan Thermal Electric Power Plant that lacked fuel and maintenance, (b) lowering of Nurek HPP's potential because of silting, and closing down of several hydropower plants because of lack of spare parts and adequate technical maintenance (Sharma et al., 2004). In addition, electricity trade was adversely affected with imports falling by 56% from

3.9 billion kWh in 1990 to 1.7 billion kWh in 2000, and exports plunging by 85% from 2.7 billion kWh to 0.4 billion kWh in the same period (Sharma et al., 2004).

**Figure 9: Electricity consumption by sector**

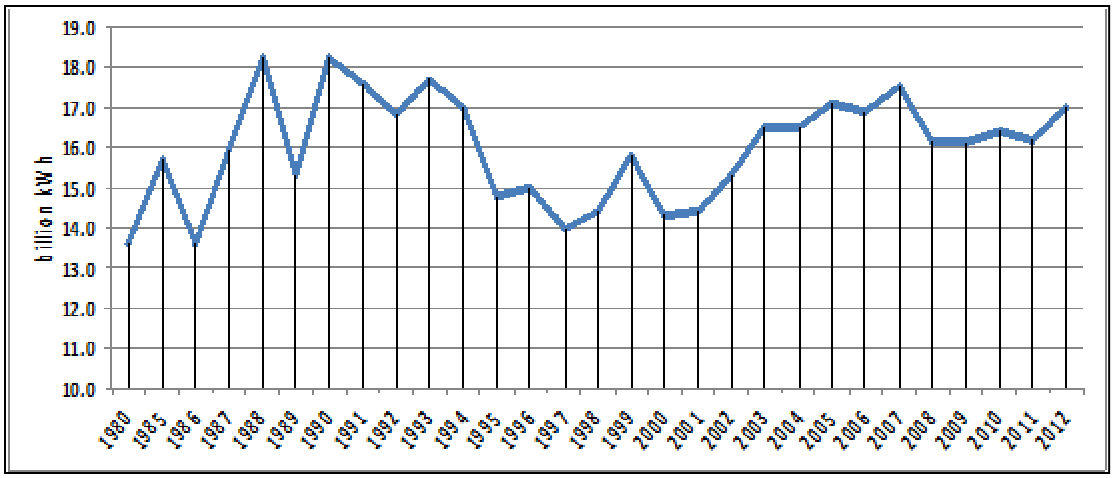



Source: IEA Online Energy Statistics Database (2014).

The use of electricity for agriculture has exhibited three periods. It was on the rise from 1980, peaking in 1994, but then it gradually declined, hitting the lowest point in 2008. Consumption of electricity bounced back the next year and kept on increasing ever since. The reason for the first period of increase was the operation of Nurek HPP that provided more electricity for water pumping stations and also made more water available for irrigation, owing to its large reservoir capacity (10.5 km$^3$ – full and 4.5 km$^3$ – useful volume, Barki Tojik website). The primary function of Nurek HPP's was storing of water during non-vegetative season and releasing it for irrigation during vegetative season. Electricity production was considered a useful bi-product (Fields et al., 2013).

The decline in the second period had to do with electricity output reduction during this period (see Figure 10). Furthermore, less power was actually allocated to the agricultural sector because TALCO began to recover from the downturn and increase its usage of electricity.

**Figure 10: Electricity output**




Source: Agency for Statistics, Tajikistan (2013).

Yet another explanation is that ageing agricultural infrastructure and unavailability of spare parts, along with lack of access to fuels to run agricultural machinery, contributed to lower electricity demand. More importantly, according to Lerman & Sedik (2009), agricultural reform in Tajikistan introduced a series of dramatic changes regarding the use of land. Large unprofitable farms (*kolkhoz* and *sovkhoz*[5]) were restructured into a new form of organization called *dekhkan (peasant)* farm, which were of three types: individual, family and collective ("partnerships").

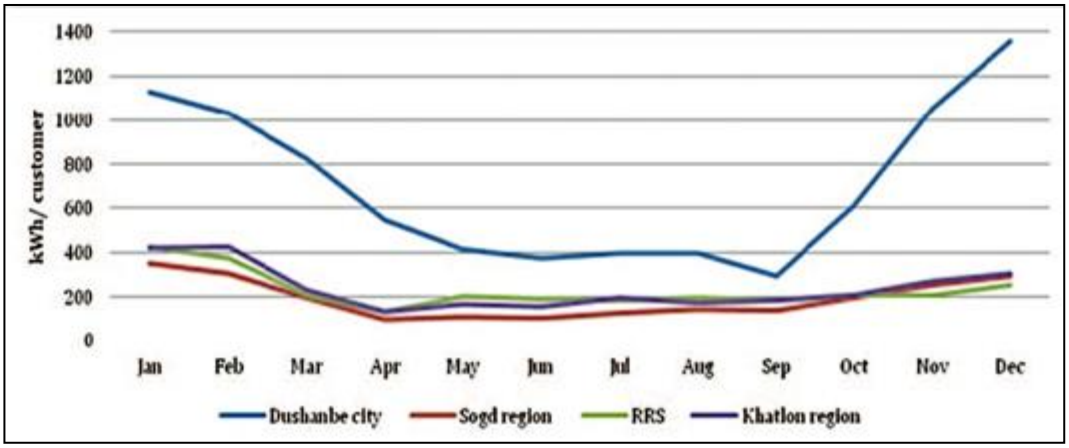
[5] Kolkhoz – from "kolektivnoe khozyaistvo" meaning "collective farm"; Sovkhoz – from "sovetskoe khozyaistvo" meaning "soviet farm".

The changes did not improve efficiency of the farms because they continued to function like their predecessors. However, the decrease in the land area sown to cotton could have a notable impact on reduced electricity intake. Because cotton is water intensive, less cotton sown meant less water pumped, and thus, less power consumed.

Household (residential) consumption of electricity has gradually grown during the period from 1980 to 2012 (see Figure 10). There was a sharp drop in consumption between 2008 and 2009. Extremely low temperatures and heavy snowfall in winter, coupled with disruption of electricity imports from Turkmenistan through Uzbekistan and gas imports from Uzbekistan, led to a severe energy crisis. Electricity was rationed at 2 hours a day for rural consumers, while in the capital city, blackouts stretched to 9 hours a day. Households were desperate for wood, coal, paper boxes, and other materials to cook their food outdoors and stay warm by the fire. Offices were closed, surgeries suspended, and water supply was disrupted when pipes burst under the pressure of cold. Maternity hospitals reported the tragic death of newborns (Laldjebaev, 2010).

The regional distribution of electricity consumption reveals that Dushanbe city dwellers use a substantially larger share compared to rural households (Figure 11). This is because electricity in the city is the sole energy source to satisfy primary needs in terms of lighting, cooking and heating. In the absence of electricity, rural households resort to using traditional biomass for their cooking and heating needs. The seasonal pattern of consumption follows the respective availability of electricity dictated by the nature of hydropower production.

**Figure 11: Average residential electricity consumption, 2011**




Source: Swinkels (2014).

Tariffs also play a role in determining the level of consumption. As Table 6 shows, residential consumers are charged the second highest price of all. This raises the issue of affordability and equity. Notably, pumped irrigation and TALCO are charged less than households. Nevertheless, the tariffs are considered among the lowest in Europe and Central Asia (Fields, 2013; Swinkels, 2014).

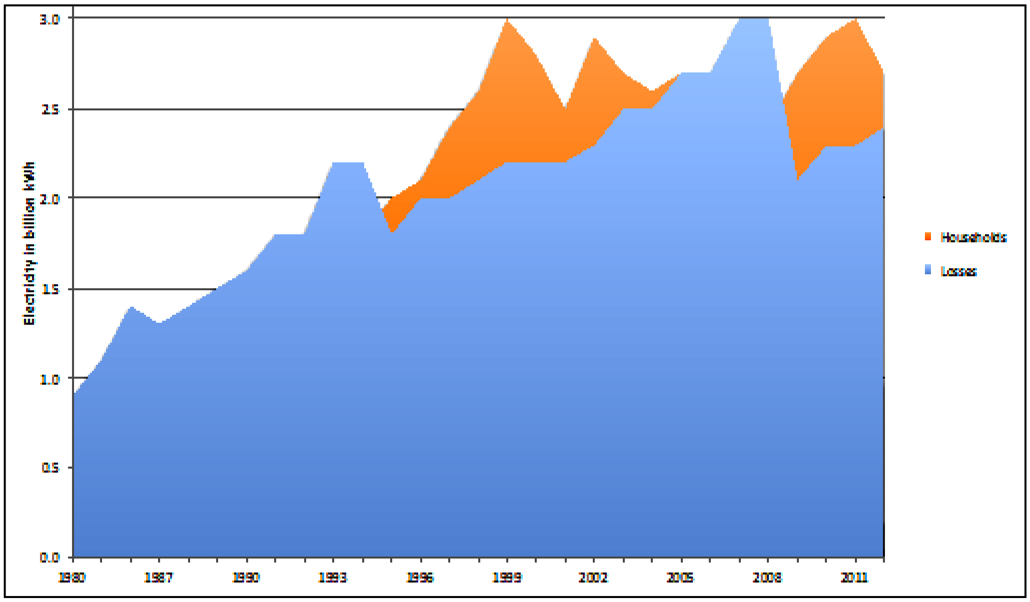
**Table 6: Electricity tariffs as of January 1, 2010**

| # | User categories | Diram per kWh | *US cents per kWh |
|---|---|---|---|
| 1 | Industrial and non-industrial users | 21.3 | 5.0 |
| 2 | Tajik Aluminum company (TALCO) | 8.2 | 2.0 |
| 3 | Pumped irrigation and electricity transport | 5.7 | 1.3 |
| 4 | State organizations and communal services | 8.5 | 2.0 |
| 5 | Residential customers (VAT included) | 9.0 | 2.1 |

Source: Energy Charter Secretariat (2010). **Exchange rate used 1 US cent = 4.3 dirams as of January 2010.*

In addition to insufficient supply, there are sizable electricity losses that are on par with household consumption (see Figure 12). This is partly due to ageing energy infrastructure and energy-intensive production of aluminum at TALCO. The other part is due to economic losses in terms of low tariffs, low collections and chronic indebtedness of the state-owned electricity company, Barki Tojik (Fields, 2013; Swinkels, 2014).

**Figure 12: Electricity losses vs household consumption**




Source: IEA Online Energy Statistics Database (2014)

Winter energy shortages have now become a pattern, which is due to the seasonality of electricity generation by hydropower plants. To get out of this cycle, the government of Tajikistan aims to build new power plants, and upgrade existing ones. As part of the former Soviet Union, Tajikistan had better electricity provision, due to the regional resource sharing mechanism established among the Central Asian republics, discussed next.

### *4.6 Resource sharing in post-Soviet Central Asia: The case of Tajikistan and Uzbekistan*

The five countries of Central Asia – Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan – all together have substantial natural resources, including land, water, oil, gas, and mineral resources. Table 7 below illustrates the distribution of resources.

**Table 7: Primary energy sources in Central Asia**

| Energy Source | Unit | Kazakhstan | Kyrgyzstan | Tajikistan | Turkmenistan | Uzbekistan | Total |
|---|---|---|---|---|---|---|---|
| Crude Oil | MTOE | 1,100 | 5.5 | 1.7 | 75 | 82 | 1,264.20 |
| Natural Gas | MTOE | 1,500 | 5 | 5 | 2,252 | 1,476 | 5,238 |
| Coal | MTOE | 24,300 | 580 | 500 | Insignificant | 2,581 | 28,231 |
| Total | MTOE | 26,900 | 591 | 507 | 2,327 | 4,409 | 34,734 |
| % of Total | | **77.4** | 1.7 | 1.5 | 6.7 | **12.7** | 100 |
| Hydro Potential | GWh/year | 27,000 | 163,000 | 317,000 | 2,000 | 15,000 | 524,000 |
| | MTOE/year | 2.3 | 14 | 27.3 | 0.2 | 1.3 | 45.1 |
| % of Total | | 5.2 | **31.1** | **60.5** | 0.4 | 2.9 | 100 |

Source: Adapted from Sharma et al. (2004).

As the highlights in Table 7 indicate, over 90% of fossil fuels are found in the territories of Kazakhstan and Uzbekistan, whereas over 90% of the hydropower potential rests with Kyrgyzstan and Tajikistan. The difference in resource distribution hints at mutually beneficial cooperation in resources sharing. However, as the subsequent discussion will show, optimal use of resources in the region, as well as the mechanism of resource sharing, has a long way to go.

The development policies of the Soviet Union in Central Asia were linked to capitalizing on the abundant natural resources, with which the region is endowed. Extensive energy and agricultural development assisted in the overall development of the region, as well as in raising the standards of living for the population in Central Asia. However, on the downside, significant damage had been inflicted to the environment because of resource overexploitation and neglect of ecological functions in development and management plans. The case in point is the desiccation of the Aral Sea.

The two largest rivers – Amu Darya and Syr Darya – are the lifeblood of the region. Starting in the mountains of Hindu Kush and Tien Shan, the rivers cross the territories of Central Asian countries stretching for 2,574 km and 2,337 km respectively, and make up total annual flow of 116.5 $km^3$. Watering the fields and satisfying the needs of humans as well as ecosystems, the rivers ultimately drain into the Aral Sea. Today, only a few ponds remain of what once used to be the fourth largest inland water body in the world, due to brutal overexploitation of water resources during the $20^{th}$ century. The tragedy of the Aral Sea is undoubtedly one of the vivid examples of how humans strived for material wellbeing at the expense of the environment.

For better or worse, the regional development policies were linked to the overall development plans for the entire Soviet Union, and these inter-linkages determined the scope and direction, which the Central Asian economies followed in earnest. Since the region acted as the resource base for the rest of the Soviet Union economy, optimization in resource utilization was achieved on a regional basis. Thus, the regional economy was closely inter-dependent. This interrelationship was exemplified in the mechanism of resource sharing between upstream and downstream countries in the context of agricultural development. The functioning of this mechanism is illustrated in the case of Tajikistan and Uzbekistan.

Located at the upstream on the Amu Darya and Syr Darya, the mountainous Tajikistan is endowed with abundant water resources, while downstream Uzbekistan has vast area of land and is rich with fossil fuel resources, such as oil and gas. Agricultural development, focusing on cotton production, necessitated that reliable water flow was secured for irrigation. This was mainly achieved through construction of water reservoirs in the headwaters of the two rivers (in Tajikistan and Kyrgyzstan). The reservoirs collected water during the fall and winter seasons, and released it where needed for irrigation in the spring and summer seasons. Another important function of the reservoirs was that hydropower plants were constructed to produce the electricity needed to run the industrial sector, power households and also operate the water pumps needed for irrigation. During the non-irrigation (cold) season electricity output decreased because the reservoirs were in water-collection mode. To make up for this loss, Uzbekistan channeled coal, electricity and gas to Tajikistan. Water and energy allocation was strictly administered from Moscow – the capital of the Soviet Union – so that the resource sharing mechanism functioned effectively. This mutually beneficial inter-dependence, however, began malfunctioning after the collapse of the Soviet Union, and the subsequent removal of oversight authority.

The newly independent Uzbekistan embarked on an exclusive strategy of development focusing mainly on the growth of its own economy. Unfortunately, Tajikistan was caught in the devastation of an almost decade-long civil war, and began recovering only at the turn of the century. The mechanism of regional resource sharing suffered correspondingly.

Tajikistan could no longer ensure reliable supply of water, whereas Uzbekistan reduced the flow of energy, primarily electricity and gas, due to domestic demand and favorable export prices, especially for gas, in world markets. In response, Tajikistan had to release water from the reservoirs during the winter season to produce more electricity, which further decreased water availability for downstream agricultural use. As this series of responses played out over the years, the countries could no longer be assured of mutual cooperation in the sharing of resources.

The volume of electricity trade between the five Central Asian countries had changed (see Table 8). There are stark differences between 1990 and 2000. Overall, both exports and imports significantly declined. In case of Tajikistan, imports were diversified by source country in 2000, essentially a result of low level of bilateral relations with Uzbekistan.

**Table 8: Shifts in electricity trade in Central Asian Power System 1990 – 2000**

| Electricity Trade 1990 (GWh) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Imports | | | | | | | |
| Exports | Kazakhstan | Kyrgyzstan | Tajikistan | Turkmenistan | Uzbekistan | Outside CAPS | Total Exports |
| Kazakhstan | -- | 277 | 0 | 0 | 310 | 0 | 587 |
| Kyrgyzstan | 697 | -- | 0 | 0 | 2383 | 0 | 3080 |
| Tajikistan | 0 | 324 | -- | 0 | 2344 | 0 | 2668 |
| Turkmenistan | 0 | 0 | 0 | -- | 6066 | 0 | 6066 |
| Uzbekistan | 8139 | 0 | 3927 | 946 | -- | 0 | 13012 |
| Outside CAPS | 0 | 0 | 0 | 0 | 0 | -- | 0 |
| Total Imports | 8836 | 601 | 3927 | 946 | 11103.2 | 0 | |
| Electricity Trade 2000 (GWh) | | | | | | | |
| Imports | | | | | | | |
| Exports | Kazakhstan | Kyrgyzstan | Tajikistan | Turkmenistan | Uzbekistan | Outside CAPS | Total Exports |
| Kazakhstan | -- | 0 | 0 | 0 | 0 | 0 | 0 |
| Kyrgyzstan | 1253 | -- | 154 | 0 | 1926 | 0 | 3333 |
| Tajikistan | 0 | 126 | -- | 0 | 244 | 0 | 370 |
| Turkmenistan | 35 | 0 | 819 | -- | 68 | 0 | 921 |
| Uzbekistan | 0 | 195 | 729 | 32 | -- | 0 | 956 |
| Outside CAPS | 2224 | 0 | 0 | 0 | 0 | -- | 2224 |
| Total Imports | 3512 | 320 | 1702 | 32 | 2237 | 0 | |

Source: Sharma et al. (2004).

The significant reduction in electricity trade meant that Tajikistan had to struggle through cold winters without adequate power supply. Not only did the economy suffer, but extreme hardships were imposed on the population. As was noted above, the winter energy crises of 2008 and 2009 were exceptionally harsh. The crises could have been avoided if the flow of electricity and natural gas was not interrupted from Uzbekistan, due to poor interstate relations. This is by far the greatest evidence of the failure of the resource sharing mechanism since the countries' independence. The relations between the two countries have unfortunately deteriorated more over time, and the scope for cooperation appears to be very limited. In fact, since the beginning of 2010 the situation was exacerbated and the debate over water and electricity mounted to the international level, particularly revolving around the contentious Rogun HPP project that Tajikistan plans to construct.

### *4.7 Energy security assessment: Vulnerability approach*

The analysis above of the energy situation in Tajikistan provides the foundation to discuss the prospects of achieving energy security for the country. In this discussion, a working definition of energy security – *low vulnerability of vital energy systems and sustained provision of modern energy services* – is based on the work of the Global Energy Assessment in 2012 (Cherp et al., 2012). Using this approach actual and potential threats and responses to Tajikistan's energy system will be identified along with the services that such a system provides. The assessment of vulnerabilities will address the two major components of the energy system: electricity, and fuel sector (including coal, oil and gas).

#### *4.7.1 Energy system vulnerabilities*

As the analysis above showed, key vulnerabilities of the energy system in Tajikistan include:

- insufficient production capacity that falls short of meeting energy demand, particularly in wintertime;
- unreliability and high cost of energy imports;
- dwindling infrastructure: power houses, transmission and distribution lines as well as water pumping stations;
- inadequate transparency in operation and financial soundness of the electricity sector
- inefficient power use due to technical and economic losses;
- lack of mutually beneficial regional cooperation in energy and water resource sharing;
- lack of environmental stewardship guidelines to support energy system robustness; and,
- inadequate financial resources to address all of the above.

The government of Tajikistan has taken steps to address these vulnerabilities. Plans and projects are under way to build small, medium and large hydropower plants to not only provide for domestic demand, but also to sell power abroad. Existing thermal power plants are switching to coal; new ones are under construction, primarily aiming to provide for heating needs in the winter. To ensure sufficient supply, development of new coalmines are proposed. In addition, discovery of potentially large resources of natural gas and oil is attracting attention for further exploration and seismic surveys. International players are involved, but the prospects of actual extraction remain uncertain. Fuel imports are likely to remain as a primary option in powering the transportation and industry.

#### *4.7.2 Access to energy services as vulnerability*

A key vulnerability that is important in the context of many developing countries, including Tajikistan, is lack of access to energy services, which is called “energy poverty” (discussed in Chapter 2). When a majority of people is energy poor, their income-generating opportunities are limited. As population grows and demand for jobs increases, but there is a lack of commensurate increase in number of jobs - which is also a function of lack of reliable energy supply for small and large scale industry - there is a threat of disenfranchisement and subsequent political unrest. The latter, as Alhajji (2010) also indicates, is an issue of national security.

Unlike other developing countries, over 90% of the population in Tajikistan is connected to the national grid - a legacy of the Soviet Union’s rural electrification programs. But connectivity to the grid loses its significance when electricity does not run through its lines half the time, or is very expensive to use when it does run. Households in the rural areas do not have reliable access to electricity in the winter because electricity generation at the hydropower plants is reduced due to low water levels in the rivers. To address the winter energy shortage, one of the energy supply priorities nationwide is construction of the Rogun HPP. This large-scale hydropower plant is planned not only to fully cover energy demand nationwide, but also export electricity to neighboring countries (namely, Afghanistan and Pakistan). While this projection may well materialize in terms of generation capacity, there is concern about actual consumption of electricity at the household level, particularly in rural areas.

Households use electricity predominantly for lighting and information and communication (e.g. watching television and charging cellphones). For cooking, the most energy consumptive activity, electricity is used only occasionally. This has to do with the unaffordable cost of electricity. In fact, some households manage to avoid higher bills through “saving” energy by cooking with fuelwood on traditional clay stoves. Therefore, rural households primarily rely on burning wood and animal dung for their thermal needs all year round (see Chapter 2 for detailed discussion). Now, a paradoxical situation arises here: if for their cooking households continue to use biomass and are not using electricity, which is available in the summer, how likely would they be to use electricity when it becomes reliable in the winter? Perhaps, a reduction in cost would motivate them to do so? But the gradual increases in electricity tariffs (July 1, 2014 and November 1, 2016) are an indication that prices are unlikely to fall. Therefore, current national policy falls far short of addressing the issue of energy access in rural areas of Tajikistan, and rural households remain vulnerable to energy shortages, and the related negative consequences.

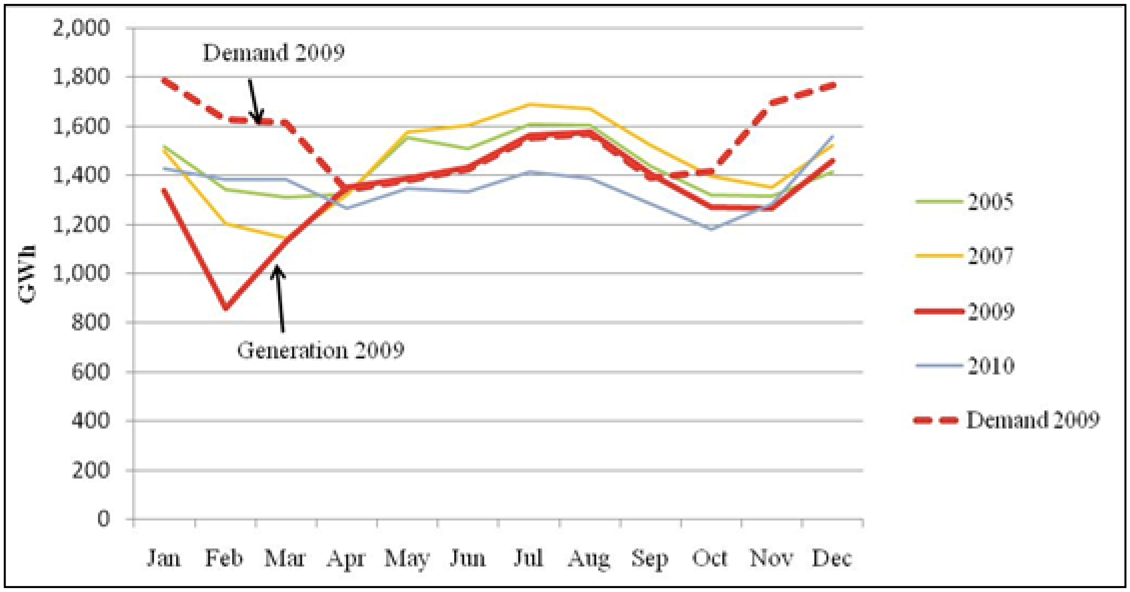
## *5. Evaluation of options to achieve energy security in Tajikistan*

This section discusses three sets of options for achievement of energy security in Tajikistan. These options are based on studies conducted by the World Bank, the United Nations Development Program, and the Government of Tajikistan. The section provides a critique of the options, weighing the advantages and shortcomings of each in addressing the risks and vulnerabilities, and concludes by offering an alternative way of energy security analysis that ties back to the conceptual framework of energy services developed by Practical Action (2014).

### *5.1 Option 1: National energy security – a traditional approach*

The electricity system in Tajikistan "is in a state of crisis", claimed a recent Word Bank report pertinently entitled "Tajikistan's Winter Energy Crisis: Electricity Supply and Demand Alternatives" (Fields et al., 2013). As the title suggests, this study inquires into the state of electricity provision in the country, particularly focusing on recurring winter shortages, and then proposes a set of alternatives to break out of the crisis. The report summarizes that electricity shortages stem from inefficiencies in electricity infrastructure, growth in demand and insufficient supply. Winter shortages are primarily due to lower flows in the rivers that lead to reduced electricity production at hydropower plants. At the same time, there is an increase in demand for heating, which necessitates increased use of electricity, because alternative energy sources are unavailable or unaffordable. The mismatch between supply and demand, as illustrated in Figure 13, creates a deficit that translates into load shedding.

**Figure 13: Electricity demand and supply for 2009, Tajikistan**




Source: Fields et al., 2013.

According to the World Bank study (Fields et al., 2013), the size of unmet demand for electricity was estimated at about 2,700 gigawatt-hours (GWh) or 24% of total demand for electricity in 2012. The associated economic losses are estimated at over US$200 million, or 3% of GDP every year. Social costs also arise from burning wood and coal that cause indoor air pollution and are oftentimes insufficient to maintain adequately warm temperatures at homes and schools, thus adversely impacting human health, particularly of women and children. Unless serious action is undertaken, the winter demand is expected to exceed 15,000 GWh by 2020, of which 6,800 GWh or 45% will not be met, and, therefore, would exacerbate the hardships that people endure every winter (see Table 9).

**Table 9: Unconstrained growth in demand for electricity**

| | 2012 | 2016 | 2020 |
|---|---|---|---|
| Peak demand before tariff and energy efficiency (MW) | 3,500 | 4,110 | 4,710 |
| Deficit before measures (MW)[a] | 1,250 | 1,840 | 2,550 |
| Winter energy demand before tariff and energy efficiency (GWh) | 11,213 | 13,215 | 15,181 |
| Winter shortage before measures (GWh) | 2,700 | 4,510 | 6,800 |

Source: World Bank data as cited in Fields et al. (2013). Note: a. Accounts for capacity additions gained during rehabilitation of existing assets.

In an attempt to address the crisis situation, the World Bank study identifies a range of measures that could bridge the energy gap and put the country on the path towards long-term energy security. The actions identified in the study are aimed at a short-term period that can start fairly quickly to address winter shortages. In this regard, large-scale hydropower projects (with seasonal storage) are excluded from this study, because such projects tend to be complex and take longer time to establish. At the time of the study, a parallel assessment was underway of the technical and economic, as well as social and environmental impacts of the Rogun HPP[6] (see sub-section 5.3).

The measures proposed by the study to reduce the winter electricity deficit are presented in Table 10. As shown, the suite of measures, ranging from efficiency to fuel switching to new generation to imports, gradually narrows the gap, managing not only to close it by 2018, but reverse the trend afterwards. It is notable that by 2020, additional electricity produced over and above the demand is expected to be about

[6] The assessments were completed and final report released on September 1, 2014 (available at http://www.worldbank.org/en/region/eca/brief/rogun-assessment-studies).

2,700 GWh, which is equivalent to unmet demand in 2012. In other words, the measures purport to transform the energy sector and turn the deficit into surplus in a mere 8 years, and all that without any new addition of large hydropower capacity.

**Table 10: Eliminating winter shortages**

| | | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|
| Deficit without measures (incl. rehab upgrades) | | **2700** | **3170** | **3640** | **4100** | **4510** | **5000** | **5410** | **6300** | **6800** |
| Measures to reduce deficit | | | | | | | | | | |
| Energy efficiency | Tariff increase | 0 | 30 | 102 | 276 | 464 | 665 | 877 | 1101 | 1339 |
| | T&D Loss reduction | 13 | 96 | 186 | 295 | 409 | 498 | 586 | 677 | 771 |
| | TALCO EE | 0 | 0 | 0 | 359 | 418 | 475 | 531 | 531 | 531 |
| | Demand management | 0 | 0 | 7 | 14 | 22 | 41 | 61 | 82 | 102 |
| TALCO maintenan ce program | Increased maintenance in winter | 0 | 0 | 150 | 150 | 150 | 150 | 150 | 150 | 150 |
| Fuel switching [a] | From gas to coal fired | 0 | 44 | 88 | 130 | 172 | 214 | 255 | 296 | 357 |
| New generation | Thermal | 0 | 250 | 500 | 500 | 1000 | 1000 | 2104 | 2104 | 3208 |
| | Hydropower | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 539 |
| Imports [a] | Uzbekistan | 0 | 400 | 1400 | 1400 | 1150 | 900 | 650 | 400 | 400 |
| | Turkmenistan | 0 | 0 | 0 | 400 | 400 | 400 | 970 | 2110 | 2110 |
| Deficit after measures | | **2690** | **2350** | **1210** | **580** | **320** | **660** | **-770** | **-1150** | **-2710** |

Source: World Bank data as cited in Fields et al. (2013). Note: a. The coal-fired plant and imports are assumed to operate base-loaded for 6 months, and 50 percent of the time for 2 months, for a total of 5,000 hours/year. Numbers are in GWh.

A list of priority actions necessary to bring about this transformation is summarized in Table 11. As shown, the actions are grouped under four categories, namely, energy efficiency, investment preparation, trade promotion and energy policy. A detailed discussion of each category is presented below.

**Table 11: Power supply alternatives for Tajikistan – Priority actions to 2020**

| | Action | Winter Energy (GWh) | Investment (US$ millions) | c/kWh |
|---|---|---|---|---|
| Energy efficiency | Encourage conservation through pricing (tariff) | 1,339 | — | — |
| | Accelerate T&D energy loss reduction programs | 771 | 36 | <1 |
| | Strengthen demand-side energy efficiency measures (incl. TALCO) | 634 | 144 | <1, as a group |
| | Switch heating demand away from electricity | 357 | 100 | 5 |
| | TALCO winter maintenance program | 150 | — | — |
| | **Subtotal** | **3,250** | **280** | |
| Investment preparation | Prepare financing plan | n.a. | — | — |
| | Rehabilitation – Protect existing hydropower with priority on Nurek | n.a. | 1,105 | n.a. |
| | Dushanbe –2 (dual fired) | 1,000 | 349 | 8.7 |
| | Shurob-1/2 (dual fired) | 2,208 | 1,046 | 9.9 |
| | Sanobad (run-of-river hydropower) | 539 | 285 | 3.5 |
| | **Subtotal** | **3,747** | **2,785** | |
| Trade promotion | Reconnect with Central Asia Power System | 800 | Negligible | 6.0 |
| | Develop Turkmenistan/Afghanistan power links | 1,710 | Included in tariff | 11.8 |
| | Construct transmission lines for exports | | 360 | n.a. |
| | Diversify trade routes south and north | | No estimate | No estimate |
| | **Subtotal** | **2,510** | **360** | |
| Energy policy | Develop exports in line with domestic needs | | n.a. | n.a. |
| | Reassess hydropower (rightsizing, new sites, storage) | | Potential cost savings | |
| | Accelerate natural gas investigations | | n.a. | n.a. |
| | Revise tariff policy (incl. social safety nets) | | n.a. | n.a. |
| | **Subtotal** | **n.a.** | **n.a.** | **n.a.** |

Source: World Bank data as cited in Fields et al. (2013). Notes: n.a. = not applicable; – = not available.

### *5.1.1 Energy efficiency*

The energy efficiency efforts are aimed at optimizing the energy service-input ratio, for example, through provision of same services with less energy input or more services with the same level of input. Primary among energy efficiency measures is a pricing mechanism, particularly an increase in average tariff from 2.25 U.S. cents (effective in 2012) to 7 cents per kWh of electricity consumed by 2025. This increase is estimated to be commensurate with consumers' willingness to pay and expected to encourage conservation, thereby keeping the growth rate in demand between 1 and 1.8% annually. The resulting reduction in electricity demand is expected to be about 1,300 GWh, or 9% of annual demand by 2020.

The next sizeable contribution to efficiency comes from reducing losses in transmission and distribution networks. The electricity infrastructure is aged and losses are estimated at around 18%. A reduction of these losses to 12% would translate into 771 GWh, or 5% of demand by 2020. Furthermore, reducing the energy intensity of the economic activity from 0.21 kgoe (kilograms of oil equivalent) per GDP by about 50% is considered feasible as it was realized in Lithuania and Poland between 1990 and 2009. Energy savings may come from introduction of efficient light bulbs, insulation of residential buildings, enforcement of efficiency standards and labeling for household appliances, and introduction of solar (water) heating. These measures on the demand side could reduce the winter energy demand by 102 GWh, or 1% by 2020.

Implementation of energy efficiency measures at the Tajik Aluminum Company (TALCO) could bring about an additional 531 GWh, or 3% demand reduction, by 2018. As a single largest consumer of electricity accounting for 36 to 45% of total electricity consumption, TALCO's electricity costs constitute more than 50% of its total production costs. The company paid about 1.8 cents per kWh of electricity tariff in 2012, below the average tariff of 2.25 cents per kWh. The suggested measures include change of technological processes, improvements in efficiency of autonomous boiler house, better insulation and replacement of lighting. Moreover, shifting of major maintenance works from summer to winter months could make about 150 GWh of electricity available in winter for other consumer groups. The efficiency measures, if implemented, would be economically profitable to TALCO, allowing recouping related investments within 2.5 years.

Last but not least in the list of energy efficiency measures, is switching from electricity-based to coal-based (and subsequently to gas-based) heat supply to urban households via centralized district heating systems. The expected reduction in demand is 357 GWh, or 2%, by 2020 assuming that up to 65% of households are provided by this system (up from current 15%). This ambitious target involves not only rehabilitation of existing and construction of new dual-fired thermal power plants and related distribution infrastructure, but also significant expansion of coal production. Although at 5 cents per kWh coal-based heating is considered economically feasible, it is expensive compared to an electricity tariff of 2.25 cents per kWh. Therefore, the World Bank study recommends designing an incentive mechanism or raising the electricity tariff to make fuel-switching attractive for residential customers.

#### *5.1.2 Investment preparation*

Addition of new generation capacity through building of three new thermal power plants is expected to reduce winter energy demand by about 3,200 GWh, or 21%, by 2020. The plants are dual-fired, which allows switching from coal to gas with improved access to the latter. The study characterizes access to domestic sources of natural gas as a “game-changer” for Tajikistan, because it would displace coal and imports. This hopeful view is buoyed up by recent explorations that reportedly discovered 3.2 trillion cubic meters of gas and 8.5 billion barrels of oil and condensate in Tajikistan. Further assessments, however, are required to substantiate the availability of reserves (because no drilling has been done yet), as well as the level of economic feasibility (because the reserves are reportedly located deep underground).

Apart from thermal power plants, new generation is expected from the Sanobad run-of-river hydropower plant, adding about 500 GWh, or 4%, by 2020 to curb the winter demand. This plant is to be located on the Panj river that demarcates the border between Tajikistan and Afghanistan, and contributes about 43% of the flow of Amu Darya river (Wegerich, Olsson, & Froebrich, 2007). Transboundary issues of sharing this water resource will need to be negotiated in order for the project to be realized. The study also recognizes other run-of-river projects identified by the government of Tajikistan with installed capacities varying from 90 to 2,100 MW and combined total capacity of 13,000 MW. However, their contribution to winter energy supply is limited as their expected winter generation is about 40% of summer generation, due to low river flows and lack of water storage capacity.

Both thermal power and hydropower plants require substantial investment. Funding is also required to maintain existing hydropower capacity, particularly to rehabilitate the Nurek HPP, which accounts for about 70% of total electricity generated in the country. Undoubtedly, a sound investment plan has to be prepared to manage the large amount of capital needed to implement the proposed actions.

### *5.1.3 Trade promotion*

Revitalizing the energy trade with Uzbekistan and Turkmenistan, and expanding the same with Afghanistan through construction of new transmission lines would result in diversification of trade routes and lead to greater energy security. As for electricity trade, plugging back in to the Central Asia Power System (CAPS) is technically as easy as reconnecting the lines (though ageing infrastructure is a concern) that used to transmit around 1,500 GWh of electricity to cover the winter energy need in Tajikistan. In the summer, the same amount would be transmitted back into the system allowing the thermal power plants in Uzbekistan to be put to rest, and thus, save energy (because hydropower is comparatively cheaper). In the past, electricity was procured from Turkmenistan as well and transmitted through Uzbekistan until the CAPS was switched off for Tajikistan in 2009. Alternative routes through Afghanistan would require new lines, but it could make Turkmen electricity once again available for import during winter. Moreover, Tajikistan would be able to sell more of its summer surplus to Afghanistan, and even beyond to Pakistan, as is envisaged by the Central Asia South Asia Electricity Transmission and Trade Project (or shortly CASA-1000). Feasibility studies were conducted for the latter project that would connect Kyrgyzstan and Tajikistan (suppliers) with Afghanistan and Pakistan (buyers), and were rendered the project economically viable (SNC Lavalin, 2011). The CASA-1000 project was officially launched on May 12, 2016 in Tursunzade town in Tajikistan, and was lauded as a "transformational project [that] will give a much-need boost to energy security … across two regions at a critical time … [and it] is a win-win for all involved" (Dixon, 2016). The estimated cost is over $1 billion, but funding has been secured from seven financiers: World Bank (through the International Development Association, IDA), the European Investment Bank, the Afghanistan Reconstruction Trust Fund, the Islamic Development Bank, the United States Government, the UK Department for International Development, and the European Bank for Reconstruction and Development (World Bank, 2016).

Along with electricity trade, imports of natural gas from Uzbekistan, which were halted in 2012, could be reinstated and even expanded given the gas trunk line capacity of 7 billion cubic meters. Imported gas could fuel power plants in Tajikistan and further reduce the energy shortage in winter. Mutually agreeable terms of trade, specifically on price and delivery schedules, are necessary to resume imports.

#### *5.1.4 Energy policy*

Combining all of the above measures under a robust energy policy is arguably the most important action item proposed in the study. Such an energy policy would balance domestic needs with export and import potential, so that foreign exchange is earned while every home remains powered. In this balance the role of new power plants, both thermal and hydro, would be adequately laid out so that the need for power is met economically according to acceptable social and environmental standards. With potentially promising reserves of domestic natural gas, the way forward would be to accelerate the prospecting efforts. When it comes to paying for energy services the policy would make sure the rates are affordable, and social safety nets are designed as necessary. All in all, the proposed actions signify major changes to the energy system of Tajikistan with the hope of bringing about greater energy security.

In economic terms the measures would cost over US$3.4 billion till 2020, requiring on average of about US$380 million in annual disbursements. The detailed allocation of costs by year is shown in Table 12.

**Table 12: Investment funding requirements from 2012 to 2020**

| | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | Total | % share |
|---|---|---|---|---|---|---|---|---|---|---|---|
| New hydro generating capacity | 0 | 0 | 0 | 0 | 43 | 100 | 86 | 57 | 0 | 285 | 49 |
| New thermal generating capacity | 121 | 140 | 87 | 183 | 209 | 314 | 209 | 131 | 0 | 1395 | |
| Rehabilitate generating capacity | 56 | 261 | 274 | 205 | 100 | 210 | 0 | 0 | 0 | 1105 | 32 |
| Reduce system energy losses | 0 | 6 | 6 | 6 | 6 | 3 | 3 | 3 | 3 | 36 | |
| Investments in end-use efficiency | 0 | 21 | 50 | 50 | 31 | 22 | 22 | 22 | 27 | 244 | 19 |
| Transmission for power export | 0 | 0 | 0 | 0 | 360 | 0 | 0 | 0 | 0 | 360 | |
| Total investment requirements | 177 | 427 | 417 | 444 | 749 | 648 | 320 | 213 | 30 | 3425 | 100 |

Source: World Bank data as adapted from Fields et al. (2013). Note: Amounts are in 2012 US$ million.

About half of financing goes to addition of new capacity, with rehabilitation accounting for a third, and efficiency and construction of power export transmission lines for the remaining one fifth of the total. To put the figures in perspective, as shown in Table 13, the investment required makes up on average about 5% of the GDP annually, which is a sizable amount for one sector of the economy.

**Table 13: Investment requirements to finance power additions from 2012 to 2020**

| Year | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|
| Projected GDP growth rate (%) | 7.0 | 7.2 | 7.3 | 6.0 | 6.0 | 6.0 | 5.0 | 5.0 | 5.0 |
| Projected GDP ($) | 6379 | 6838 | 7337 | 7777 | 8244 | 8739 | 9176 | 9634 | 10116 |
| Investment ($) | 177 | 427 | 416 | 444 | 749 | 648 | 320 | 213 | 30 |
| Investment as % of GDP | 2.8 | 6.2 | 5.7 | 5.7 | 9.1 | 7.4 | 3.5 | 2.2 | 0.3 |

Source: World Bank data as cited in Fields et al. (2013). Note: Amounts are in 2012 US$ millions; excludes investment costs for new supply commissioned/demand measures implemented after 2020.

### *5.1.5 Critique of World Bank proposal for energy security*

The World Bank plan aims to resolve the winter energy crisis through a range of measures that were discussed above. The proposal is very compelling; however, several issues require further investigation. The study recognizes that the costs represent the most significant risk and would require careful consideration of tariff policies along with private sector involvement and donor assistance, as well as potential earnings from power exports to mitigate the risks (Fields et al., 2013). Apart from economic costs, there are social and environmental costs that also require mitigation.

Tariff increases, aimed at encouraging energy conservation, although estimated to be in line with consumers' willingness to pay, are difficult to implement. The study estimated annual increases could be around 11%, from 2.25 to 7 cents per kWh between 2014 and 2025. Such an increase would make a dent in already strained household budgets. Cast against the background of already severe energy shortages it would create additional burden, particularly for the poorer consumers, unless a safety mechanism is designed and properly enforced. There are also serious political implications with tariff raises. It is alleged that in neighboring Kyrgyzstan, increases in utility rates played a major role in massive protests that led to overthrowing of the government within 24 hours of protests start on April 8, 2010 (Kramer, 2010).

Private sector involvement in the energy sector would require substantial effort to improve the overall business climate in the country. According to Ease of Doing Business report in 2013, Tajikistan ranked 143 out of 189 economies, occupying the place between Sierra Leone (142) and Liberia (144). It ranks much lower compared to neighboring Kyrgyzstan (68), which is similar in terms of population, geography and resource endowments (World Bank, 2013).

Exports of electricity are active with Afghanistan during the summer months when river flows are high and surplus is generated at hydropower plants. However, since Tajikistan's electricity network was severed from the Central Asian Power System (CAPS) in 2009 the summer excess capacity remains mostly idle. Only a small fraction is exported to Afghanistan. The loss to the economy of idle discharge of water from power plants is estimated between US$90 and $225 million a year (Fakirov, 2012). In order to realize this economic potential, and also compensate for winter shortages, reconnection to CAPS and revitalization of electricity trade among Tajikistan, Turkmenistan and Uzbekistan is recommended by the World Bank study. It is, however, very difficult, if not impossible, in the short term to improve the political relations with Uzbekistan, particularly given the latter's fierce opposition to the construction of Rogun HPP. Notably, the climate of tense relations was a contributing factor to halting of gas supplies from Uzbekistan in 2012.

On September 11-12, 2014, attendance of Islam Karimov, the President of Uzbekistan, at the summit of Shanghai Cooperation Organization in Dushanbe six years after his last visit, was initially expected to be a sign of apparently warming relations with Emomali Rahmon, the President of Tajikistan (Mukhametrakhimova & Faskhutdinov, 2014). However, no breakthrough was achieved during bilateral meetings between the two presidents. The Tajik side reported the meeting as constructive and expressed confidence that the existing stalemate in relations would be resolved within the framework of the 2000 treaty on perpetual friendship between the two countries. The official government press release also noted with regret that the trade volume between two countries plunged from US$300 million in 2007 to mere US$2.1 million in 2014, whereas the potential is around US$500 million (President.tj, 2014). In contrast, the Uzbek government press release contained only a single line about this meeting, namely that "the heads of two states swapped views on diverse issues on the bilateral and regional agenda" (Press-Service.uz, 2014). It is an indication that relations are still far from thawing, and that little progress was made during the face-to-face meeting of the leaders.

Given the dim prospects of regional energy trade, domestic resources of coal become attractive. The proposal for fuel-switching to coal-based heating, however, brings with it associated health and environmental impacts in terms of increased emissions and air pollution. The Dushanbe-2 thermal power plant that was considered in the World Bank study was inaugurated in January 10, 2014. Many had raised the issue of negative impacts on the environment and human health, which could be immediately experienced given the plant's location within 2 km of a residential area, a children's amusement park and botanical gardens. The authorities reassured that the plant would make use of modern, clean and efficient technologies that reportedly capture hazardous emissions up to 99.8%. However, soon after the plant's operation reports emerged of citizens complaining about a thick layer of coal dust on the surfaces of their property and black soot spoiling laundry clothes hung outside for drying (AsiaPlus, 2014; Sodiqov, 2014; Kalybekova, 2014). Following the complaints the plant's operation was stopped for 24 hours, after which the issue was dismissed as one-time release. In any case, the particulate matter may be better captured with improved filters, but emissions that are not easily traceable (e.g. CO2, SOx, NOx and mercury) would be much harder to deal with. The associated social and environmental costs would threaten to nullify the benefits of warmth and comfort for city residents on top of the impact that increased tariffs would make in their household budgets.

Implementation of household level energy efficiency measures, such as thermal insulation of homes, and use of solar water heating, would require substantial upfront costs at the household level. Furthermore, more efficient bulbs and other energy appliances are also costly, although they are more economical in the long-run. The suggested measures may not be affordable for many residents, particularly the poorer segment of the population that needs the benefits the most. Therefore, some form of subsidy or low-interest loan scheme may be necessary to encourage technology adoption.

Similarly, TALCO may be able to implement the efficiency measures and shift maintenance works to winter economically, but the latter may not be technically feasible due to the temperature requirements for the repair. Furthermore, the company may be constrained by its long-term contracts with suppliers of raw materials upstream and buyers of manufactured product downstream. These actors determine the time and volume of production that may conflict with the suggested transfer of repair works from summer to winter. To date, however, there is no indication of actual measures put in place by the company.

In short, the proposed plan for addressing winter energy shortages identifies some important aspects of energy policy in Tajikistan. The extent to which the measures are feasible is subject to debate, because they touch on technical, economic, social and political spheres that raise more questions requiring further deliberation.

## 5.2 Option 2: Energy security for rural and vulnerable households

The United Nations Development Program prepared a set of three documents that address energy sector challenges and propose solutions towards "ensuring reliable and affordable energy supply as a main prerequisite for enhanced economic development and reduction of poverty" in Tajikistan (Bukarica et al, 2011). These documents are:

- Intermediate Strategy for Renewable Energy Sources (RES) based Integrated Rural Development (IRD) (cited as Morvaj et al, 2010a);
- National Programme for Renewable Energy Sources (RES) based Integrated Rural Development (IRD) – National Scaling-Up (cited as Morvaj et al., 2010b);
- Energy Efficiency Master Plan (EEMP) (cited as Bukarica et al., 2011).

The foci of these documents are twofold: to deploy renewable energy sources (RES) and improve energy efficiency (EE). The financial mechanism to implement the proposed measures is identified as the National Fund for RES and EE. A detailed discussion of each document as well as the funding mechanism is provided below.

### 5.2.1 Intermediate Strategy for RES based IRD

In the first document, the Intermediate Strategy, the priority is accorded to small-scale community based hydropower plants, solar energy in terms of thermal collectors and photovoltaic devices to generate electricity, and some low cost energy efficiency measures. Notably, apart from being poorly studied, other renewable sources such as biomass (biogas), wind and geothermal are not part of this strategy because they present lower potential, require higher cost and/or make little use of local resources to spur economic activity locally. Due to high cost and long duration of building large-scale hydropower plants and rehabilitating the electricity grid, these options are considered long-term measures and therefore, not discussed in this strategy (Morvaj et al., 2010a).

### *5.2.2 National Program for RES based IRD*

The second document, the National Program, makes a case for nation-wide scaling up of the measures proposed in the Intermediate Strategy. The program's objective is to provide a set of options to improve access to energy with the view of achieving greater economic development, particularly addressing poverty in rural areas in Tajikistan. To attain this objective, the program is designed on the basis of the so-called 4A criteria, namely, provision of access to affordable, locally available and acceptable energy. The proposed mechanism to realize the program objective is by harnessing the potential of small-scale hydropower plants (SHPPs), and in some cases solar energy, because these are claimed as the "only source of energy which meets the 4A criteria" (Morvaj et al., 2010b, p. 2). The program sets a specific target of reaching 100,000 vulnerable households providing each household with access to a minimum of 1 kW of safe and reliable electricity by 2015. However, it is recognized that provision of 2 or 3 kW of power through SHPPs would result in even greater benefits. About US$110 million would be required to install 200 MW of SHPPs for the duration of the program until 2020 (see Table 14).

**Table 14: Plan for installed SHPPs capacity for the period 2009-2020**

| Period | Planned total installed grid connected sHPP capacity [kW] | Additional stand alone capacity sHPP [kW] | Planned annual electricity production from the installed capacity [MWh/year] | Required money to incentivize newly installed capacity in the given period [US$] | Total required money in the given period for incentives [US$] | Required money to cover investment costs of the stand alone sHPPs [US$] |
|---|---|---|---|---|---|---|
| 2009-2011 | 43.530 | 5.000 | 280.843 | 5.616.868 | 5.616.868 | 5.000.000 |
| 2012-2015 | 32.850 | 18.620 | 185.067 | 3.701.344 | 9.318.212 | 18.620.000 |
| 2016-2020 | 26.801 | 73.199 | 175.735 | 3.514.706 | 12.832.918 | 73.199.000 |
| Total 2009-2020 | 103.181 | 96.819 | 641.646 | 12.832.918 | 12.832.918 | 96.819.000 |
| **Total installed capacity [MW]** | **200** | | | | **Total [US$]** | **109.651.918** |

Source: Morvaj et al. (2010a). Note: The total amount of money needed for guaranteed buy-back of electricity from micro and small HPPs is calculated using the following formula: *Req.money (USD) – Elec.production (kWh) x [Guaranteed power purchase price (USD/kWh)] – Average elec.production price (USD/kWh)]*.

Installation of solar photovoltaic (PV) and solar thermal systems (for hot water) is recommended for social institutions, including hospitals, schools and kindergartens. This measure would increase the comfort and better delivery of services at these institutions. In addition, energy efficiency measures are proposed to conserve energy and lower demand for households and institutions. These measures include insulation of buildings by using local resources (straw and cane) and technologies (lathing and furring), installation of double glazed windows, and improving cooking/heating stoves. It is estimated that rolling out of solar energy would require over US$50 million and efficiency measures US$1.65 million investment until 2020 (see Table 15).

**Table 15: Plan for installed PV and STC systems together with EE improvements**

| Period | Number of targeted households | Number of targeted social facilities | Required money to incentivize EE improvements[US$] | Required money for installing stand alone PV and STC systems [US$] |
|---|---|---|---|---|
| 2010-2011 | 1.000 | 10 | 555.000 | 110.000 |
| 2012-2015 | 20.000 | 60 | 10.330.000 | 660.000 |
| 2016-2020 | 79.000 | 80 | 39.940.000 | 880.000 |
| Total 2009-2020 | 100.000 | 150 | 50.825.000 | 1.650.000 |

Source: Morvaj et al. (2010a). Note: PV – photovoltaic; STC – solar thermal collector.

Total costs estimated for the SHPPs, solar energy and efficiency measures would be over US$162 million for the period from 2010 to 2020 (see Table 16). The benefits of the program, though not monetized, are expected to be significant and diverse. Taken together, improved access to energy from hydropower and solar systems and enhanced energy efficiency, would lead to reduced demand for fuelwood for cooking, which in turn would relieve physical hardship of collecting wood, and would free up more time, especially for women and children, to engage in other productive activities. Instead of burning dung, households would use it as fertilizer, thus increasing agricultural productivity. In addition, positive impacts would result in terms of reduced indoor air pollution and emission of greenhouse gases into the atmosphere. Furthermore, installation and maintenance of small-scale technologies would create jobs and advance the local economy, thereby accelerating the progress toward poverty alleviation in rural areas (Morvaj et al., 2010b).

**Table 16: Total costs estimates for the period 2010-2020**

Total money required [US$]

| Period | sHPPs | EE improvements | PV+STC systems | Total |
|---|---|---|---|---|
| 2009-2011 | 10.616.868 | 555.000 | 110.000 | 11.281.868 |
| 2012-2015 | 27.938.212 | 10.330.000 | 660.000 | 38.928.212 |
| 2016-2020 | 86.031.918 | 39.940.000 | 880.000 | 126.851.918 |
| Total 2009-2020 | 109.651.918 | 50.825.000 | 1.650.000 | 162.126.918 |

Source: Morvaj et al. (2010a).

### *5.2.3 Energy Efficiency Master Plan*

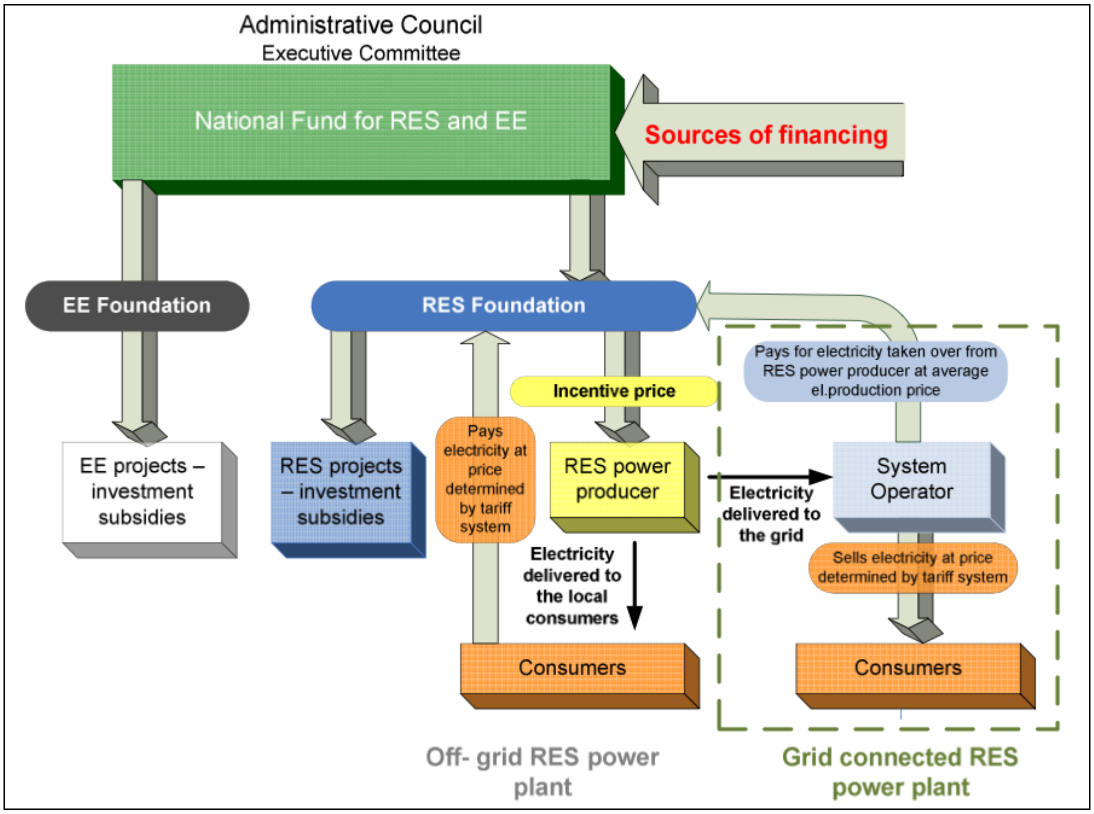
The third document, the EEMP, proposes a range of policy measures to strengthen the legal and regulatory standards of energy use, as well as institutional capacities to oversee implementation of energy efficiency activities. The master plan does not set specific targets to be achieved by 2020 referring to insufficiently developed energy statistics and chronic energy shortage in the country. The plan includes actions to revitalize district heating systems and curb transmission and distribution losses, thus improving energy supply (see Table 52 in Appendix 1). At the demand side, the actions are adapted to urban and rural settings according to their energy use patterns. For urban areas a host of instruments and measures are proposed to improve energy efficiency in residential and service buildings, as well as public lighting. Explained in greater detail in Table 52 in the Appendix 1, these measures address various aspects, ranging from buildings codes to energy equipment standards to energy audits to training and education, and to metering and billing. Overall, expected energy savings gained by 2020 through implementing the demand side measures is estimated up to 77 ktoe (895 GWh), which in 2011 would constitute 3.6%

of total final energy consumption in the country or 11.4% of total final energy consumption in buildings and public lighting sectors. In rural areas, thermal insulation of buildings, installation of double glazed windows and cooking/heating stove improvements are suggested that would also make use of local materials and workforce (Bukarica et al., 2011).

#### *5.2.4 National Trust Fund for RES and EE*

In order to provide for successful implementation of the suggested measures, the documents propose establishment of the National Trust Fund for Renewable Energy Sources and Energy Efficiency in Tajikistan. The Trust Fund for RES and EE is a financial instrument that acts as an intermediary between energy producers (small-scale community based hydropower plants) and the utility (Barki Tojik) that essentially bridges the price differential between an ‘incentive’ price guaranteed to the producer and the average electricity price in the system. In other words, the System Operator pays average price to the Fund for electricity received from the RES power producer, which, in turn, receives a higher than average price from the Fund – the difference being compensated by the Fund (see Figure 14). It should be noted that average price is lower than retail price, which allows the System Operator to function without losses. In case of off-grid operation, the Fund acts as intermediary between RES power producer and final consumers – guaranteeing incentive price to the producer. In a nutshell, the Fund is aimed at stimulating local economic activity through income generation by sales of electricity produced at small-scale community based hydropower plants, and also providing reliable electricity throughout the year that enables enterprise development such as small agroprocessing factories in rural areas (Morvaj et al., 2010a).

**Figure 14: Organizational structure of National Fund for RES and EE**




Source: Bukarica et al. (2011).

### *5.2.5 Other funding sources for RES and EE*

In addition to electricity fees collected from the system operator (or directly from consumer in the standalone mode of operation), other sources of funds for the Trust Fund are identified based on a review of instruments applied in other countries. As shown in Table 53 in the Appendix 1, none of the instruments promise a guaranteed stream of money without negative impacts on the economy and population, and therefore, the degree of their applicability to Tajikistan is very low (except for the existing ecological charge for motor vehicles). Assuming annual contribution of the applicable and recommended sources of funding, the total amount that can be expected over ten years from 2010 to 2020 could reach about US$334 million[7]. This would be more than double the expected cost of promoting RES and EE initiatives in the amount of US$162 million (see Table 8). If the petroleum levy is excluded due to its potential to cause a progression of poverty, the total expected amount would drop to $196 million, which is still above the estimated costs.

### *5.2.6 Critique of UNDP proposal for energy security*

The three strategic documents produced by the UNDP chart a course towards achieving energy security through small-scale technologies and energy efficiency initiatives that would stimulate local economic development activity and reduce poverty in rural areas of Tajikistan. This proposal has many merits that have been discussed above. Nevertheless, several key issues related to the proposal require further consideration.

The crux of the energy plan is development of small-scale hydropower plants (SHPPs), and connection of these to the national electricity grid. Mountainous landscapes and availability of streams and rivers make this plan attractive. However, the documents do not provide an analysis of the potential for hydropower production, particularly in terms of availability of sufficient flow in wintertime. Furthermore, no spatial analysis is done to show where such potential could be realized. This is an important consideration because resource availability does not always coincide with population centers. Proximity to where electricity is needed is a major criterion for

[7] The sum of special charges for motor vehicles ($875,000+$1.75 million), special charge for imported vehicles ($17 million), and petroleum levy ($13.8 million) as in Table 10, multiplied by 10.

making SHPPs successful because the further the plant is located, the larger are the losses in transmission (and distribution). Another criterion is that generation capacity of the plant has to match the demand for energy in the service area. Connection to the grid, therefore, would be advantageous in both cases, when energy supply from the plant either exceeds or falls short of satisfying demand. However, given the nature of electricity generation in the country that produces surplus during high flows and runs shortages during low flows, connection to the grid may actually offer little advantages. This is because the same pattern of high and low flows also affects SHPPs' operation during summer and winter months. The real benefit of SHPPs would be in meeting the winter energy shortage provided the flows are sufficient to produce enough power for the serviced population.

The program of national scale-up, as proposed in the UNDP documents, is germane to addressing energy needs of about a million of the most vulnerable people in rural areas and improving their living conditions. The scale-up, however, is based on a single project that was implemented in Vahdat district, in the outskirts of the capital city of Dushanbe. Implemented according to the principle of integrated rural development (IRD), this pilot project built a 100kW SHPP to serve 100 households (installing 1kW limitators in every household), and refurbished a health center in line with energy efficiency practices and installed photovoltaic and solar thermal systems for the center. The next stage was to build a second SHPP to power a small milk processing facility, and refurbish a kindergarten and a school in the same community. Taken together, all of these project activities constitute a package that is proposed for rolling out throughout the country. While this seems like an attractive plan, many questions arise regarding the applicability of the project experience to other communities. First, and very importantly, it is not specified whether the pilot project was able to cover the energy deficit in the winter. Second, the geographic conditions (including water flows) and the nature of demand in the project location are not specified. Therefore, it is difficult to ascertain the extent to which this project could be characterized as “typical”, so as to be applicable to other locations. A degree of modification could be allowed in cases where local conditions are similar to that of the project, and therefore, allow for its scale-up. Third, it is more likely than not, conditions in other locations would be drastically different from the project area. This is defined by the landscape of the country that spans highlands and highland valleys with low population densities, to lowlands with more dense settlement areas. In this regard, the needs of the people in different areas would be different. Finally, it is not clear, even in the pilot project, that all energy needs – including but not limited to heating, cooking, lighting, information and communication, and earning a living – would be satisfied with the provision of 1 – 3 kW of electricity per household, along with some energy efficiency measures. An analysis of energy needs at the household and community levels is first necessary to ascertain the nature and magnitude of those needs, and to assess the extent to which those needs could be met with any set of energy options.

Relying on Barki Tojik as the system operator to purchase power from SHPPs entails several challenges. Acting as the single utility in charge of generation, transmission and distribution for the whole country (except GBAO), Barki Tojik has faced difficulties in managing its activities in all fronts. A recent assessment of the company's financial performance revealed several inconsistencies (Kochnakyan et al., 2013). In the reporting period the company incurred large cash deficits that crippled its ability to perform required system maintenance and to ensure domestic power supply. The shortfall was due to high system losses, low rates of collecting payment for energy bills, high overhead expenses and other unclassified costs. The latter is arguably a sign of corruption, where, for example, collectors strike "deals" with consumers and pocket the money. Barki Tojik was indebted with US$524 million outstanding sovereign guaranteed debt as of January 1, 2013, which accounted for 20% of Tajikistan's total public debt. It failed to make any debt service payments in 2011-2012. Furthermore, the company faced difficulties in paying for the power purchased from the independent power producers. A prominent case is Barki Tojik's indebtedness to Sangtuda-1 HPP that produces about 15% of annual electricity in the country. Because Barki Tojik failed to pay Sangtuda-1 HPP US$84.8 million, the latter in turn failed to pay US$10.9 million in taxes owed to the government. The tax authority then threatened to freeze the accounts of Sangtuda-1 HPP, which led to signing of an agreement between the parties involved on a schedule of payments (Interfax, 2013). Apart from causing such quai-fiscal deficits in the country's budget, Barki Tojik is apparently scaring away potential investors from the country's energy sector. Timely payments are particularly relevant for the operation of the National Trust Fund for RES and EE as recommended by the UNDP documents. If Barki Tojik, acting as the system operator and power purchaser from SHPPs is actually unable to pay its dues in a timely manner, it is unlikely to act otherwise in case of SHPPs – even though the latter may generate comparatively less power to sell to the utility.

With regards to the issue of funding for the RES and EE plan as proposed in the UNDP documents, estimates of potential funds exceed estimated costs of the plan. This is true even under the conservative scenario of raising money solely from vehicle charges. However, this would mean that all the costs of RES and EE would be borne by one sector of the economy. Apart from possible adverse impacts on mobility, reliance on a single source of financing is not in line with risk management practices. For example, fluctuations in prices of vehicles and gasoline would affect the demand for and supply of vehicles, and this would in turn translate into vulnerability for the RES sector.

As a final note, no documentary evidence was found of whether or to what extent the proposed measures have been implemented[8].

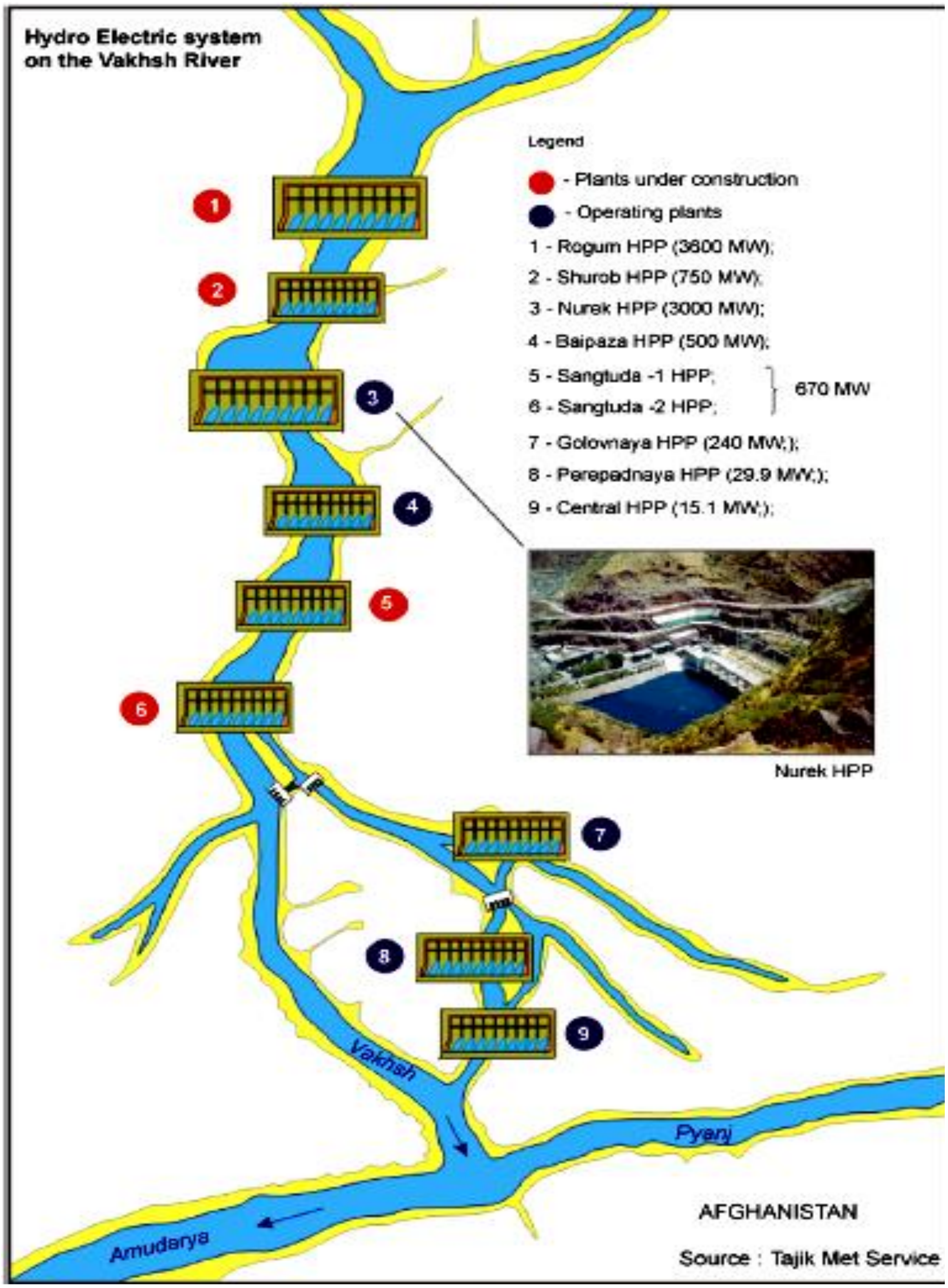
[8] Despite multiple requests during field research, UNDP officials did not agree to be interviewed and provide comment on progress thus far.

### *5.3 Option 3: Rogun HPP to address energy shortages*

As the resource sharing mechanism began to falter after independence, and especially, after suffering two consecutive energy crises during the winters of 2008 and 2009, Tajikistan firmly resolved to capitalize on its massive hydropower potential in order to secure sufficient power for domestic use and increase electricity exports to foreign markets. In terms of the potential for hydropower production, Tajikistan occupies the leading position in Central Asia with 69% of 317 billion kWh per year that is economically feasible. Current utilization, however, stands at around 5% (EDB, 2008). It is this untapped potential that promises to break the country out of the recurring cycle of winter energy shortages.

Tajikistan's electricity production strategy is centered on realizing the hydropower potential through construction and rehabilitation of a series of hydropower plants (see Figure 15). The most significant of these hydropower plants is the Rogun Hydropower Plant (HPP), with a projected 335 meters high dam and 3,600 MW installed capacity. Although Rogun HPP is expected to satisfy the domestic demand for electricity, it is also envisaged to generate surplus for potential export to neighboring countries. There are projections that with the addition of Rogun HPP's annual generation of 13.1 billion kWh, together with Sangtuda 1 and 2 HPPs, the overall generation in Tajikistan will reach 33.5 billion kWh, which will exceed the projected domestic demand of 23-25 billion kWh, and thus, create a surplus of about 10 billion kWh that can be exported to neighboring countries (Gulov, 2007, p. 23). Furthermore, Rogun HPP is designed like the existing Nurek HPP to serve the dual purpose of electricity generation and water storage for irrigation. Hence, the flows out of the reservoir will be conditioned, ideally, to achieve both objectives.

**Figure 15: Hydroelectric system on the Vakhsh River**




Source: Sharma et al. (2004). Note: Sangtuda-1 and Sangtuda-2 HPPs are now operational.

### *5.3.1 Critique of the Rogun HPP*

Along with the prospective economic benefits, the construction of large hydropower facilities is also accompanied by complex geo-political, social and environmental impacts. In terms of the geo-political aspect, there is a strong opposition by the downstream neighbor, Uzbekistan, towards construction of the Rogun HPP. Specifically, Uzbekistan is concerned that the accumulation of water in the reservoir will lead to further reduction in the size of the Aral Sea and exacerbate associated environmental problems there. But the alleged motivation behind the opposition is the suspicion that having gained an assured control of water flow, Tajikistan may literally turn off the tap and leave the large agricultural fields of Uzbekistan without water at any time. The resulting loss from agriculture is estimated at $600 million annually (Jalilov, DeSutter, & Leitch, 2011).

In addition, there are tremendous social impacts associated with involuntary relocation and resettlement of the population from the inundation zone. Despite the officials' claims of making necessary provisions for the resettlers, some evidence has been reported of the local residents' resistance towards resettlement. A news agency reports tens of thousands of people refusing to leave their place of residence (Ismonkulov, 2011). Furthermore, some people are dissatisfied with the amount of compensation offered by authorities, claiming it does not reflect the market value of their property and is not sufficient to build a new house. Another group is outright opposed to the relocation, as well as to the project itself, because the reservoir is going to inundate the graveyards where their relatives are buried. Noting the absence of a resettlement plan and inadequate preparation by authorities in the resettlement project, Sodiqov (2009) observes that the situation of the newly resettled families "resembles a spontaneous refugee camp" (p. 17), where people lack basic sanitary conditions and it is not certain when they would receive the materials to build houses and move out of tents. Moreover, people are not accustomed to a more humid and warmer climate, and cultivation of cotton as opposed to their traditional agricultural practices of growing wheat and potatoes.

In response to these concerns, and in an effort to facilitate informed decision-making, the World Bank commissioned independent evaluations of the Rogun HPP in 2010. The evaluations that span technical, economic, social and environmental aspects have been completed and final reports were disclosed on September 1, 2014. At the same time, the World Bank (2014) released a note highlighting key issues in the assessment reports and called for attention to further related concerns. Effectively, the assessments were positive and gave green light to construction of the Rogun HPP with some modifications suggested. In particular, as the World Bank note summarized it:

> The assessment studies (a) conclude that, subject to design changes and mitigation measures, a hydropower project could be built and operated at the Rogun site within international safety norms, (b) recommend mitigation and monitoring measures to manage the environmental and social impacts, particularly regarding resettlement and potential changes in downstream hydrology, and (c) find that building a dam at the Rogun site would be a lower cost solution to meeting Tajikistan's energy needs than any of the alternatives (p. 16).

In terms of financing structures, a combination of the following elements was hypothetically considered: *(a) full government self-financing with equity, (b) a preferential loan from a foreign government, (c) multilateral and commercial loans,* *and (d) foreign bond issuance.* Various estimates put the cost of the Rogun HPP between US$3-5 billion (Forss, 2014), or about half of Tajikistan's annual gross domestic product.

The position of Uzbekistan, nevertheless, remains unchanged. After the conclusion of the fifth and final round of riparian consultations in July 2014, the First Deputy Prime Minister of Uzbekistan, Rustam Azimov, officially stated that the findings were "completely unacceptable" because Uzbekistan's concerns over international safety considerations, transboundary water management and related socio-economic issues were not adequately addressed, and that "Uzbekistan never, and under no circumstances, will provide support to this project" (Azimov, 2014).

The Rogun HPP project is claimed to be a silver bullet solution that would resolve all energy shortages and also support the country's economic development. Construction of Rogun HPP, however, is considered a long-term option. Facing the stalemate in bilateral relations and limited prospects for financing, the government of Tajikistan is struggling to realize the Rogun HPP project. The project has taken the life of its own and has become elevated to the status of "symbol of the nation" and a "national idea" (Suyarkulova, 2014). In other words, there is a massive political baggage tied to the project that goes beyond economic and technical considerations. It should be noted that this is likely the main reason why it is difficult to get experts to share their views of energy security matters in Tajikistan.

## 6. *Energy services approach to alleviating energy poverty and ensuring energy security*

The three proposals evaluated in the previous section present different sets of options for achieving energy security in Tajikistan. The action plan proposed by the World Bank study (Fields et al., 2013) addresses winter energy shortages nationwide. The measures outlined by the three strategic documents of the UNDP (Morvaj et al., 2010a; Morvaj et al., 2010b; Bukirica et al., 2011) set out to alleviate energy poverty in rural areas. The Government of Tajikistan's Rogun HPP project aims to generate electricity to meet domestic demand and export the surplus to neighboring countries. The World Bank and UNDP plans propose an intermediate strategy by the year 2020, focusing on energy efficiency measures and technologies other than deployment of large-scale hydropower. The latter is considered more complex, costly and therefore, a long-term option. On the other hand, the Rogun HPP precisely takes on this long-term perspective.

The World Bank plan offers national level solutions that include raising of electricity tariffs to cost-recovery levels, improving efficiency of the grid and reducing transmission and distribution losses, shifting the supply of heating away from electricity into coal-based thermal power, and revitalizing energy trade with neighboring countries. All of these options can potentially meet winter energy requirements, if sufficient funding is sourced to cover the associated costs. However, a rigorous analysis of financing mechanisms or funding sources is missing from the plan.

The UNDP proposal is also a national level initiative, albeit with a focus on small-scale technologies and energy efficiency measures, often at the household level. Building of small-scale hydropower plants is at the heart of the strategy to improve the living conditions and livelihood opportunities of the most vulnerable people living in rural areas. Provision of energy for urban areas and larger industry is not the domain of this plan. The costs are, therefore, substantially less than that required for the World Bank plan. The UNDP plan identified potential funding sources and a mechanism of financing for its proposed initiatives.

The Rogun HPP option is a national, and potentially an international level initiative, because it aims both to meet domestic demand and contribute to meeting demand in the neighboring countries. It can achieve both objectives, as it will have a sizeable generation capacity once constructed. However, substantial finances are required to materialize this project. More critically, the political challenges emanating from transboundary issues of water sharing and poor bilateral relations with the downstream country pose a real threat to the viability of the project.

A comparison of the costs, given in Table 17, shows the magnitude of differences among the three plans. The World Bank proposal and the Rogun HPP would be very costly as it can be inferred from comparison to the country's GDP. Taken together, the short- and long-term plans require substantial amounts of investment that may need to come from domestic, as well as outside, funding sources. The share of the latter might actually be larger, given the scarcity of domestic funds.

Therefore, sourcing international support and investment is key to realizing the proposed plans for energy security.

**Table 17: Comparison of costs of energy security options**

| UNDP studies [a] | World Bank study [b] | Rogun HPP [c] | GDP [d] |
|---|---|---|---|
| US$162 million | $3.425 billion | US$3-5 billion | $8.045 billion |

Sources: a) Morvaj et al. (2010a); b) Fields et al. (2013); c) Forss (2014); d) CIA World Factbook (2015)

The options for energy security discussed above claim to address the energy needs of Tajikistan in different ways. However, substantial challenges are associated with implementing these options. An alternative approach may be required that addresses people's energy shortages in ways that are more conducive to their long-term wellbeing. One such approach is that of *energy services*. This approach conceptualized by the NGO Practical Action in its Poor People's Energy Outlook (PPEO) 2014 publication specifically looks at energy for the services that it can provide to people. Energy needs are framed as a range of services that can be provided by tapping on different energy sources. As such, the PPEO 2014 stratifies the energy needs/services in terms of their immediacy to basic survival necessities of people: *energy services for households*, *for earning a living*, and *for community*.

Although they recognize that energy is needed for some purpose, none of the proposals discussed above take the energy services approach in their analyses. The World Bank proposal can be characterized as a traditional approach to analyzing energy security issues. It takes a stock of how much energy is produced, derives a demand function that shows a gap with supply, and proposes a set of standard solutions to close the gap. The proposal does not engage in further detail on how much of the energy is used for different purposes, such as heating, cooking, lighting, ICT or productive uses. Neglecting the use patterns runs the risk of miscalculating actual energy needs for each purpose. Moreover, it errs on the side of generalizing energy as a physically uniform entity, rather than realizing its multiple forms that are appreciated for different uses. For instance, taking the uniformity stance one could argue that everyone should use electricity to bake bread because it is the most efficient form of energy for this purpose. The multiplicity viewpoint would counter that baking bread in a *tanoor* (clay oven) by burning wood gives bread unique flavor and taste that is desired by the people, and is unlikely to be replicated successfully in an electric oven. In other words, other criteria also become important when an energy services approach is taken in the analysis.

The UNDP proposal is relatively closer to taking the energy services approach. In view of its focus on providing rural households with energy, the study discusses options to provide lighting and thermal comfort for homes (*energy for households*) and social buildings (*energy for community services*), as well as enabling some productive economic activity such as operating small processing factories (*energy for earning a living*). However, it falls short of taking a further step to define what is needed at the household and community level that could be addressed through some form of energy provision.

The Rogun HPP proposal is a one-size-fits-all approach that claims to address all energy problems at once. It may provide physical access to electricity that is more reliable. However, it is highly unlikely to be an affordable solution to rural people. Furthermore, electricity alone cannot provide for the diversity of energy services. Finally, it is uncertain when, if at all, the project will start generating electricity. In the meantime, energy shortages will continue to keep people in poverty, unless alternative solutions are seriously considered.

In short, the options fail to fully relate their proposed measures to energy services needed for poverty alleviation and energy security. Assessment of energy security is incomplete, if not outright erroneous, without first understanding the nature of energy needs and the forms of energy that could potentially meet those needs. Therefore, a rearrangement is required to place energy services at the center of analysis and redraw the implications for Tajikistan. This shift in focus, delved into detail in Chapter 2, presents alternative perspectives on how to provide energy access in ways that also contribute to people's wellbeing. The role of local people in achievement of a better quality of life through acquiring access to energy is very important, and this is discussed in Chapter 3 with regards to energy sovereignty.

## *7. Conclusion*

This chapter first explained and then applied the vulnerability approach to assess the energy security situation in Tajikistan. It revealed a set of key vulnerabilities in the energy system that stem from lack of diversity in energy sources (predominant reliance on hydropower), shortfalls in production capacity, unreliable and expensive energy imports, crumbling and inefficient infrastructure, lack of transparency and accountability in energy provision, political stalemate in regional water and energy relations and insufficient financial wherewithal to address the challenges. Three options that are currently proposed to improve the energy security situation were evaluated and found to be inadequate to achieve this lofty goal. A more realistic plan is needed to provide energy access, and by doing so improve people's wellbeing. The energy services approach offers a potentially relevant way to first understand the energy use patterns, and then open a door of opportunities to effectively provide access to energy. This approach is followed in Chapter 2, while Chapter 3 discusses the ways to achieve the goal of energy security through local energy sovereignty.

# CHAPTER 2: UNDERSTANDING AND ALLEVIATING ENERGY POVERTY IN TAJIKISTAN


### *Abstract*

Lack of cooperation among Central Asian countries led to serious problems in water and energy sectors in the post-Soviet period. Poor governance, inadequate management capacity, ineffective policy and outdated practices constrain access to energy in the region. Drawing on a survey of 386 households in mountain areas of Khatlon region, Tajikistan, this chapter argues that lack of access to energy services keeps people in *energy poverty*. Rural communities continue to rely on solid biomass (wood, straw, animal dung) to meet their thermal energy needs. Electricity is unaffordable, and during winter, households experience daily blackouts. Sharing of water and energy resources among Central Asian countries is a much-lauded possibility; yet, it breeds more controversy than cooperation. This chapter, in contrast, recommends capitalizing on small-scale technologies such as solar home systems, micro-hydro units, biogas digesters, improved cookstoves, residential wind turbines and thermal insulation of homes. Easily deployed, maintained and configurable to needs, plus cost-effective and environmentally sustainable in the long-term, these technologies are optimal to rural areas. Businesses together with governments and civil society organizations can take advantage of technologies to lead the transition from energy poverty to security.

## *1. Introduction*

There is no internationally accepted definition of energy poverty. It is commonly understood as lack of access to electricity and reliance on solid biomass to satisfy the cooking and heating needs of households (IEA, 2012). However, this understanding is as limited as its underlying *energy ladder* model (Hosier & Dowd, 1987; Hiemstra-van der Horst & Hovorka, 2008; Gregory & Stern, 2012). The model suggests that households go through a three-stage transition: at the bottom are crude biomass fuels such as wood and dung, in the middle are charcoal, coal and kerosene, and at the top are liquefied petroleum gas, electricity and biofuels. It is expected that households move up the "ladder" as their affluence increases, which is essentially a modernization idea based on the trajectory of progress that all society are assumed to go through. It is assumed that households inherently prefer "modern" or "advanced" over "traditional" fuels (Hosier & Dowd, 1987; Hiemstra-van der Horst & Hovorka, 2008; Gregory & Stern, 2012). The rationale is that modern fuels (e.g. liquefied petroleum gas, electricity) are more energy dense and "efficient" in delivering energy services than are traditional fuels (e.g. wood, dung). However, as discussed in the subsequent sections, the *energy ladder* model is incongruent with the ways households use energy sources, from the so-called "primitive" to "advanced" fuels.

An alternative model of *energy stacking* challenges the *energy ladder* model and suggests that households use multiple fuels, adding new fuels on top of existing ones, and the relative use of each fuel is context-dependent (Masera and Navia, 1997; Masera et al., 2000; Heltberg, 2005; Pundo and Fraser, 2006; Van der Kroon, Brouwer, & van Beukering, 2013). As the *energy stacking* model is prevailing with evidence, it is necessary to adjust our perspective on energy poverty. Although this model helps to show the actual use of energy by households, it falls short of explaining why households use energy the way they do. In other words, the diversity of needs and plurality of energy options that can be used to address those needs are not taken into account.

To address the shortcomings of existing models the *energy services* approach provides a compelling alternative. Energy services are divided into three broad categories: *energy for households*, *energy for earning a living* and *energy for community services*. The energy services approach requires that we first understand the energy needs, and then consider the options to address those needs (Practical Action, 2014).

Energy poverty reflects the inadequate access to energy services at the level of the community and household. In Tajikistan rural communities continue to rely on solid biomass (wood, straw, animal dung) to meet their thermal energy needs, and many households are not connected to the electrical grid. Even when households are connected to the grid, their access to electricity is neither reliable nor affordable. During winter, when energy needs are particularly acute, households experience daily blackouts. To assess the level of energy poverty is to take account of energy needs, such as cooking, heating, and lighting, and the extent to which they are met. The fundamental need of a household is expressed through its specific energy requirement. Thus, energy poverty must be assessed starting at the level of the household and community.

Adapting the *energy services* approach, a representative survey of 386 households was conducted in Khatlon region of Tajikistan to better understand the scope of energy poverty in rural mountain areas. Empirical work is pertinent to assessing energy poverty in developing countries more generally because it focuses on rural agricultural communities that other studies indicate as being energy poor (World Bank, 2011; Practical Action, 2014; Sovacool et al., 2014). Many factors influencing energy access, from technical and economic to socio-cultural and political dimensions, require close attention in order for solutions to work (Heltberg, 2005; Pundo and Fraser, 2006; Nnaji et al., 2012; Mensah and Abu, 2013). Navigating this complexity is the greatest challenge in improving energy access, and it requires a transdisciplinary approach to tackle the problems effectively.

The rest of the chapter is organized as follows. Section 2 reviews the literature on household energy focusing on energy ladder, energy stacking and energy services approaches. In section 3, the methods of the research including the design, sampling, data collection and limitations are described. Next, results of the field research are presented in section 4, followed by their discussion in section 5. Finally, section 6 concludes with some policy implications.

## *2. A review of literature on household energy*

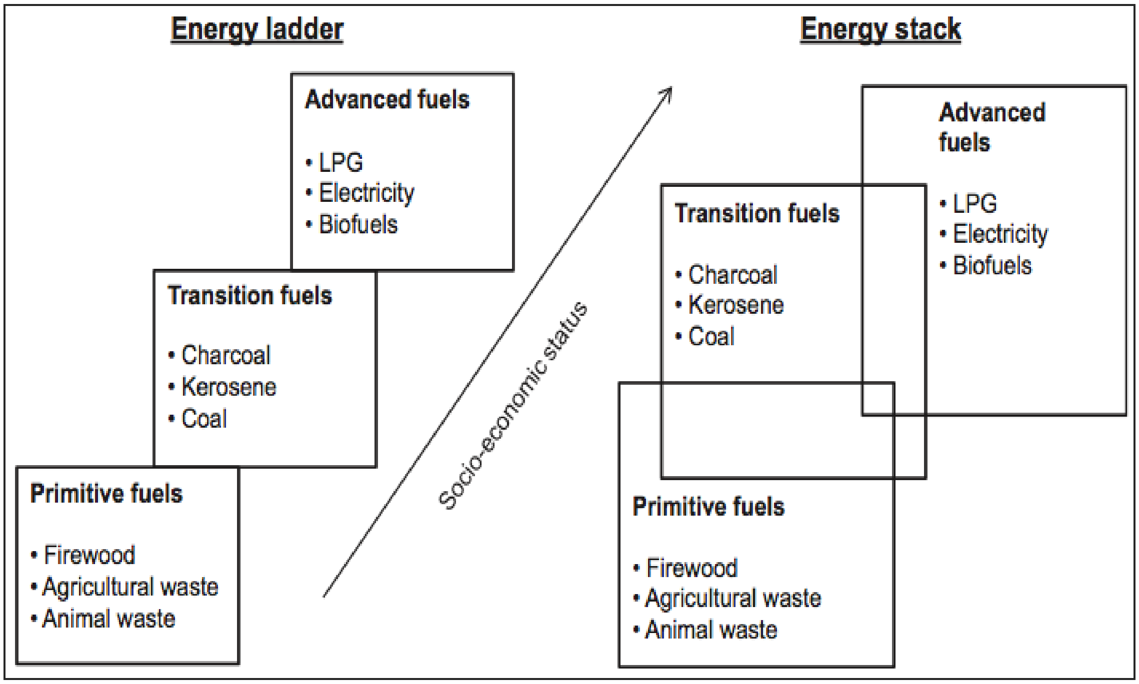
The energy services approach is used in this study because it provides a nuanced understanding of energy poverty compared to the energy ladder and energy stacking models. The nuance comes from intentional consideration of diversity of sources, needs and ecological as well as sociocultural context of energy use. In this section the merits of the models are discussed and the adaptation of the energy services approach is justified.

### *2.1 Energy ladder*

The implications of energy poverty on people's livelihoods are large and varied. To capture this complexity theoretically, the concept of *energy ladder* has been developed to illustrate energy poverty in terms of efficiencies of energy sources used by people with different socio-economic statuses to meet their household energy needs. The literature on the subject has evolved over the past three decades, with the *energy ladder* model prevailing in the studies in the late 1980s through the early 1990s and, then, an alternative *energy stacking* model gaining ground since late 1990s (Van der Kroon, Brouwer, & van Beukering, 2013).

The earlier studies posited that as household income rises, they shift away from lower-quality towards higher-quality energy carriers. Income is considered the main determinant of household energy use. This understanding was formally conceptualized under what is now known as *energy ladder* model (see left panel on Figure 16).

**Figure 16: The energy transition process**




Source: Van der Kroon et al. (2013).

According to this model, households go through a three-stage transition: at the bottom are crude biomass fuels such as wood and dung, in the middle are charcoal, coal and kerosene, and at the top are LPG (liquefied petroleum gas), electricity and biofuels. It is expected that households move up the “ladder” as their affluence increases. The model presumes an inherent preference by the households for “modern” or “advanced” over “traditional” fuels (Hosier & Dowd, 1987; Hiemstra-van der Horst & Hovorka, 2008; Gregory & Stern, 2012). However, these characteristics are problematic in that they assume a certain definition of “modernity”, which is based on the idea of unidirectional progress. For example, placing wood at the bottom of the ladder imposes a perception of “backwardness”. Yet, wood remains an important energy source even in households in industrialized countries along with electricity and natural gas. Therefore, such ranking of sources ignores the complexity and contextual significance of energy use. The discussion in subsequent sections of this chapter will shed further light on this critique.

The rationale is that modern fuels are more energy dense and therefore, more “efficient” in delivering particular energy services that households desire. For example, compared to wood and dung, kerosene is three to five times, and LPG is five-to-ten times more efficient when used for cooking purposes (Barnes & Floor, 1996). More simply, 1 kg of LPG gives out as much cooking heat as 11 kg of wood (Barnes et al., 2010). These efficient fuels are also cleaner in that they pose comparatively less health and environmental risks (to the immediate vicinity of use) than burning biomass indoors.

The *energy ladder* model is theoretically compelling as it effectively demonstrates the problem of energy poverty by relating fuel efficiency to income. The technological underpinning that ranks fuels by their technical efficiency implies that a shift should occur from “traditional” to “modern” fuels in order to overcome energy poverty.

Empirical evidence demonstrates some support for the *energy ladder* model. In one of the earlier tests of the model, Hosier and Dowd (1987) looked at fuelwood, coal, kerosene and electricity use patterns in a cross-sectional survey of household energy use in Zimbabwe. The study found support for the energy ladder model in that households with higher incomes used more of the commercial fuels (e.g. kerosene, electricity). Fuelwood was preferred at lower levels of income, whereas kerosene was considered a transitional fuel, inferior to electricity. The authors concede that their evidence is primarily useful for urban fuel transition, whereas "[r]ural areas may largely have to fend for themselves through wood fuel conservation and rural afforestation" (p.360). Gregory and Stern's (2012) survey of recent literature suggests that the energy ladder model is also applicable in the case of India. Although an important predictor, the authors recognize that income is not the primary or sole determinant of energy use. Moreover, the analysis takes into account only monetary income from wage labor and sales (or valuation) of agricultural products, leaving out important non-monetary indicators such as housing quality, household composition, social status, family networks, access to water and sanitation services, etc.

Although still in use, the *energy ladder* model was later found to be inadequate in explaining factors other than income that were observed from empirical studies of household energy use. Particularly, the one-way transition was not clear as households tended to use a mix of fuels across all income categories. Other economic factors (e.g. fuel price differences and fluctuations) and cultural factors (e.g. food tastes and cooking habits) were found to significantly influence household energy use (Masera and Navia, 1997; Masera et al., 2000; Heltberg, 2005; Pundo and Fraser, 2006; Hiemstra-van der Horst & Hovorka, 2008, Jan, Khan and Hayat, 2012; Lambe and Atteridge, 2012).

### *2.2 Energy stacking*

The ideological basis of the *energy ladder* is rooted in "progress" and "modernity" – a worldview that all societies inevitably go through a linear path of development, at the peak of which are the industrialized societies. Although the modernization theory has been debunked by many scholars, including Andre Gunder Frank and Immanuel Wallerstein, it is implicit in much of the energy transitions literature. The following analysis will demonstrate that progressive narratives bear little evidence on the ground. Heterogeneity and complexity in energy use is the norm rather than an exception, and therefore, reliance on reductionist approaches, of which the *energy ladder* is a prime example, is ill-advised for the study of household energy in developing countries.

A major challenge to the *energy ladder* model came after about a decade since Hosier and Dowd's (1987) empirical work. Masera and Navia (1997) identify several important gaps in the literature on household energy use patterns. In particular, they find the *energy ladder* model to be relevant mostly to urban residents. In addition to inadequate applicability to rural situations, the model does not adequately explain household use of multiple fuels, partial transition to modern fuels and use of different fuels for different purposes (p.347). Diversity of needs and contextual relevance of resource use is a key omission. In their study of three villages in Mexico, Maser and Navia (1997) find that rural households use multiple fuels (in this case both fuelwood and LPG) because each fuel has a specific advantage. Furthermore, they find that households prefer a certain fuel because it best serves a particular cooking task. Since such (cultural) preferences can only be revealed through a detailed study of households' energy use (e.g. via interviews with the users), the more deterministic energy ladder model (based on larger aggregate data) is likely to overlook such nuances, and therefore, arrive at inappropriate conclusions (and policy recommendations that will not necessarily be adopted).

In a later study of fuel switching process in Mexico, Masera et al. (2000) level a stronger critique of the *energy ladder* model, and formulate a *multiple fuel* or *fuel stacking* model. Their proposed model suggests that new fuels are added on top of existing ones, and the relative use of each fuel is context dependent, i.e. depends on the types of fuel and appliance use, availability of fuel, and socio-cultural factors (see right panel on Figure 16).

In a further critique of the *energy ladder* model, Van der Horst and Hovorka (2008) reveal two inherent assumptions within the model: (a) fuelwood is considered as "fuel of the poor" because their low incomes prevents them from transitioning to "modern" fuels; (b) everyone prefers "modern" fuels over "traditional" ones and prices do not matter so long as households can afford the more sophisticated ("superior") fuels. The authors find that transition along the *energy ladder* has not been a reliable predictor in Sub-Saharan Africa. Transition was either slow, never occurred or even reversed. Moreover, households tended to use multiple fuels (e.g. wood, kerosene, LPG) instead of switching completely to "modern" fuels. Households use multiple fuels because each fuel is directed for a different purpose (thus not fully inter-substitutable), and its relative price also plays a decisive role as households tend to economize on energy spending.  Importantly, "[d]ue to the pervasive influence of energy ladder thinking, efforts to account for these trends have largely focused on how consumer decision-making can be *restricted* rather than examining why households might *prefer* to make choices other than those predicted by the model" (emphasis in original, p.3335). Main reasons for incongruence of the energy use patterns to the energy ladder model has been explained by transition constraints, such as inadequate distribution of modern fuels limiting physical access, high upfront costs of appliances that use modern fuels, and irregularity of supply (and fluctuating prices) of modern fuels. However, as Jane Trac (2011) demonstrates in case of rural households in Caoxiu village in China, these constraints cannot explain continued use of firewood alongside electricity, especially because this village has received reliable and affordable electricity for over thirty years. This case study is particularly relevant as it "challenges the inevitability of modernity" (p. 320), which is a flawed assumption behind much of energy transition thinking, policy and practice (e.g. rural electrification).

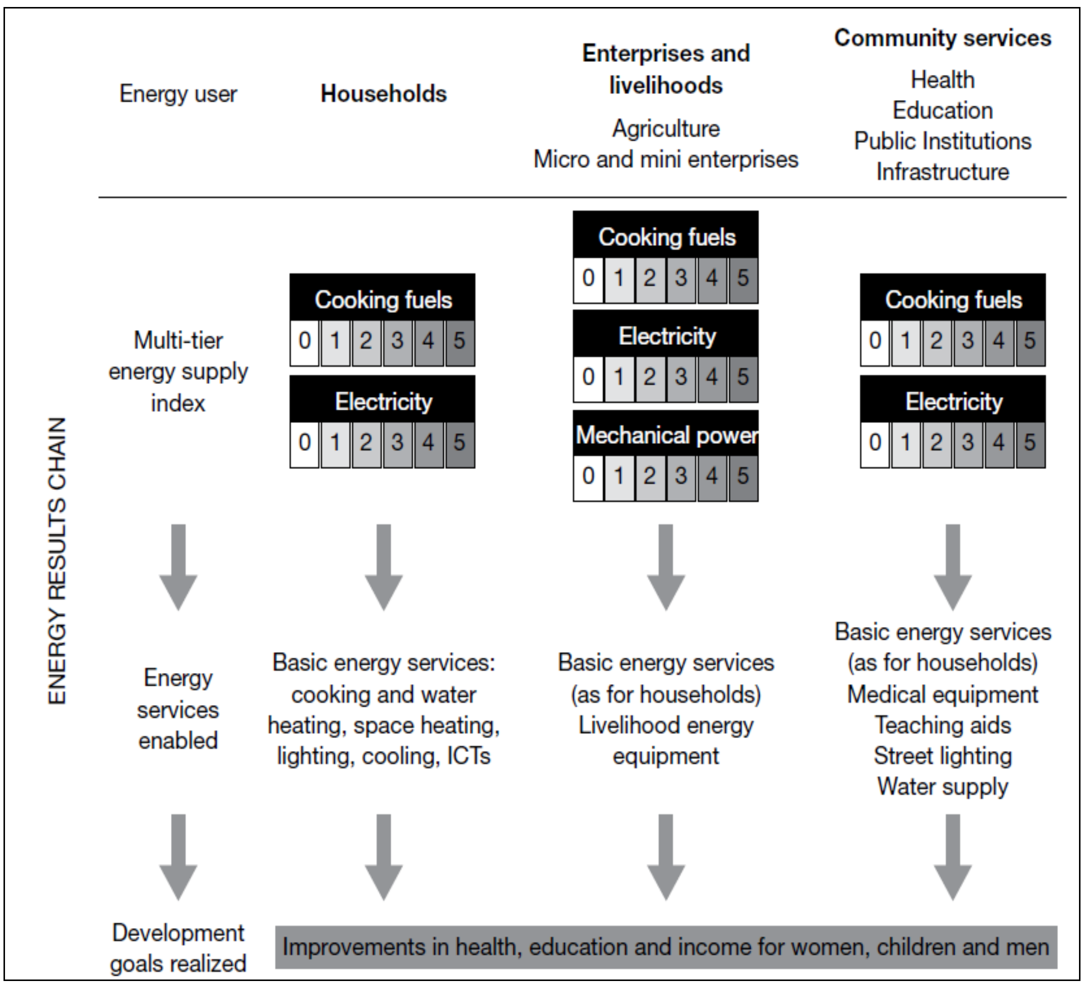
Van der Horst and Hovorka (2008) consider the alternative model of *energy stacking* as dramatically different from the *energy ladder* model, as the former explains the use of multiple fuels including the traditional ones as well. Jan, Khan, and Hayat (2012) also found evidence to support the *energy stacking* model. In a study of two villages in Pakistan they found that other than income, access to alternative energy sources and user's preference for certain energy qualities also influence the rural residents' fuel choice. The study of four villages in India by Lambe and Atteridge (2012) indicates that household energy use is influenced by a set of factors, ranging from social to cultural to financial. Cultural factors such as taste preferences and cooking habits are difficult to capture theoretically and assess quantitatively (Heltberg, 2005). Nonetheless, some proxy indicators can be useful in revealing the effect of culture on energy use. Households in urban Java, Indonesia consuming more steamed rice were found to use more energy (specifically, kerosene), compared to those boiling their rice (Fitzgerald, Barnes, and McGranahan, 1990). Cooking time is also an important consideration in that meals taking longer time are cooked with firewood, whereas those taking shorter time are cooked using either charcoal or kerosene. This choice is partly motivated by higher prices of the latter fuels, which makes them more expensive for longer time cooking (Pundo and Fraser, 2006). Even in relatively well-off households "cultural beliefs may keep working women to a common culture and societal life style of using firewood" (Pundo and Fraser, 2006).

It is evident from the discussion above that the *energy ladder* model's income and fuel efficiency, while important, are not the only variables worthy of consideration in the analysis of energy use patterns. With evidence mounting in support of the *energy stacking* model as a prevailing theoretical framework, it is necessary to adjust the lens through which energy poverty is viewed. This adjustment means taking into account an array of factors, ranging from economic to technical to cultural that prevent people from accessing the quantity and quality of energy that they desire, which is the real essence of energy poverty.

*2.3 Energy services*

To better understand the situation of energy access in developing countries, the *energy services* approach provides a compelling alternative. This approach is advocated by Practical Action – an international non-governmental organization that aims to address poverty in developing countries by deploying technology. Three categories of services are identified: *energy for households*, *energy for earning a living* and *energy for community services* (see Figure 17).

**Figure 17: Conceptualizing energy services and energy poverty**




Source: Adapted from Practical Action (2014).

These categories are called *energy services* because they provide the respective services that are enabled through harnessing some energy source. Together these services encompass a broad spectrum of energy needs. The energy services are satisfied from a mix of energy sources with the ultimate goal of improving the quality of life of the people. In other words, the *energy services* approach requires that we first understand the energy needs, and then consider the options to address those needs (Practical Action, 2014).

Energy services particularly in the context of rural development can be distinguished by two categories of use. First is provision of cooking, heating and lighting services at home, which is referred to as "residential use" or "consumptive use" (i.e. final energy consumption). Such energy use is "expected to positively impact the rural quality of life or improve rural living standards" (Cabraal et al., 2005, p.118). Second is called "productive use" because energy is used to produce goods and/or services needed for households and/or other consumers within, as well as beyond, the village boundary. This type of energy use is "expected to result in increased rural productivity, greater economic growth, and a rise in rural employment" thus curbing rural outmigration (Cabraal et al., 2005, p. 188). Going beyond this traditional division of energy uses, and referring to a number of studies, Cabraal et al. (2005) argue that the residential use can also be productive due to the positive relationship, for instance, between provision of electricity and education and health improvements that are in turn associated with higher income. In other words, educated and healthy men and women with access to energy are more productive, and, therefore, better-off than those who are not.

In alignment with Cabraal et al. (2005) and Practical Action (2010), Bazilian & Pielke (2013) propose the term "modern energy access" defined as a level of energy necessary to alleviate poverty, and advocate for going from currently "unacceptably modest" to a broader "more ambitious" conception of modern energy access that encompasses equitable provision of clean and efficient energy to enhance productivity and thus improve quality of life. Although the term "modern" certainly comes with attached normative assumptions about progress, application of this new concept demands a re-examination of mainstream attitudes towards energy provision, particularly from a technological, financial, institutional, and ecological systems perspective in the context of development practice.

A notable omission in the *energy services* approach is *mobility* service. Ability to travel is important for rural households to access markets to buy necessary goods and sell their products, benefit from health and education facilities beyond their village, and be able to relocate quickly in the event of natural disasters. Similarly, local enterprises and community organizations need mobility to provide products and services to households more effectively. Furthermore, mobility increases peoples' options to fulfill their needs. Therefore, addition of mobility as a cross-cutting service into the *energy services* model is necessary to better understand and address energy poverty.

Given the comprehensiveness of the *energy services* approach, it was adapted with inclusion of mobility, as a conceptual framework for the study of energy access in rural areas of Tajikistan. The focus was set on the category of *energy for* *households* that comprises five sub-categories: lighting, cooking and water heating, space heating, cooling, and information and communications, in addition to mobility. This is because there is a lack of information on energy source and use patterns at the household level. The remaining categories of *energy for earning a living* and *energy for community services* were not covered in this study due to time and resource constraints. Nonetheless, these categories are important, and therefore, recommended for future research.

### *3. Methods*

To assess the level of *energy poverty* is to take account of energy needs such as lighting, cooking, and heating and the extent to which they are met by using such energy sources as grid electricity, firewood, animal dung, etc. This study employed mixed methods, particularly the *sequential design* (Teddlie and Tashakkori, 2009). Initially, qualitative interviews were conducted at a smaller scale to get a sense of energy use patterns. Then, statistical significance of insights emerging from the interviews was tested at a larger scale using a quantitative survey. The study area was in the rural mountain villages of the Khatlon region, Tajikistan (see Figure 18). In this chapter, the results of the survey are reported, because the initial phase of the research consisting of interviews serves as a springboard for a quantitative study.

During this first qualitative phase, villages were selected based on the key criterion of diversity of energy sources used. All communities in this mountainous region use firewood and animal dung for cooking and heating. A majority of households also receive electricity from the national grid for lighting and entertainment (and sometimes cooking and heating as well). However, some communities are not connected to the grid. Among the latter, some use solar home systems or small wind turbines that produce sufficient power for lighting (and sometimes entertainment). These new technologies were provided to these communities by non-governmental organizations (NGOs). As pilot projects, in some communities (regardless of connectivity to the grid), one household was given a biogas digester to use manure gas for cooking purposes. Overall, the range of sources for the sample included firewood, animal dung, electricity, solar and wind power, and biogas.

A *purposive sampling* strategy was used to select villages, where at least one source was used by households. This strategy enabled the study of those households (communities) that use different sources of energy. In a sense, the sample should be representative by capturing the maximum variation between households using different sources.  Expert judgment was key to identifying the range of variation of different sources. Therefore, a partnership was built with a local NGO – the Mountain Societies Development Support Program (MSDSP) – working on energy-related problems in the Khatlon region of Tajikistan.

**Figure 18: Map of Tajikistan showing the research area in Khatlon region**


Source: Nations Online Project (http://www.nationsonline.org/oneworld/map/tajikistan-political-map.htm). Note: Green box indicates the research area.

Six rural communities were selected as study sites in three districts of Khatlon region, namely Baljuvon, Khovaling and Shurobod districts. These villages were selected based on the use of the energy source(s) that each represented within the identified range of the sources (firewood, animal dung, electricity, solar and wind power, and biogas). Next, within each village, households were selected randomly for interviewing from a list obtained from local village authorities. In large villages every fifth household was selected from the list until reaching 30 households. In small villages about half of households (every other) was selected. The random technique was applied to ensure representativeness of different households within villages.

Based on the above criteria, and in consultation with MSDSP that partnered with this research, six villages were selected and a total of 111 households were interviewed.

Semi-structured interviews were used to reveal the energy use patterns of selected households. The interviews were conducted in Tajik language in participants' homes, each taking about one hour to complete, and the information was captured in handwritten notes. In particular, households were asked about the sources of energy (e.g. firewood, animal dung, electricity, solar and wind power, and biogas) they use to satisfy their energy needs (e.g. lighting, cooking, heating and entertainment). The interview guide used in the interviews is provided in Appendix 6. Due to seasonality of differences in energy use, the interviews were conducted in summer of 2013 (warm season) and in winter of 2015 (cold season) with the same households. During the summer season interviews, which constituted the preliminary phase of the research, households were also asked to recall their energy use in the previous winter season. This information was used to formulate questions about energy use during the subsequent phase of the research in winter season. Furthermore, in winter questions were asked about energy use in previous summer. This iterative process allowed for corroborating the responses and assessing the reliability of recall.

The analysis of handwritten notes was carried out in the following way. First, all of the notes were thoroughly read, which revealed a varied narrative about household energy use. Although many households used wood, dung and electricity, the reasons for using these energy resources varied among the interviews. For example, households clearly differentiated between cooking and bread baking, and stated different preferences for energy sources to provide these services. Households used electricity only occasionally for cooking, and never for bread baking. Some used only wood, while others relied predominantly on dung for bread baking. Yet others used a mix of wood and dung for both cooking and bread baking. Unreliability and unaffordability of electricity were mentioned, but most common explanations for using wood or dung had to do with how well these energy sources were suited to cook traditional foods and bake bread. Therefore, the next step in the analysis was to enumerate the instances of such explanations, followed by grouping them into categories that formed the basis for what was later construed as factors of household energy use.

To test the statistical significance of these factors a survey was conducted in the quantitative phase of the research (see Appendix 7). The households sampled for the survey were taken from a study that was conducted by a local NGO – the Mountain Societies Development Support Program (MSDSP) – in 2012 that included the districts of Baljuvon, Khovaling and Shurobod. These districts are representative of the mountain areas in Khatlon region. It should be clarified that the MSDSP study pursued a different objective that was relevant to the organization, and it had no substantive impact on my survey beyond borrowing their design to reach out to the households in the study area.

Households were selected based on the *probability proportionate to size* (PPS) of the population method. This type of *area sampling* is relevant when naturally occurring groups in space can be found, which is the case in the context of Tajikistan.

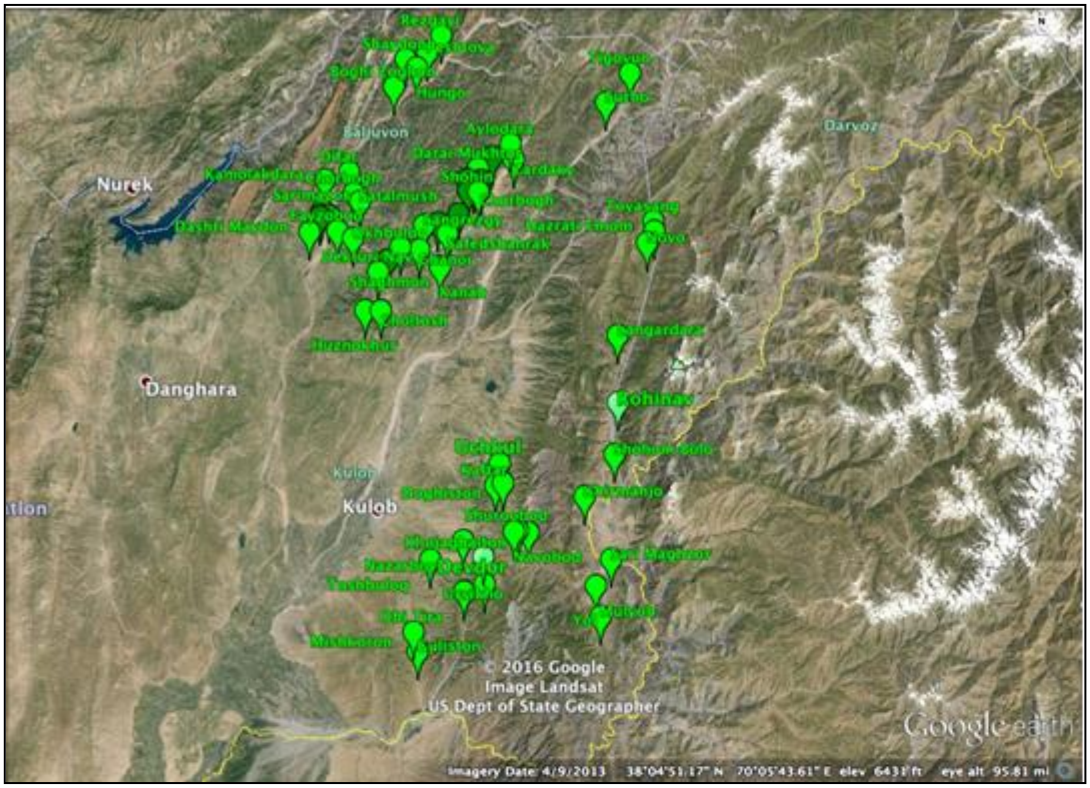
The largest administrative structure is *viloyat* – region or province – of which there are three in the country. The survey was conducted in the southeastern part of Khatlon region. The next level in the administrative structure is *nohiya* – district or county. The districts are geographically distinct in that mountains and valleys are defining features. Settlements along the valley belong to one district that is separated by a mountain ridge from another valley that belongs to another district. Within districts there is *jamoat* – sub-district – that includes a cluster of four to seven and rarely more than ten *deha* or *qishloq* – villages. Proximity is the measure used to group villages under sub-districts for administrative purposes. For the purposes of this survey the sub-district level is omitted because this administrative level can include villages of different sizes, located along different elevation gradients, etc. that confounds rather than clarifies understanding of energy use. Furthermore, it should be noted that village and district are used (not the sub-district) by people in reference to place of origin, and are considered an identity marker. For instance, when asked about where you are from, the response is usually that I am from such district; and if asked for further specification, the name of village is given, but not that of the sub-district.

According to the PPS method, the population for the area of interest is obtained (usually from the government census) for each village. Next, a four-column table is created, in which the first two columns are filled with village names and their respective populations. The third column contains the cumulative population (i.e. adding the population of one village to another going down the list). In the fourth column the clusters for the survey are determined. In this study, 20 clusters were chosen (the range for a large survey is 15 to 30 clusters) for each district.

To find the sampling interval between clusters, the total population is divided by the number of clusters. The first cluster is selected by a randomly generated number that falls between one and the sampling interval. Subsequent clusters are assigned by adding the sampling interval to the previous number cumulatively. In other words, if $x$ is the random number and $k$ is the sampling interval, then $x+k$ shows the location of the second cluster. To this number $k$ is added to locate the third cluster, and so on. In villages with large populations, more than one cluster is selected.

In each of the 20 clusters seven households were selected for a total of 140 households in each district for the study. The total for all three districts was 420 households. However, due to three households dropping out of the study, the counts for districts were 139 households for Baljuvon, 138 for Khovaling and 140 for Shurobod, which were targeted with the survey. During the survey, some households on the list could not be found in the villages. It is likely that some errors might have occurred in the data entry in name of households. Furthermore, some households could not participate because no adult household member was present at the time of the visit. Due to these reasons the number of households surveyed dropped to 124 in Baljuvon, 129 in Khovaling and 133 in Shurobod, comprising 386 households located in 59 villages (Figure 19).

**Figure 19: Map of villages in the survey**




Source: Google Earth. Note: Pins indicate villages in the survey.

The sampling unit was a household that was nested within a village that was in turn nested within a district. Within households a knowledgeable adult person was selected as the lead person to complete the survey on a volunteer basis. An enumerator would read the questions out loud and record the responses on the paper copy of the questionnaire. The survey was conducted in Tajik language in participants' homes and it took about one hour to administer per household. The division of responsibilities for meeting energy needs and other related activities was specifically recognized on the survey. For selected activities that were gender and age differentiated e.g. women and children responsible for wood collection, the related questions were answered by the person responsible for the activity. Therefore, the questionnaire reflected responses from different members of the household. The objective here was not representativeness, but target activity that needed to be captured. This interaction strategy was learned from experience. During the 2013 fieldwork, household members would often be curious and sit around listening to the conversation with the head of the household. In the process the lead interviewee would refer to the members to answer a question or they would volunteer responses, either ahead of the lead interviewee, or afterwards, if they felt information had to be clarified. This mode of interviewing was very useful as it ensured accuracy and validation of responses on the spot.

A team of four enumerators was trained to conduct the survey in winter of 2015. The enumerators had prior experience conducting interviews for other projects; so they had some knowledge of the mechanics of survey research. During the one-day training the enumerators studied the survey questionnaire question by question, with lead researcher providing guidance. Next, they tested the questionnaire by asking each other the questions and recorded the responses. This testing was appropriate because the enumerators lived in the villages in the research area and responded as if their own household was being selected for the survey. Therefore, further modification was made to the questionnaire (see Appendix 7). Beyond the questionnaire, a separate session was devoted to ethical considerations, including treatment of respondents and confidentiality of information. Enumerators' previous experience with interviewing was helpful here as well because they had received similar training in the past. After the training the enumerators drove to the villages in late February 2015 and completed the survey by late March 2015.

Prior to conducting the study, the protocols for the research were reviewed and approved by the Institutional Review Board for Human Participants (IRB) of Cornell University (protocol #1412005226; see Appendices 3 and 4). Furthermore, a letter of support for the research was obtained from the Ministry of Economic Development and Trade, Tajikistan to facilitate access to villages. The enumerators first visited the government administrative offices in the respective districts, presented the letter and obtained permission to conduct the study.

The information collected through the survey was input in a relational database dBASE PLUS (version 2.6.1.5 by dataBASED Intelligence, Inc., 1999-2008). Two statistical software programs, RStudio (version 0.99.467 by RStudio, Inc., 2009-2015) and Microsoft Excel (version 15.04867.1000, part of Microsoft Office Professional Plus 2013), were used to analyze the data. The process of data analysis began with the cleaning of data, during which simple descriptive statistics (e.g. mean, min, max, range) were computed and visual graphics (e.g. histograms) produced for all variables to identify possible typos and other errors. Next, the variables of interest (e.g. household characteristics, energy sources, income, land ownership, etc.) were imported into a new spreadsheet. This spreadsheet then served the basis for exploring the relationships among the key variables. As will be shown in the Results section below, a number of statistical and visual representation tools, including simple and multiple linear and logistic regressions, least square means comparison, boxplot, barchart, histogram, scatterplot, etc. were used to analyze the data, which in turn helped inform the understanding of household energy use. These techniques will be specified in the notes that accompany the visual displays, wherever relevant.

Some limitations of the study should be acknowledged. First, the study was delimited to rural mountain communities of Khatlon region, in the southeast of Tajikistan. These communities are of particular interest due to their diversity of energy use that is in part due to introduction of small-scale renewable technologies, such as solar panels, wind turbines and biogas digesters. Understanding the working of these technologies and their contribution towards meeting households' energy needs will provide key information when reviewing options for energy provision in other mountainous regions in Tajikistan and beyond. However, applicability to lowland areas and urban settings will be limited due to difference in energy needs and resources.

Second, the questions related to cash income were asked after the survey was completed. This is because due to printing errors, this question was unintentionally omitted from the questionnaire. An enumerator collected information on income by calling only those participants who shared their cellphone numbers during the survey; thus, reaching a subset (around 200) of the original participants.

Finally, survey instruments and collected data were translated between English and Tajik. Some loss of nuance is unavoidable despite efforts to ensure quality translation by the lead researcher. Interviews were conducted by the lead researcher who is fluent in both languages; thus, minimizing errors in translation.

### *4. Results*

Rural households in the Khatlon region need energy for different purposes reflected in the service categories depicted in Table 18. They use a range of energy sources to satisfy their needs for lighting, cooking, heating, cooling and information and communication.

**Table 18: Energy services and sources**

| Energy service: | Energy source: | |
|---|---|---|
| | *Most of the time* | *Occasionally* |
| **Lighting** | Electricity | Flashlight, candle, kerosene (lamp) |
| **Cooking, bread baking and water heating** | Wood, straw, dung | Liquefied gas, electricity |
| **Heating** | Wood, straw, dung | Electricity |
| **Cooling** | Electricity | |
| **Information and communication** | Electricity | |

Source: Survey 2015. Note: “most of the time” means participants indicated the source as the main one, whereas “occasionally” means they used it when main source was either unavailable or insufficient at particular times.

The range of energy sources used emanates from the range of livelihoods and households’ diverse locations with respect to energy sources. Livestock rearing gives access to dung, and cultivating crops gives access to plant biomass (e.g. straw). Some farmers also grow fruit and non-fruit bearing trees that can be used as sources of wood. Some live near forests and woodlands that they rely on for their fuelwood. Moreover, some settle in along the banks of rivers that bring driftwood from faraway mountain forests. These biomass sources provide for the thermal needs of households.

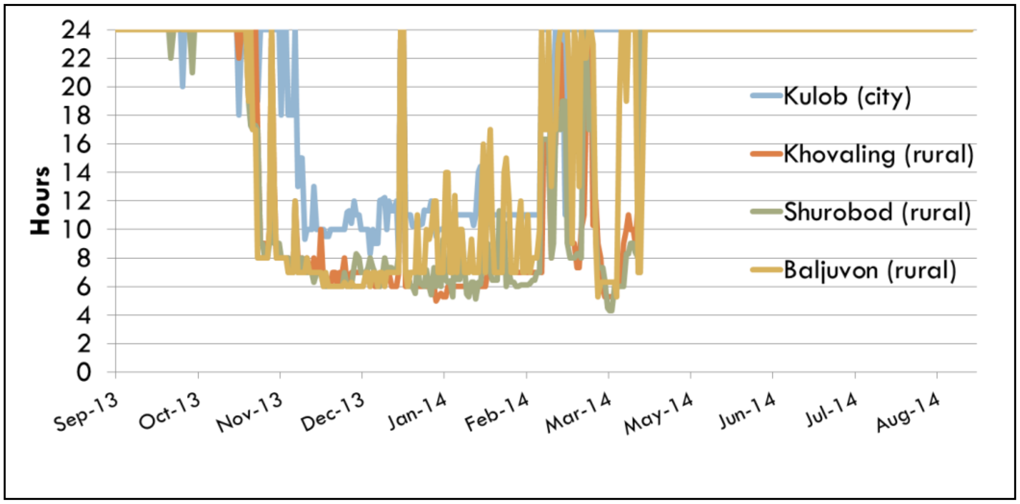
Occasionally, liquefied petroleum gas and electricity are used to cook meals. Electricity is mostly used for lighting. When electricity is not available, households rely on flashlights, candles and kerosene lamps.

### *4.1 Lighting*

Lighting is an important energy service. Having access to lighting means that when natural lighting (daylight) is not available householders can use other sources of light to enjoy their meals, socialize or engage in some productive activity. The lack of lighting makes it difficult to do certain activities after the dark, e.g. when animals need to be fed or milked. Children are engaged in household activities during the day to help their families about the house or in the field. Evening would be the time for them to do their studies. However, if there were no light it would be challenging for children to do any homework.

In the context of Tajikistan, electricity is the main source of energy for lighting, when it is available, through the national electricity grid system. Approximately, 99% of households in the country are reportedly connected to the grid (Swinkels, 2014). However, due to shortage of electricity supply in winter months, load shedding is prevalent in peri-urban and rural areas, with 6 to 8 hours a day of electricity provision divided equally between morning and evening. This pattern is shown in Figure 20 for the three rural districts in the study as well as for the city of Kulob, which is an administrative center for the districts in question.

**Figure 20: Electricity supply from September 1, 2013 to September 1, 2014**

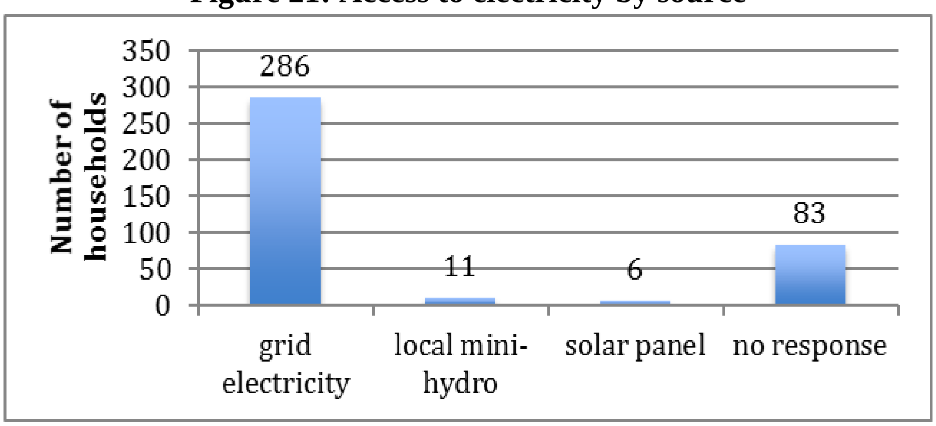



Source: Based on data available at Barknest.tj.

Generally, the supply of electricity was mostly restricted from early November 2013 to late February 2014, but it kept fluctuating until full 24-hour supply was resumed in early April 2014. It should be noted that during this period the winter turned out to be mild, which positively resulted in more hours of electricity provision during March. This is because, on the one hand, warmer weather stimulated increased snow melt in mountain peaks and brought in some rainfall that led to more hydropower production. On the other hand, the need for heating reduced in urban areas (that use electricity); thus, resulting in easing off of electricity rationing to rural areas. The rural districts of Baljuvon, Khovaling, and Shurobod received an average of 7.3, 7.5 and 8.5 hours of electricity per day respectively between November 1 and February 28. By comparison, the city of Kulob received an average of 11 hours during the same period. There is a blip in the middle of the data in Figure 20 that corresponded to December 31 – January 1. This is a one-time full supply of electricity provided throughout the country on the eve and first day of New Year. Only the capital city of Dushanbe received uninterrupted supply of electricity from Barki Tojik company – the sole utility in charge of generation, transmission and distribution of the electricity in most of the country, except Gorno-Badakhshan Autonomous Oblast. This region is serviced by a private provider, the PamirEnergy company.

Most households surveyed in the Khatlon region have access to electricity. As shown in Figure 21, at least 286 or 74% of surveyed households get their electricity for lighting from the national grid; 11 get it from a local mini-hydropower plant, and 6 households have stand-alone solar panels. Although 86 or 22% of households did not respond to this question about access to electricity, they may or may not be connected to the grid; however, it is certain that grid electricity is not their main source of lighting. This finding seems to contradict the 99% electrification rate reported by Swinkels (2014), suggesting more households may not be connected. Nonetheless, it is difficult to establish whether or not the lower connection rate in mountain villages of Khatlon is within the national aggregate statistics. A representative survey at the national level is required to shed further light on this inconsistency.

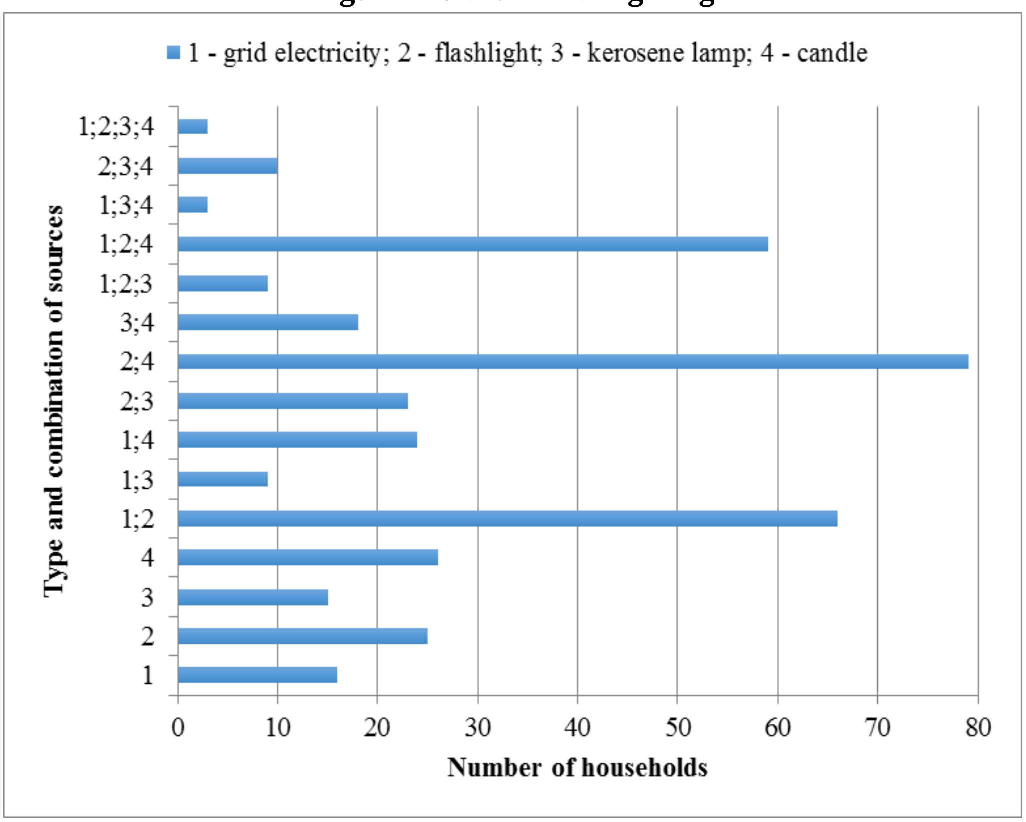
**Figure 21: Access to electricity by source**




Source: Survey 2015.

Households can use multiple sources of lighting (see Figure 22) that serve as back-up options. The highest use is reported for flashlights and candles that are used either alone, or in combination with other devices. The primary reason for using several devices is that households lack reliable access to any single source.  Most commonly, they use an electricity storage mechanism by recharging their electric flashlights when electricity is available. The flashlights also run on dry-cell batteries, which can be used when recharging is not possible because electricity is out for longer periods. Households also use candles as lighting source after flashlights. For those not connected to the main grid and living in remote villages, kerosene lamps and candles remain the primary sources of lighting.

**Figure 22: Sources of lighting**




Source: Survey 2015. Note: The Y axis shows the sources of lighting and their combinations, e.g. 1;2;3;4 means all four sources are used by households in that group.

When asked about sufficiency of lighting, 46% of households stated that their device provides enough lighting, compared to 52% that stated that it does not provide enough lighting. There are many reasons for why households do not have enough lighting. The top three reasons reported are 1) lack of electricity, 2) expensive cost of kerosene and 3) expensive cost of candles. Having more than one source of lighting can enhance sufficiency of lighting up to a point. As shown in Table 19, having two and three sources is positively associated with access to enough lighting (as stated by respondents). To help better understand the trends, raising the coefficients into exponent shows that access to two sources increases the odds of having enough lighting by 1.82 times and three sources – by 3.09 times. Having four sources, however, decreases the odds by a very small margin, albeit the relationship is not statistically significant. The effect of four sources can partly be explained by a small number of households that reported using that many sources (see Figure 22). Another explanation is that not having enough lighting or a reliable source pushes households to seek out more different sources.

**Table 19: Sufficiency of lighting by number of sources**

| | Estimate | Std. Error | z value | Pr(>\|z\|) |
|---|---|---|---|---|
| **(Intercept)** | -0.6931 | 0.2357 | -2.941 | 0.003274 ** |
| **Two sources** | 0.6013 | 0.2719 | 2.211 | 0.027007 * |
| **Three sources** | 1.1304 | 0.3296 | 3.429 | 0.000605 *** |
| **Four sources** | -13.8729 | 624.1939 | -0.022 | 0.982268 |

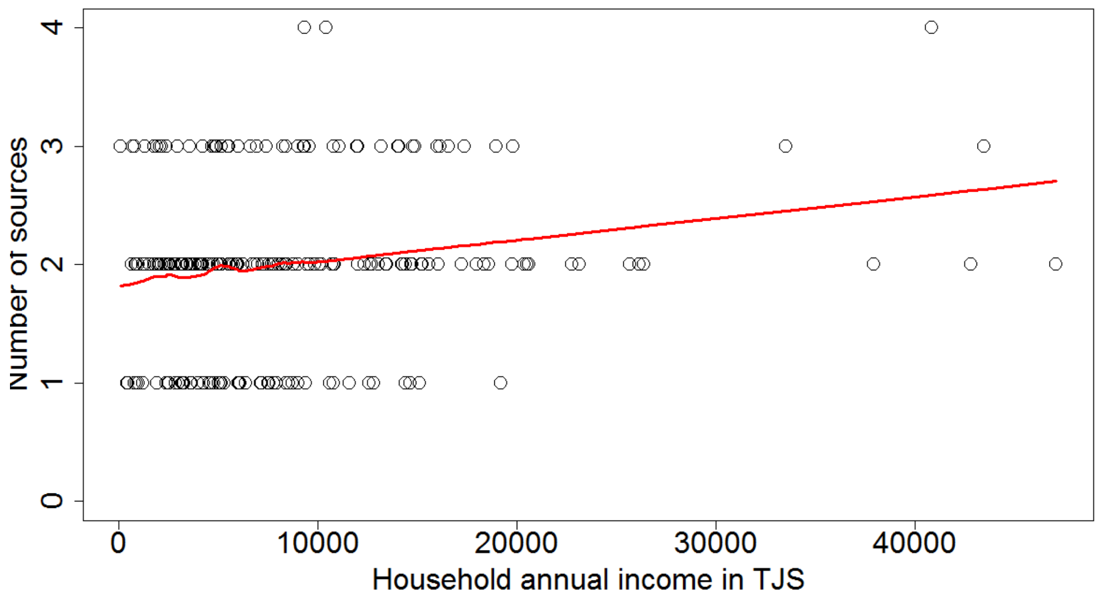
Source: Survey 2015. Note: Logit regression between access to sufficient lighting (1 or 0) and the number of lighting sources. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

Associated with the absence of lighting (and electricity), the respondents shared that they cannot engage in three types of activities: watching TV/movies, studying, and reading books or newspapers. When asked what they would do if they had enough lighting, the majority of respondents said they would complete some household work. This suggests that householders understand the productive use of lighting, and that they would take advantage of it if it became available. They would also continue using electricity for watching TV/movies as well as children's studying and reading books.

Household income may have an influence on energy use patterns. In the survey, it is measured in two ways. For the members who reported a cash earning activity, including a salary or some business activity, they were asked to provide the best estimate of their earning for a month. In cases where irregular income was reported the monthly estimate was normalized (averaged out for the number of months income was earned). This estimate was then converted to annual income, taking into account the number of months the income was earned (particularly for irregular sources of income). For those engaged in agricultural activity, they were asked to provide an estimate of how much cash they earned by selling their farming produce, including fruits, dairy products, eggs, honey, etc. These estimates were reported for a year. The two estimates of income from salary/business and agricultural activity were then combined to represent household's annual cash income from all sources.

Comparing households along the income gradient, as shown in Figure 23, two observations can be made. One is that use of multiple energy sources is weakly related to household income. The slope of the line is positive, which means that more sources are associated with greater income, although many low income households also use multiple sources. The second observation is that below 20,000 TJS[9] per year income (equivalent of $2,545), households can be expected to be using one or more sources of lighting. Taken together, these observations indicate that in rural areas of the Khatlon region there is a diversity of access options to lighting, and it is not necessarily driven by economic wellbeing of households. Given that electricity is highly unreliable, all households essentially resort to using multiple sources of lighting. Therefore, switching entirely to using electricity would require a reliable supply.

**Figure 23: Relationship between income and sources of lighting**

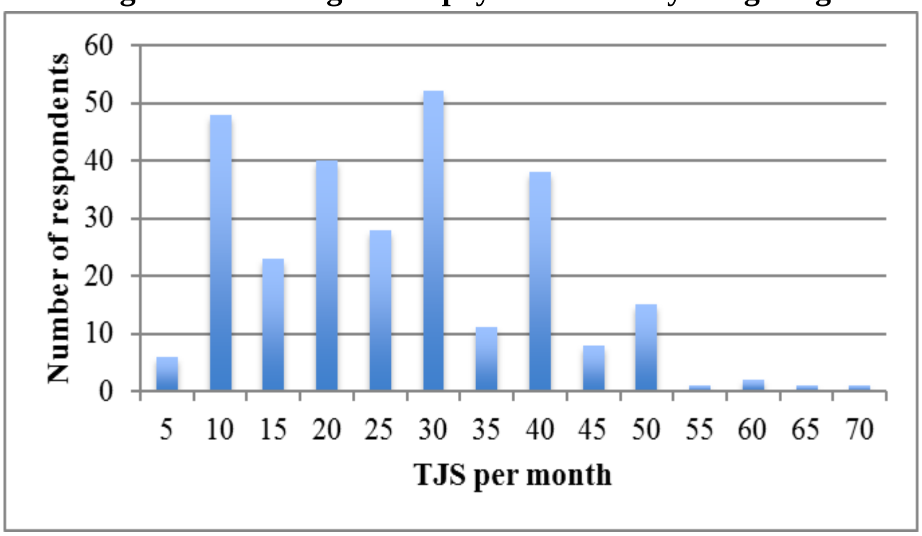



Source: Survey 2015. Note: Red line is produced using supersmoother ("supsmu" function in R), which runs numerous simple local (nearest neighbors) linear regressions at each x point to determine the best y value at that point. It is useful to showing trends in complex data.

[9] TJS – is an international code for currency of Tajikistan called *somoni.* 1USD = 7.86TJS on June 6, 2016 according to the National Bank of Tajikistan (http://www.nbt.tj/en/kurs/kurs.php)

Householders value lighting and they are willing to pay for electricity that is reliable. As Figure 24 shows, a wide range of willingness to pay for lighting was reported from under 5 to 70 TJS ($0.6 to $8.9) per month with a mean of 25.9 TJS ($3.3). About 90% of them are willing to pay from 5 to 40 TJS ($0.6 to $5.1). These numbers appear quite large for only lighting. It is likely that the respondents conveyed their overall willingness to pay for electricity in general, rather than only for lighting. For other services including cooking and heating respondents also reported a range of willingness to pay, which is discussed in the respective sections below.

**Figure 24: Willingness to pay for electricity of lighting**




Source: Survey 2015.

### *4.2 Cooking, bread baking and water heating*

Cooking is an indispensable energy service. Most of the foods that are consumed on a daily basis – also known as staple foods – require some kind of preparation that involves energy use. According to the Food and Agriculture Association (FAO, n.d.), "of more than 50,000 edible plant species in the world, only a few hundred contribute significantly to food supplies, [but] just 15 crop plants provide 90 percent of the world's food energy intake, with three – rice, maize and wheat – making up two-thirds of this [that are] the staples of over 4,000 million people". Although some of these staples are edible in the raw form, most are consumed after having been cooked by boiling, steaming, stewing, smoking, roasting, frying, grilling, baking and other cooking techniques that require energy.

In the context of Tajikistan, wheat in the form of bread and bakery products is the main staple followed by meat products. A recent study of household expenditure shows that Tajik households allocate about two-thirds of their spending on food consumption (Asadov, 2013). Of this estimate, over 35% is taken up by bread and bakery products, and about 15% by meat and meat products. In other words, at least half of food expenditure falls on the staples that require some form of preparation involving energy use prior to consumption. Therefore, access to cooking fuels and facilities is a very important survival need.

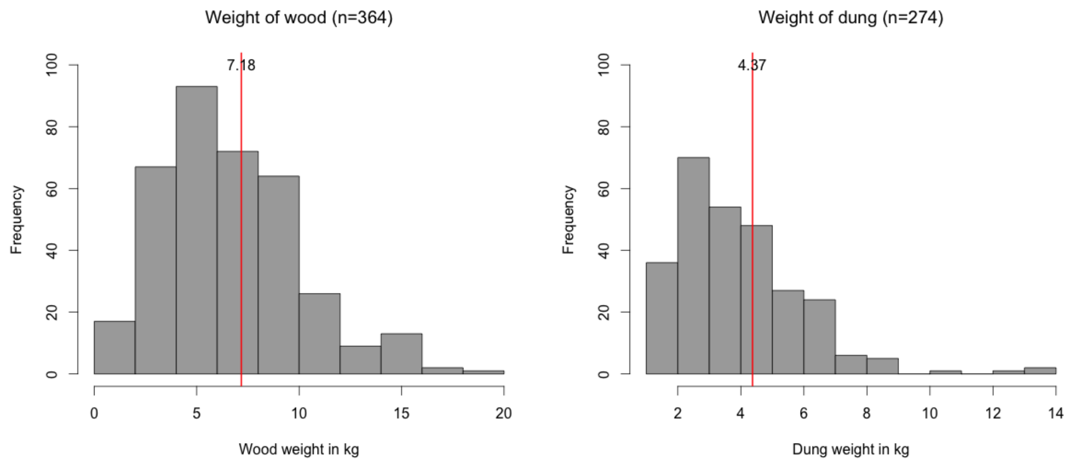
Households in Tajikistan use a variety of energy sources to satisfy their cooking needs. A recent World Bank study reports that in urban and rural areas electricity is the main source for cooking, along with gas and wood (Swinkels, 2014). However, electricity is not always available, especially for rural households during the winter months. Therefore, households turn to other alternatives such as liquefied petroleum gas, coal, wood, dung and cotton stalks to prepare food. Gas stoves are used occasionally when speed in cooking is of essence, particularly when guests are visiting. For regular cooking, the use of coal, wood, dung and cotton stalks is more prevalent. During the winter months, these fuels simultaneously provide for heating service as well. It should be noted that, throughout the year, bread is baked in traditional *tanoor* (vertical clay oven), usually outside or in a separate room, using wood and/or dung depending on availability of the source and preference of households. Not only the technique and energy sources used to bake bread but also the cultural significance of bread (discussed in greater detail in Chapter 3) necessitate that energy use for bread baking is discussed separately from cooking in this section. Similarly, water heating is a distinct activity from cooking because it is used for washing dishes and clothes, and bathing. Hence, it has been set apart in a separate analysis as well. Since few households reported using electricity for cooking, and even then only occasionally, it will not be discussed in this section.

According to field observations and interviews with households, access to energy sources for cooking is variable in the study area of the Khatlon region. Woody biomass used as firewood includes stems, branches and twigs of local trees and shrubs that are sourced from forests, fields, hills and riversides by households, and also bought at local markets or from neighbors. Straw is also used, albeit in insignificant quantities, and its primary function is to start the fire. Therefore, it is not included in the survey reports. Dung is freely available for households with livestock, but it can also be purchased in moist form from neighbors and pressed into manageable units and dried in the sun.

The survey participants reported their wood use according to local units of ‘bundle’, ‘embrace’, ‘tray’ and ‘log’. A bundle means a pile of branches tied together that has a cylinder shape. By embrace, participants describe the amount of wood they can fit in their arms. A tray is a round shape container in which wood is piled. A log is a wood stem after it is culled. Dung was reported in local units of ‘cake’ and ‘tray’. A cake is made of manure in round shape and dried in open air. Similar to wood, the same type of tray is used to pile dung in it. Along with local units a standard metric of kilograms (kg) was also recorded. This was achieved through measuring the reported amount (e.g. one bundle) of wood and dung (e.g. one cake) using a hand-scale. Note that the same method was used for measuring wood and dung for space (home) heating purposes.

Out of 386 survey participants, 364 or 95% provided information about the amount of woody biomass, and 274 or 71% reported the amount of animal dung they use for cooking. This illustrates that most households use a combination of wood and dung, while some rely on wood only. On average, about 7.2 kg of wood is used daily for cooking purpose. The range, however, is between 0.5 kg and 20 kg per day (see left panel on Figure 25). As for dung, an average of about 4.4 kg is used daily for cooking purposes, although the range is between 1 kg and 14 kg per day (see right panel on Figure 25).

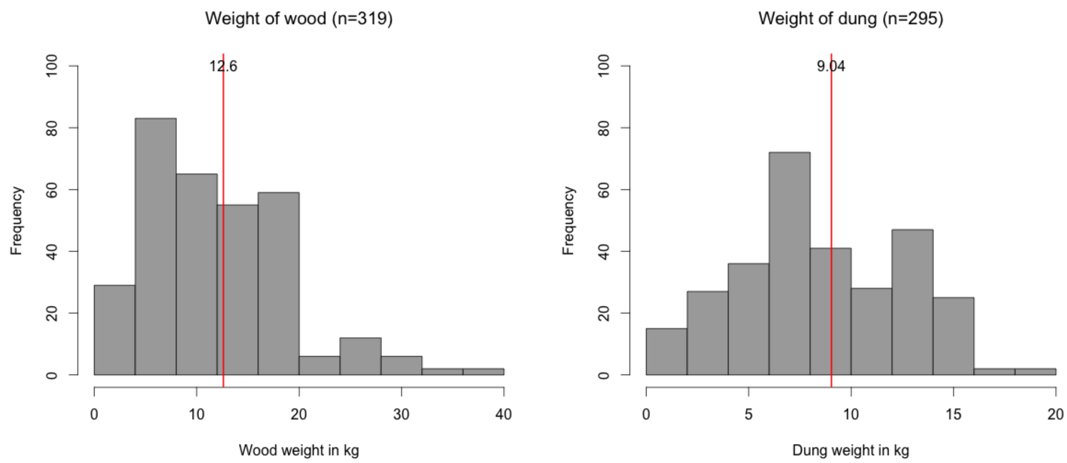
**Figure 25: Weight of wood and dung (in kg) used for cooking**




Source: Survey 2015.

Out of 386 survey participants, 319 or 83% reported the amount of woody biomass, and 295 or 76% stated the amount of animal dung they use for bread baking, illustrating that most use both wood and dung, and only a few households appear to rely on wood only for baking bread. On average, about 12.6 kg of wood is used during one bread baking session, although some households use as little as 0.4 kg. Some use a staggering 40 kg per session (see left panel on Figure 26). In one session between 5 and 40 round flatbreads are baked depending on the needs of a household, which explains the variability in energy use. As for dung, an average of about 9 kg is used during a bread baking session. The range is between 0.5 kg and 20 kg per day (see right panel on Figure 26). Compared to cooking, the average amount of wood and dung (in kg) appears almost twice as much. However, this comparison is not accurate because the temporal units are different: the amount for cooking is per day, whereas that for bread baking is per one session. In other words, the former indicates the total amount used for everyday cooking while the latter takes place only two to three times per week. Thus, on a weekly basis the amount for cooking is greater than that for bread baking.

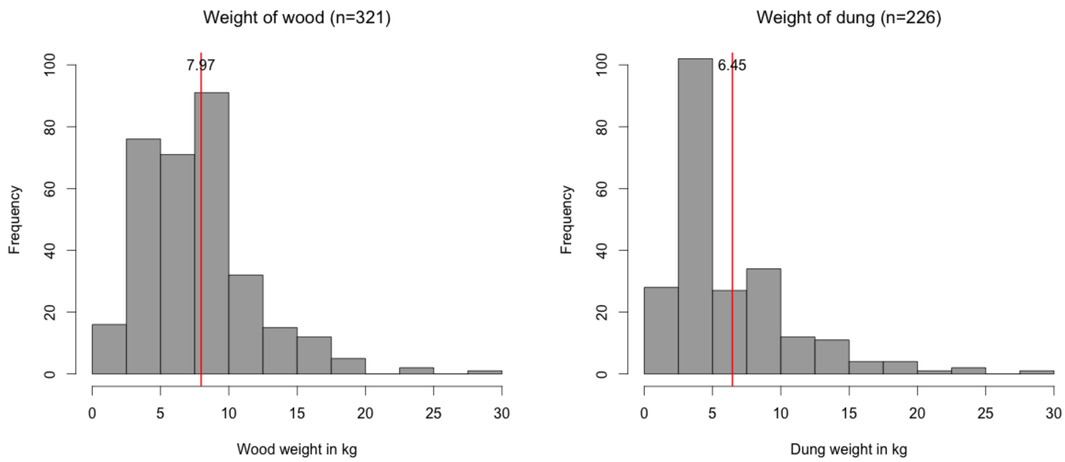
**Figure 26: Weight of wood and dung (in kg) used for bread baking**




Source: Survey 2015.

For water heating to make tea, as well as to bathe, wash dishes and clothes, out of 386 survey participants, 321 or 83% provided information about the amount of woody biomass, and 226 or 59% reported on the amount of animal dung. On average, about 8 kg of wood is used for daily water heating, although some households use as little as 0.5 kg whereas some use as much as 30 kg per day (see left panel on Figure 27). As for dung, an average of about 6.5 kg of dung is used per day for water heating. The mean falls within the range of 1 kg and 28 kg per day (see right panel on Figure 27). It should be noted that the amounts of wood and dung for water heating are comparable to the same for cooking. Both amounts are on a daily basis.

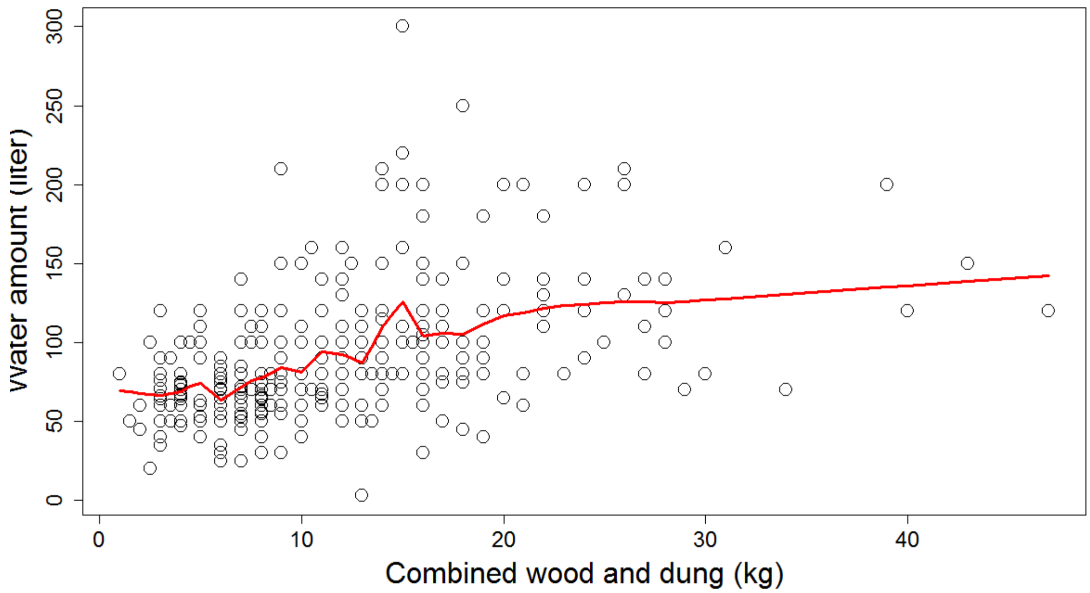
**Figure 27: Weight of wood and dung (in kg) used for water heating**




Source: Survey 2015.

In addition to the amount of fuel used to heat water, the survey participants were asked to indicate the amount of hot water. Households reported using from as little as 3 liters to as much as 300 liters of hot water per day to do their bathing, washing dishes and clothes as well as making tea. Most of the observations, however, fall within 50 to 150 liters. On average a household uses about 92 liters of hot water per day. There is no clear pattern emerging from the relationship between the amount of hot water and fuel used to heat water (see Figure 28). Nonetheless, the upward leaning trendline suggests that heating more amount of water would require more fuel.

**Figure 28: Relation between amount of hot water (liters) and fuel (kg)**

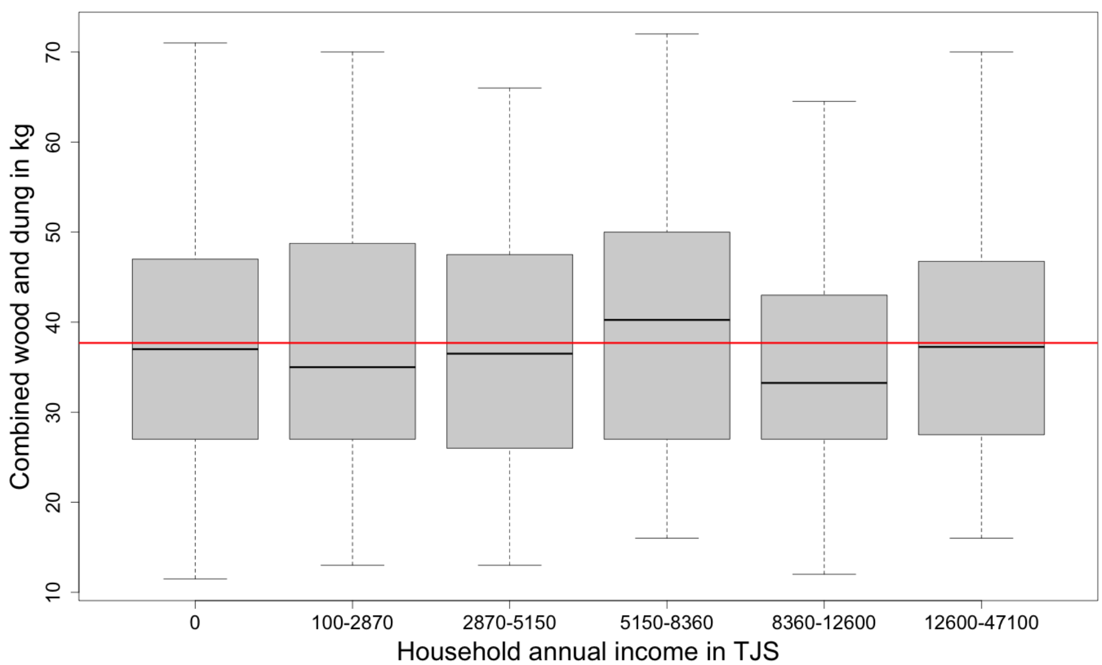



Source: Survey 2015. Note: Red line is supersmoother ("supsmu" in R).

Comparison of wood and dung use by income quintiles shows no stark differences among groups as depicted in Figure 29. The pairwise comparison of means using Tukey method with Bonferroni correction did not show statistically significant differences among groups either. Regardless of how much they earn households use the same amount of biomass for cooking, bread baking and water heating combined. The daily average is about 38 kg, which falls within a range of 11.5 kg and 72 kg. This is to suggest that it is unlikely that with increase in income less wood/dung use can be expected. The inverse relationship between biomass and income, as determined by the *energy ladder* model, does not appear to hold in case of rural communities in the Khatlon region. Had the better off households moved up the ladder, they would have used less biomass, which the data does not support. It is, therefore, reasonable to infer that households are deliberately choosing use biomass. As will be demonstrated in

Chapter 3, there are in fact compelling reasons for how households use different energy sources to satisfy their diverse needs. Nonetheless, another possible explanation for the range of energy use for cooking is that there is only so much wood and dung that can be used to cook a day’s meal for a family. Using more is unreasonable because the necessary temperature for cooking can be achieved by burning a certain amount of wood or dung. The same logic holds to baking bread and doing the washing.

**Figure 29: Relation between cooking fuel in (kg) and income (in TJS)**

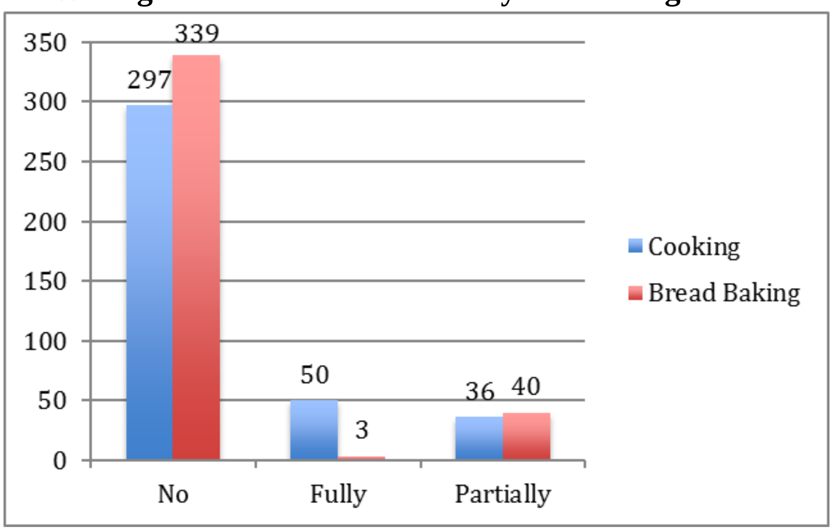



Source: Survey 2015. Note: 0 represents 106 households that reported no cash income. The rest of groups are 56 households each per quintile. Red line shows the overall mean.

Going beyond existing conditions, households were asked whether or not they would switch to using electricity if it were reliably provided all year round. Furthermore, they were asked what motivated their choice. Both questions were asked for cooking as well as bread baking.

As depicted in Figure 30, majority of households (297 out of 383 or 78% of respondents) would rather not switch to using electricity for cooking even it becomes available 24 hours a day. Among those who were willing to switch, 50 (13%) households would give up biomass use completely, whereas 36 (9%) would make only a partial shift. As for bread baking, even a larger majority (339 out of 382 or 89% of respondents) would not make the switch from biomass to electricity. Forty households would like to switch partially, while only three were willing to give up biomass completely.

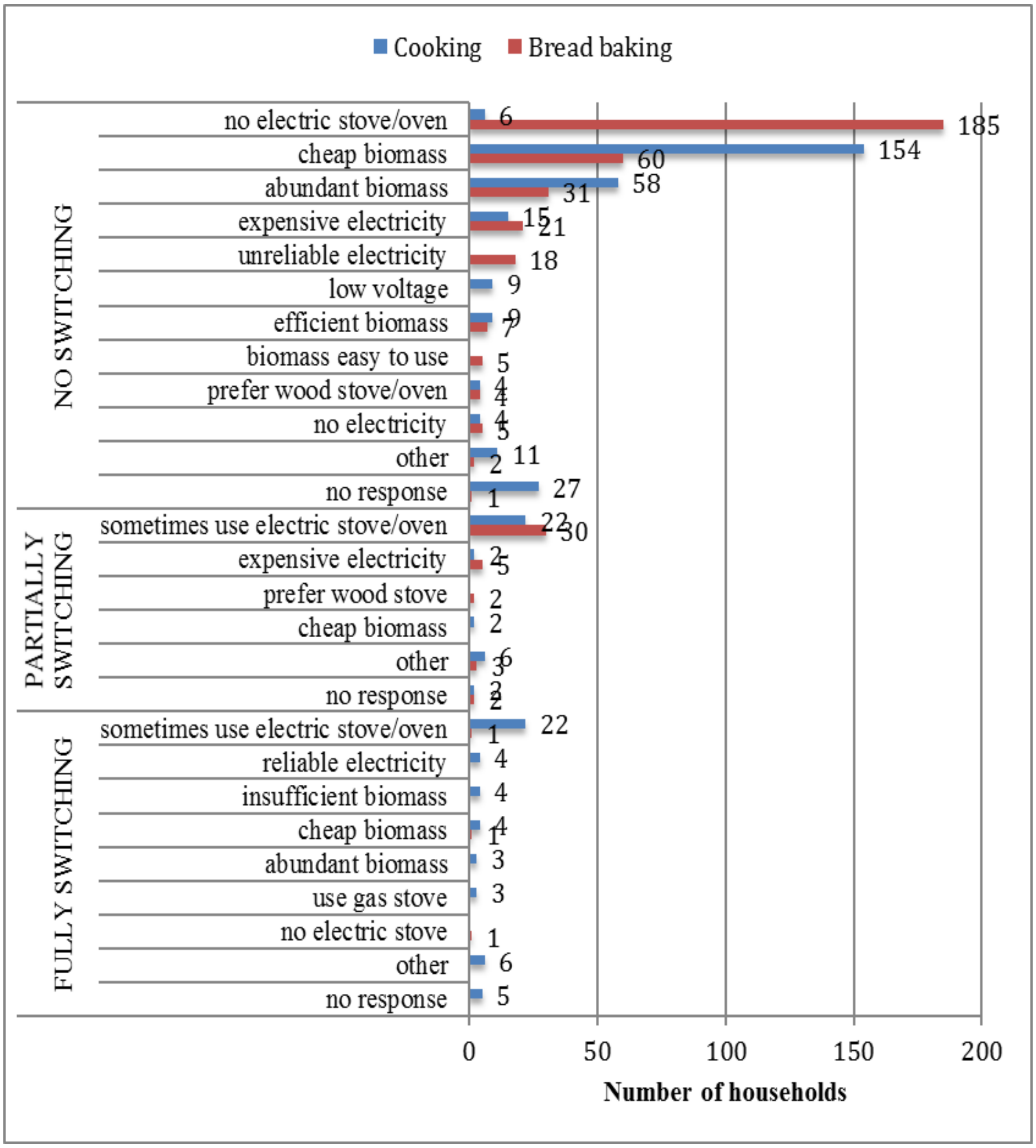
**Figure 30: Willingness to switch to electricity for cooking and bread baking**




Source: Survey 2015.

There are many reasons for whether or not households are willing to switch to using electricity for either cooking or bread baking. As Figure 31 shows, three major reasons for not switching to electricity for cooking are: having access to cheap biomass, abundant biomass, and finding electricity expensive. For bread baking, in addition to these three reasons, lack of an electric oven and unreliability of electricity supply were identified as major obstacles to making a switch. Those who are willing to partially switch indicated they would use an electric stove for cooking or electric oven for bread baking only part of the time – the other part they would like to continue using a wood stove or oven respectively.  The reasons for switching fully to using electricity for cooking appear somewhat contradictory. Similar to partially switching, households in the full switching category also noted partial use of electric stoves as a main reason. This unexpected response could be due to households actually willing to switch partially rather than fully. More fundamentally, it hints at their desire to maintain access to diverse options, which is rooted in their experience of having variable access to electricity in the past. They know that such diversity makes them more resilient in face of changes. Moreover, access to cheap and abundant biomass was also listed as reasons for making a full switch to electricity – although the number of households listing these reasons is very small. It can be surmised from these responses that households do not consider realistic enough a scenario where electricity is indeed provided reliably. Even if electricity becomes reliable, they would like to maintain access to their existing sources of biomass energy, at least as a backup option. Overall, these findings convey that cost and reliability are important considerations but so are diversity of options in household energy use in rural areas of the Khatlon region.

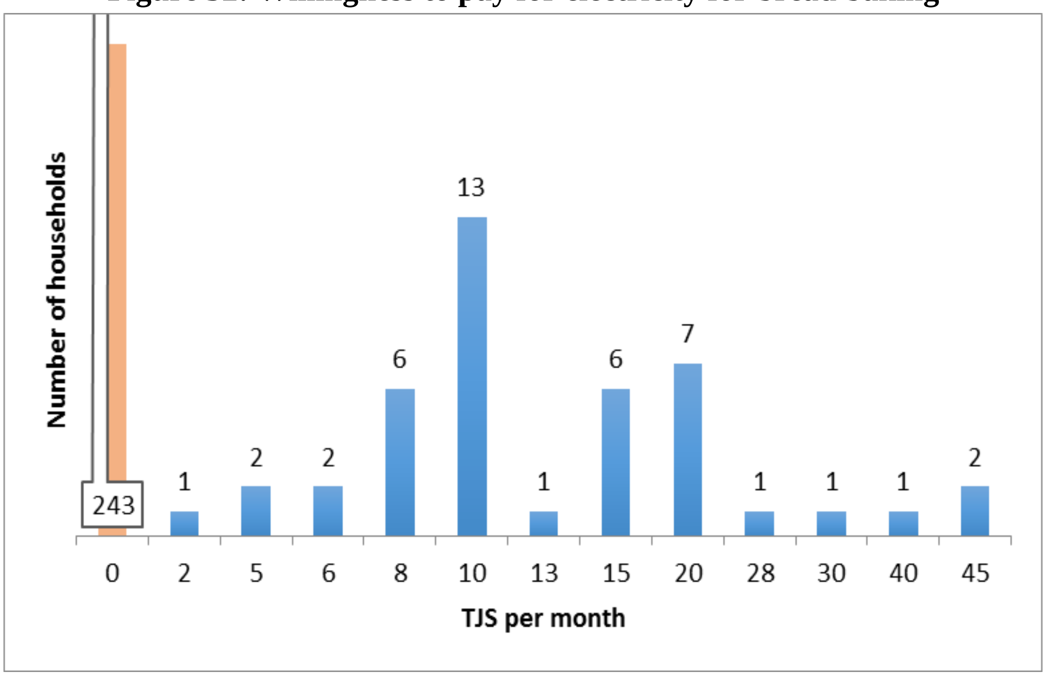
**Figure 31: Reasons for switching and not switching to electricity for cooking and bread baking**




Source: Survey 2015. Note: The left panel groups the responses under three scenarios, listing the reported reasons by order of frequency.

Regardless of their switching choices, households were asked to indicate their willingness to pay for electricity to do their cooking and bread baking, assuming electricity provision would become reliable. This question was asked of those households that were connected to the electricity grid. No household reported any willingness to pay for electricity for cooking. As for bread baking with electricity, only 43 out of 286 or 15% of households get their lighting from electricity (see Figure 21 in section on Lighting) indicated their willingness to pay. For this subset of the survey participants, the range of their willingness to pay is between 2 TJS and 45 TJS with a mode of 10 TJS (mean=14.7 TJS) per month (see Figure 32). Notably, 8 TJS, 15 TJS and 20 TJS are reported by at least 6 households each. Given the lack of response for cooking and low response rate for bread baking, overall willingness to pay for electricity for these services is expected to be very low. This suggestion is reasonable especially in light of the low willingness to switch to using electricity discussed above.

**Figure 32: Willingness to pay for electricity for bread baking**




Source: Survey 2015. Note: 243 participants reported no willingness to pay, shown in orange bar on the left (clipped to allow display of other bars).

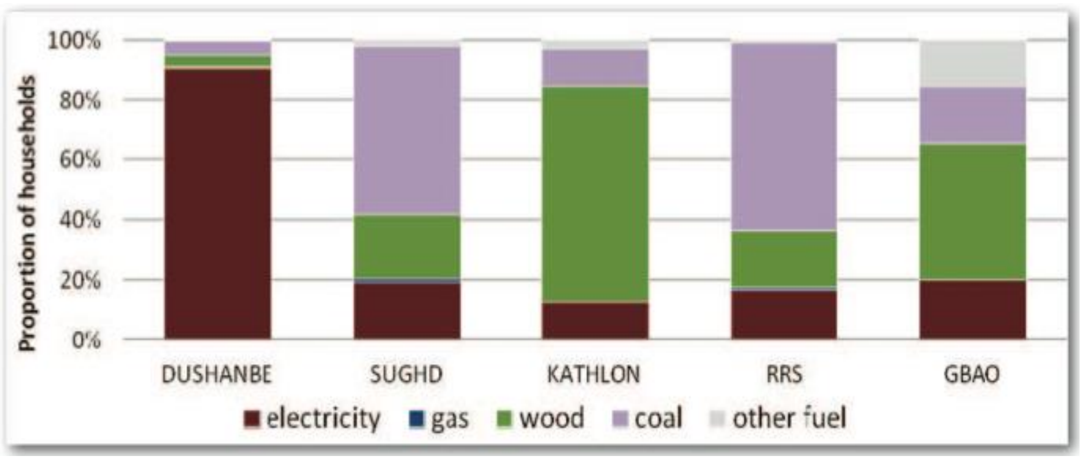
## *4.3 Space heating*

In 2009 the International Energy Agency (IEA) reported that heat constituted 47% of total final energy consumption worldwide, which is substantially larger than the share of transport (27%), electricity (17%), and non-energy use (9%) (Beerepoot & Marmion, 2012). Most of this heat consumption materializes in the industrial (44%) and residential (42%) sectors. This substantial share of the residential sector confirms that access to heating service is very important for people’s comfort and wellbeing.

In the context of Tajikistan, the use of heating differs by energy source, type of dwelling, location, and wealth category (Swinkels, 2014). Urban residents living in apartments rely on electricity, whereas other city dwellers living in private houses use electricity, coal and wood almost in equal proportions to heat their homes. Rural households mostly use coal, wood or dung to satisfy their heating needs.

Such heating source differentiation is primarily due to the availability of energy sources with respect to the location of houses. Apartment dwellers in cities and towns have access only to electricity and therefore, use electric heaters. Centralized heating systems are either no longer supplying heat to households, or they service only a handful of households due to extremely low generation capacity. Moreover, installation of biomass burning stoves is not practical in apartment buildings. Urban house residents have installed metal stoves that burn solid fuels. In general, such stoves are preferred over electric heaters because they provide better heating for larger rooms in private houses. Nevertheless, access to wood, dung or cotton stalks is limited in urban areas; therefore, households mostly rely on electric heaters. Rural residents, on the contrary, do have access to solid fuels that they obtain from their environment or as bi-products of their agricultural activity. All residents procure coal from market through a network of entrepreneurs. The use of coal is more prevalent in the northern Sughd region where coal is relatively cheaper due to imports from neighboring Kyrgyzstan. It is also prevalent in Districts of Republican Subordination[10] in the northeast, where coal is produced locally. In the southern Khatlon region and eastern region of GBAO, however, firewood is mostly used for heating. A breakdown of major heating sources by region is displayed in Figure 33.

**Figure 33: Major heating sources by region (proportion of households)**



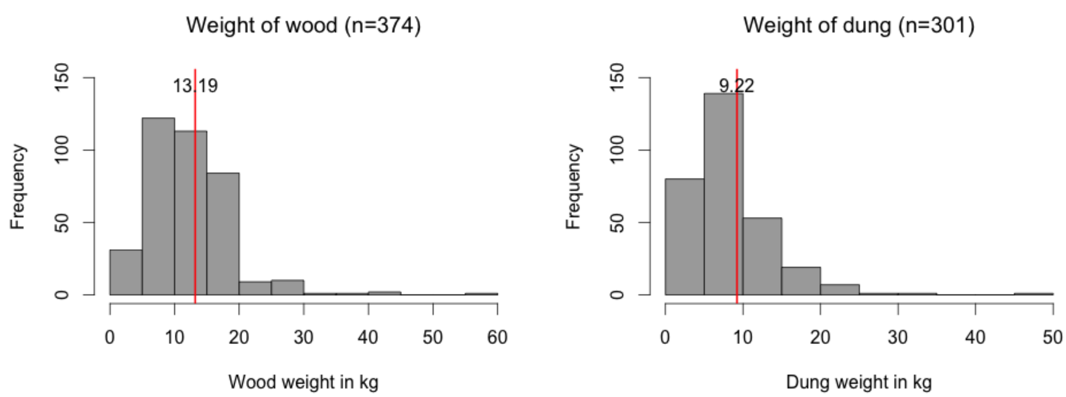

Source: Swinkels (2014).

In the rural areas of Khatlon region, households use wood and dung, as these energy resources are more accessible than other energy sources. No household among those surveyed reported using electricity for heating. Out of 386 survey participants 374 or 97% reported the amount of woody biomass and 301 or 78% indicated the amount of animal dung they use for heating their homes. On average, about 13.2 kg of

[10] This is an administrative grouping of 13 districts that lie among Sughd, Khatlon and GBAO regions. Also known in Russian language as RRP – Rayony Respublikanskogo Podchineniya.

wood is used for daily heating, although some households use as little as 0.7 kg whereas some use a staggering 60 kg per day (see left panel on Figure 34). As for dung, an average of about 9.2 kg is used per day, within a range of 2 kg and 50 kg per day (see right panel on Figure 34). The larger quantities used are due to the need to heat more space (more rooms), poor insulation of houses (resulting in substantial heat loss) and/or severe cold weather.

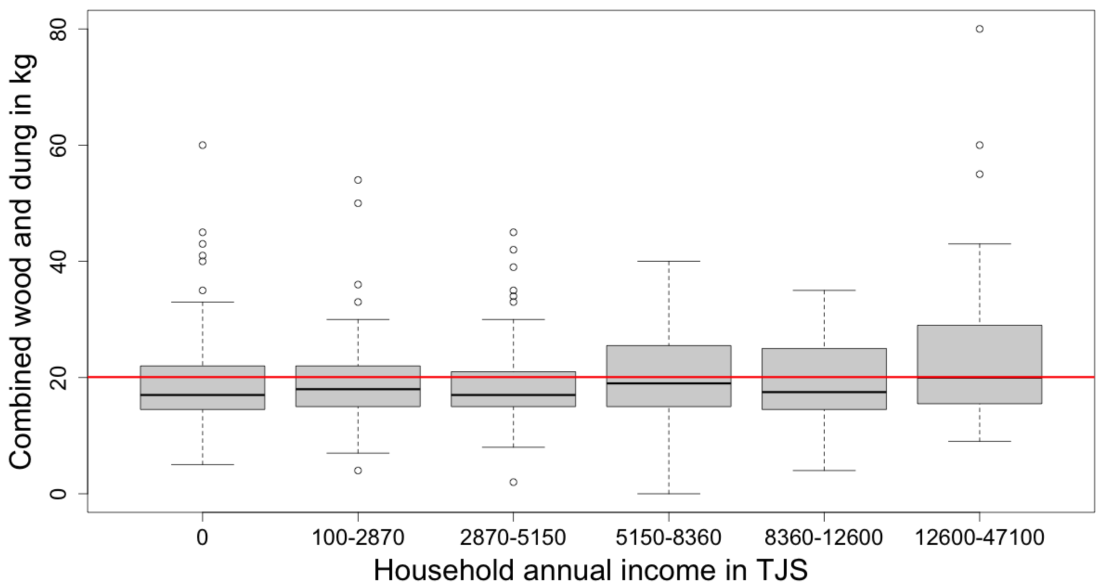
**Figure 34: Weight of wood and dung (in kg) used for space heating**




Source: Survey 2015.

Similar to cooking, bread baking and water heating, daily use of wood and dung for space heating does not differ significantly among income groups (pairwise comparison of means using Tukey method with Bonferroni correction; also see Figure 35). Similar to the finding in the previous section on cooking, all households use the same amount of biomass for heating regardless of how much they earn, and therefore, the inverse relationship between biomass and income, as determined by the *energy ladder* model, is not supported here either. Household rely on wood and dung because these resources are readily available, but also they feel that the warmth provided is qualitatively better than that gained from using electric heaters. During the interviews many households expressed that electric heaters dehydrate the rooms and cause headache. Furthermore, similar ranges in biomass amount used by different groups in the quintiles points to another possible reason that there is only so much wood and dung that is needed to heat a home. Spending more on biomass beyond that point would be unreasonable. Rather, households would allocate their money to other priorities such as food, clothes, etc.

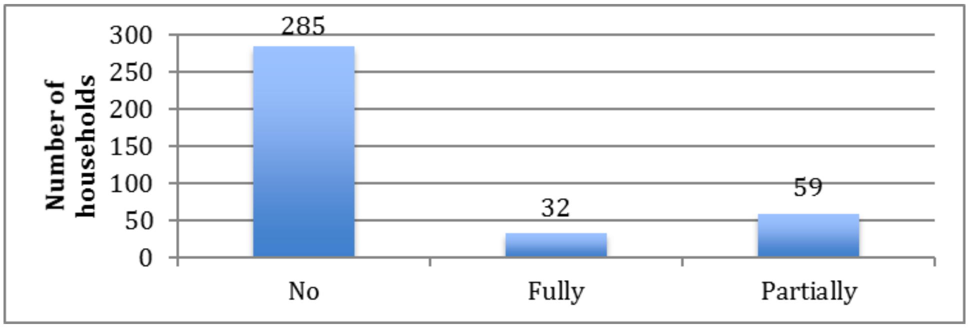
**Figure 35: Relation between heating fuel in (kg) and income (in TJS)**




Source: Survey 2015. Note: 0 represents 106 households that reported no cash income. The rest of groups are 56 households each per quintile. Red line shows the overall mean.

As with cooking and bread baking, households were asked whether and why they would switch to using electricity if it were reliably provided all year round. Similar to cooking and bread baking, the large majority of households (285 out of 376 or 76% of respondents) would rather not switch to using electricity for space heating (see Figure 36). Among those who are willing to switch, 32 (35%) households would stop using biomass completely, whereas 59 (65%) would make only a partial shift.

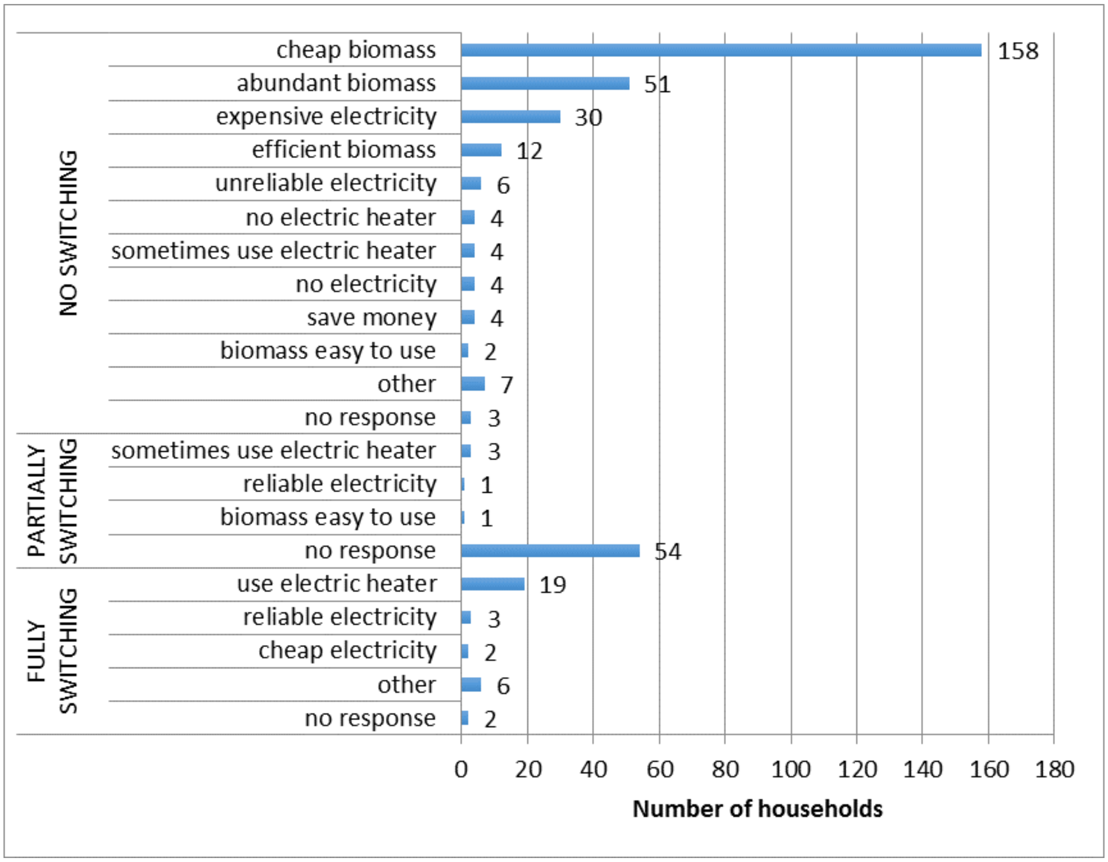
**Figure 36: Willingness to switch to electricity for space heating**




Source: Survey 2015.

Households shared several reasons for whether or not they were willing to switch to using electricity for space heating. Similar to cooking and bread baking, three main reasons include having access to cheap biomass, abundant biomass, and finding electricity expensive (see Figure 37). Another reason indicated is efficiency of biomass – meaning that households perceive biomass to give out more heat than electricity. In other words, less amount of biomass would heat a home compared to plugging in several electric heaters. This could be due to low quality electric heaters, but it is people's perception of better heating provided by woodstoves that matters most regarding their energy choice rather than abstract comparisons of kilowatt hours or joules. Moreover, according to household interviews, efficiency also implies cost savings in that using electricity for heating would be more expensive. Of those willing to partially switch, a majority did not indicate a reason. The main reason for switching fully is the use of electric heaters. In other words, households would like to be able to use electric heaters instead of their wood stoves to heat their homes. During the interviews, households conveyed that ash and soot are nuisances that they would like to avoid through cleaner heating provided by electricity. Once again, these findings underscore the role of cost and reliability as well as quality in household energy use in rural areas of the Khatlon region.

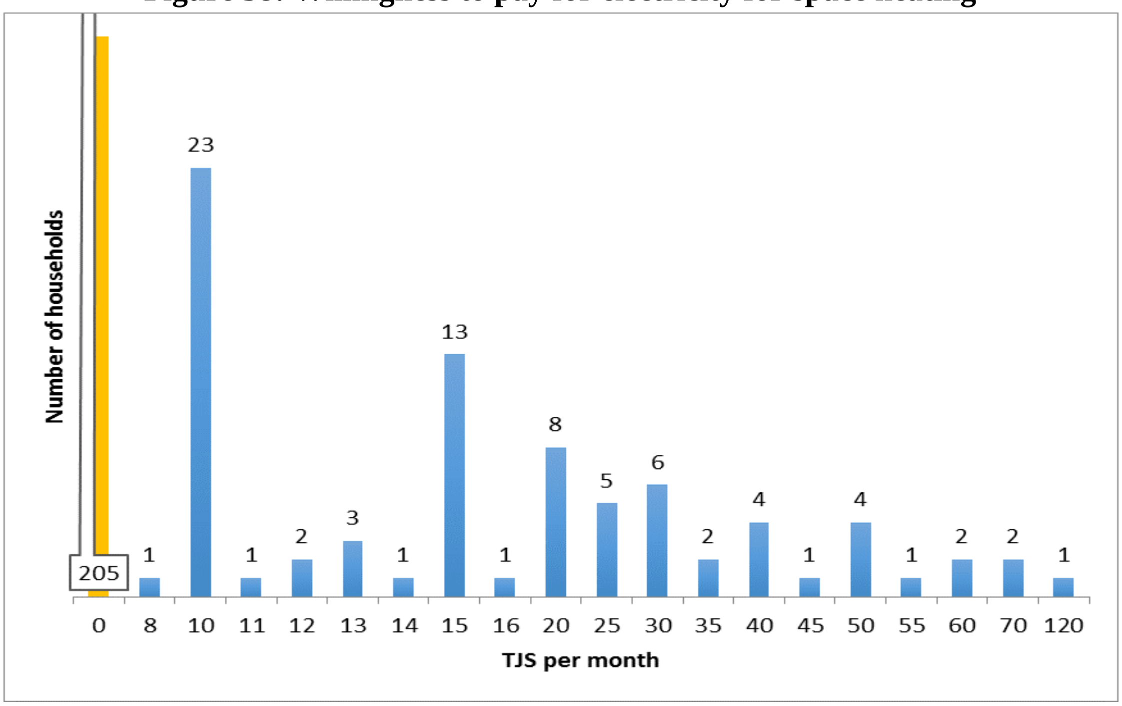
**Figure 37: Reasons for switching and not switching to electricity for space heating**




Source: Survey 2015. Note: The left panel groups the responses under three scenarios, listing the reported reasons by order of frequency.

Households were asked, assuming electricity provision would become reliable, how much they would be willing to pay for electricity to heat their homes. This question was asked of those households that were connected to the electricity grid. Compared to bread baking, almost twice as many households (81 vs. 43) responded, but the number still remains low (28%) out of 286 households that get their lighting from electricity (see Figure 21 in section on Lighting). The range is between 8 TJS and 120 TJS with a mode of 10 TJS (mean=4.26 TJS) per month (see Figure 38). It is interesting to note that the mode is exactly the same as with bread baking, and 15 TJS and 20 TJS were reported by more than six households in each case. Notably, there are more households willing to pay larger amounts. This makes sense, as home heating requires more electricity; thus, translating into larger bills, which households understand and are willing to pay. Nonetheless, these numbers should be treated cautiously given the low response rate. It is prudent to estimate the overall willingness to pay for electricity for heating as very low, particularly in light of the low willingness to switch to using electricity discussed above.

**Figure 38: Willingness to pay for electricity for space heating**




Source: Survey 2015. Note: 205 participants reported no willingness to pay, shown in orange bar on the left (clipped to allow display of other bars).

### *4.4 Comparison of biomass use for thermal energy services*

Comparison of the amounts of wood and dung used to satisfy all thermal energy services, including cooking, bread baking, water heating and space heating, provides further perspectives in energy use in rural areas of the Khatlon region (see Table 20). Firstly, the minimum amounts are very close among all services, and they are also very low. However, combined biomass (wood plus dung) at the minimum shows that daily use is at least 16 kg. Households may be using the same stove to satisfy most of the services; thus, achieving a greater efficiency in biomass use. Another explanation is that households may actually be using electricity for some of their thermal needs (e.g. cooking or water heating), which they did not specifically report in the survey. This finding indicates that future research should focus on a more accurate assessment of energy sources (including electricity) for thermal needs.

Secondly, average amounts fall within the range of 7.2 kg to 13.2 kg for wood, and 4.4 kg to 9.2 kg for dung. More wood than dung is used for all thermal energy services, possibly reflecting the relative availability and/or efficiencies of the two energy sources. Average biomass (wood plus dung) use per day is about 58 kg. Both, average and maximum amounts of wood used are greater than dung for all thermal services. When looking at totals per household, combined biomass amount is 132 kg at the maximum. These findings suggest that there is a substantial use of biomass, particularly more wood in terms of weight. Lesser use of dung can be due to its alternative value as a fertilizer. Moreover, the heat efficiency of wood is greater compared to dung, which may motivate the use of more wood. Ash content, which can be a nuisance, is larger from dung than wood, and therefore, households may minimize the nuisance by using less dung.

**Table 20: Comparison of daily biomass use for thermal energy services**

| | Min (kg) | | Mean (kg) | | Max (kg) | |
|---|---|---|---|---|---|---|
| | *Wood* | *Dung* | *Wood* | *Dung* | *Wood* | *Dung* |
| **Cooking** | 0.5 | 1 | 7.2 | 4.4 | 20 | 14 |
| **Bread baking** | 0.4 | 0.5 | 12.6 | 9.02 | 40 | 20 |
| **Water heating** | 0.5 | 1 | 7.9 | 6.5 | 30 | 28 |
| **Space heating** | 0.7 | 2 | 13.2 | 9.2 | 60 | 50 |
| **Sum of all services** | 3 | 3 | 37.2 | 22.7 | 130 | 75 |
| **Combined biomass** | 16 | | 57.7 | | 132 | |

Source: Survey 2015.

Apart from daily biomass use, the survey also probed into the stock of wood for annual consumption. Households usually collect and/or purchase certain amount of wood in the warm season that lasts them through the winter. Households reported that their stock is usually sufficient. However, during especially harsh and cold winters they may run out by early spring; so, they would buy or collect more.

Cost of fuel is another important factor in household energy use. Although generally perceived as freely available, woody biomass is actually purchased by households in rural communities of the Khatlon region. There are two ways to procure wood. One is for households to pay a certain fee to the local government's forestry department and then collect wood on their own. Second is for households to buy wood by bundles or truckloads from private vendors or neighbors. In both cases, it is a one-time cost incurred in a year, and the supply procured usually lasts until the next purchase (the following year). Therefore, it is reasonable to assume this cost as a lump sum payment for annual wood stock. Note that households did not report any purchase of dung. It indicates that they have access to dung in their own farms.

The amount of wood stocked for annual consumption differs significantly among several expenditure groups as separated according to the cost of purchase (pairwise comparison of means using Tukey method with Bonferroni correction; see Table 21). The differences in mean annual wood stock range from about 100 kg to over 2,400 kg. Households spending between 2,000 TJS and 3,000 TJS stock up substantially more than others. In other words, households that can afford to spend more on wood are able to stock more of it, and therefore, may be in a better position to meet their energy needs. But this finding should be taken in context because only 7 households in the survey belonged to this high expenditure group, whereas the group with 0 expenditure comprised 232 households. The differences among households spending less than 1,000 TJS (comprising 143 households) are not statistically significant. Put another way, whether families spend up to 1,000 TJS or nothing at all in monetary terms, their wood stock is essentially the same.

**Table 21: Pairwise differences in mean annual wood stock by wood expenditure**

| Contrast between wood expenditure (TJS) | Difference in mean annual wood stock (kg) | SE | df | t.ratio | p.value |
|---|---|---|---|---|---|
| **0 vs 200** | 232.26 | 252.94 | 376 | 0.918 | 0.9417 |
| **0 vs 500** | -567.14 | 222.06 | 376 | -2.554 | 0.1115 |
| **0 vs 1000** | -154.74 | 168.99 | 376 | -0.916 | 0.9424 |
| **0 vs 2000** | -676.63 | 188.04 | 376 | -3.598 | 0.0049** |
| **0 vs 3000** | -2256.42 | 425.82 | 376 | -5.299 | <.0001*** |
| **200 vs 500** | -799.40 | 320.42 | 376 | -2.495 | 0.1282 |
| **200 vs 1000** | -387.00 | 286.21 | 376 | -1.352 | 0.7555 |
| **200 vs 2000** | -908.89 | 297.86 | 376 | -3.051 | 0.0292* |
| **200 vs 3000** | -2488.69 | 484.44 | 376 | -5.137 | <.0001*** |
| **500 vs 1000** | 412.39 | 259.32 | 376 | 1.590 | 0.6055 |
| **500 vs 2000** | -109.49 | 272.13 | 376 | -0.402 | 0.9986 |
| **500 vs 3000** | -1689.28 | 469.06 | 376 | -3.601 | 0.0048** |
| **1000 vs 2000** | -521.89 | 230.86 | 376 | -2.261 | 0.2131 |
| **1000 vs 3000** | -2101.68 | 446.38 | 376 | -4.708 | 0.0001*** |
| **2000 vs 3000** | -1579.79 | 453.94 | 376 | -3.480 | 0.0073** |

Source: Survey 2015. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1. Note: "0 vs 200" means comparison between a group of households that reported no expenditure and a group that reported spending up to 200 TJS on wood annually. The statistical test used is pairwise comparison of means using Tukey method with Bonferroni correction.

There are differences among the households' cost of wood procurement according to their income bracket. It is evident from Table 22 that, generally, the higher the income the more is spent on wood. The highest income group spends more than twice as much as the lowest income group. The unreported income group (zero) spends by far the most – more than twice the highest income group. Except for the highest income group, the difference between the zero income group and the four income groups is statistically significant in terms of wood expenditure (pairwise comparison of means using Tukey method with Bonferroni correction). The differences in expenditure among the four income earning groups, however, are not statistically significant (hence, not shown in Table 22).

**Table 22: Comparison of wood expenditure by income groups**

| Income groups (TJS) | Mean (std. error) wood cost by group (TJS) | Income groups comparison (TJS) | Mean (std. error) difference of wood cost among groups (TJS) | p-value |
|---|---|---|---|---|
| **Up to 2,870** | 214.49 (94.55) | 2,870 vs. 0 | -697.49 (123.54) | <.0001*** |
| **Up to 5,150** | 346.52 (87.27) | 5,150 vs. 0 | -565.46 (126.56) | 0.0002*** |
| **Up to 8,360** | 332.48 (83.33) | 8,360 vs. 0 | -579.49 (132.68) | 0.0002*** |
| **Up to 12,600** | 405.83 (86.53) | 12,600 vs. 0 | -506.15 (145.35) | 0.0074** |
| **Up to 47,100** | 454.08 (127.98) | 47,100 vs. 0 | -457.91 (194.13) | 0.1742 |
| **0** | 911.98 (105.61) | - | - | - |

Source: Survey 2015. Note: Pairwise comparison of means using Tukey method with Bonferroni correction. Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1.

Two explanations can be offered for these findings. First, with an increase in income households may be able to afford more wood. It may be an effect of substitution between labor and money in procurement of wood. In other words, as members of the household engage in income earning activities (usually outside the farm) they will have less time available to collect wood. Since they earn cash they need to spend that extra earning to buy a greater share of their annual wood stock (that they did not have time to collect). Conversely, households at the lower income brackets spend less on buying wood, and therefore, may be spending more time collecting wood. This relationship has important implications for energy poverty alleviation in that expanding people's income earning opportunities along with provision of high quality energy (e.g. electricity) seems more realistic than may otherwise be perceived. Evidence showing that households are already paying for energy (wood), is a strong indication that they would be able to afford, up to a certain cost, better quality energy that is reliable.

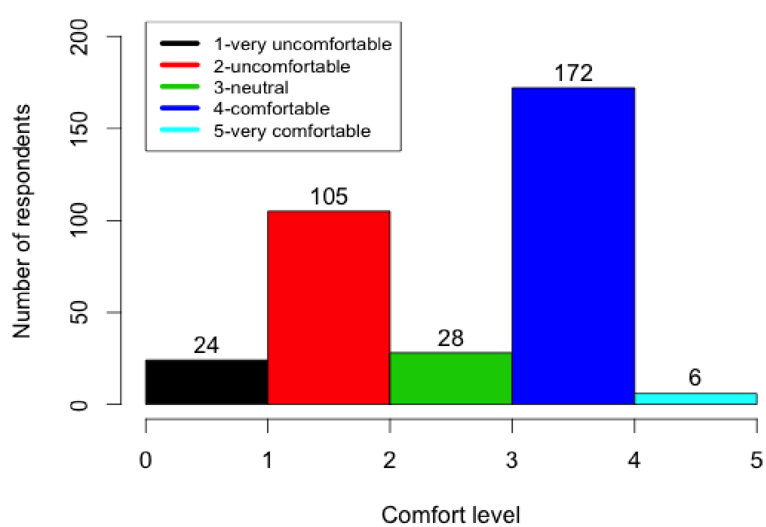
Second, the group that did not report any income may be very different from other groups in the survey. However, a comparison of such key characteristics as household size, location (district), amount of wood and dung use, and connectivity to electricity grid did not result in any statistically significant differences between the zero income group and other groups. It is possible that this group may earn a lot more, but did not wish to reveal their income in the survey. For this group, then, higher expenditure on wood would make logical sense. Conversely, the zero income group may earn very little or have irregular sources of income that they did not consider worthy of mentioning. The logic for this group could be that they prefer to buy all their wood stock, as they may not have time for collection (e.g. seasonal work outside farm). It is also possible that households in this group may not have direct access to woodlands and wood resources in their immediate proximity or not have rights to collect. Therefore, they have purchase all their wood. Nonetheless, this uncertainty presents an issue that calls for further research.

## *4.5 Cooling*

Cooling is also an important energy service for residential buildings. Air conditioning is a growing energy consumption category in places where electricity and conditioning devices are available. In the context of Tajikistan, air conditioners and electric fans are in use in some households. Refrigeration has also become prevalent in urban areas. However, the share of electricity consumption for cooling in Tajikistan is unknown due to lack of data.

Households in the study area of Khatlon region mostly rely on natural cooling for their homes. Only 19 households do cool their homes: 10 use an electric fan and 6 have an air conditioner installed. For those not using any cooling device, their comfort level with summer indoor temperature was asked. As shown in Figure 39, a majority of respondents feel comfortable, but a large number of households find it uncomfortable.

**Figure 39: People's comfort with home temperature in summer when not cooling**

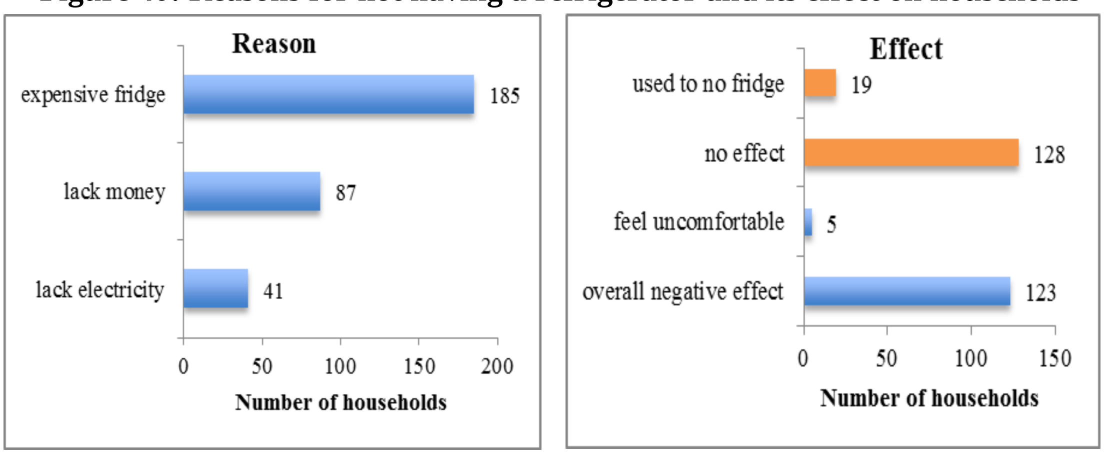



Source: Survey 2015.

Apart from conditioning room temperature, access to cold storage allows for preservation of food that is safe to consume. In the context of farms, it means that perishable produce can be kept for longer; thus, avoiding unnecessary waste and expanding food options for a longer period after produce has been removed from farmland. Dairy products are also kept safe in the refrigerator preventing bacteria growth and thus, keeping related illnesses at bay.

Access to refrigerators, however, is low in rural areas. In the survey, only 73 out of 386 or 19% of households reported having a refrigerator. Those who do not have a refrigerator reported that they could not afford to buy one, or they lack access to reliable electricity (see left panel on Figure 40). When asked about the effect of having no refrigerator, households reported contrasting views: one half described the effect as negative, whereas the other half said there was no effect in their lives (see right panel on Figure 40).

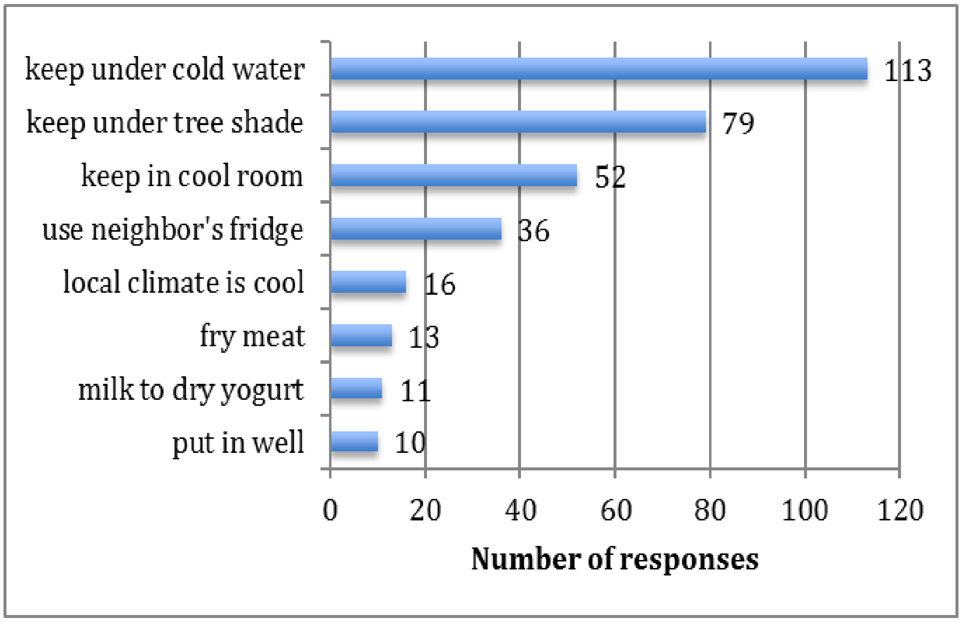
**Figure 40: Reasons for not having a refrigerator and its effect on households**




Source: Survey 2015.

In absence of a refrigerator, households use a variety of ways to preserve their food. The top four ways are: to keep it under water, in the shade of a tree, or in a cool room, or use a neighbor's refrigerator (see Figure 41).

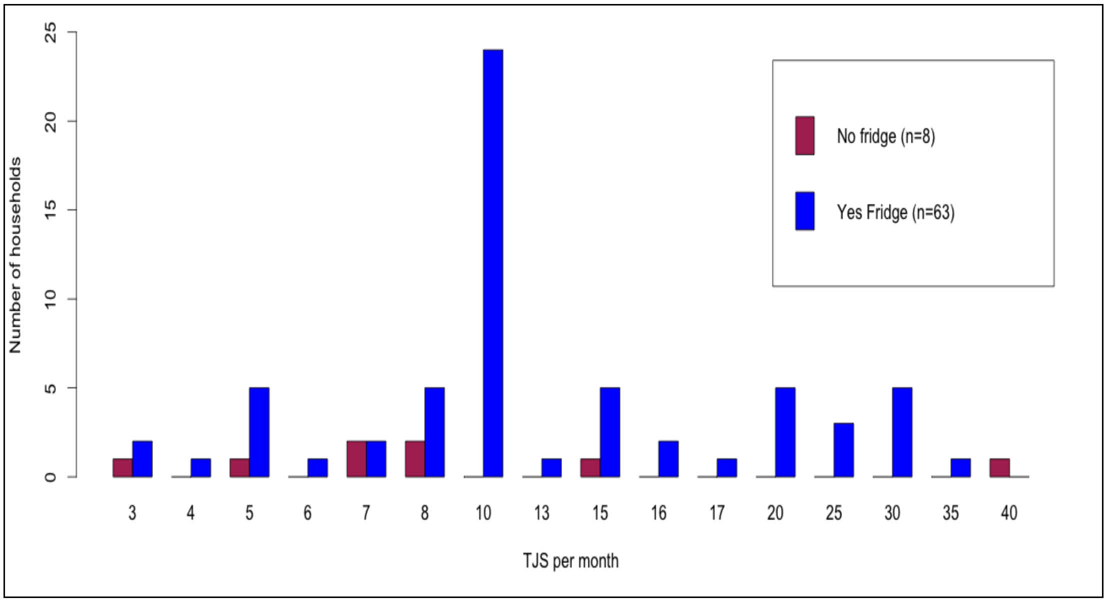
**Figure 41: Ways to preserve food in absence of refrigerator**




Source: Survey 2015.

The above strategies are especially useful because electricity supply is erratic. In light of this, households were asked how much they would be willing to pay for reliable electricity to keep their refrigerator running. Most respondents were willing to pay 10 TJS (mode) per month. Households having a refrigerator suggested a slightly higher number (13.4 TJS) on average compared to those that did not have a refrigerator (8.3 TJS, see Figure 42). It should be noted that the number of respondents was rather small – 63 and 8 respectively. Therefore, a generalization is difficult to make.

**Figure 42: Willingness to pay for electricity to run refrigerator**



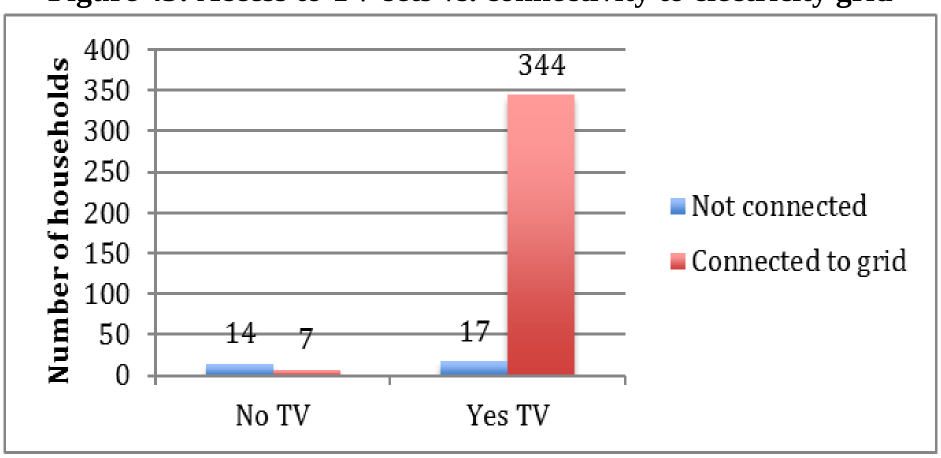

Source: Survey 2015.

### *4.6 Information and communication*

Worldwide, ability to obtain information and communicate is increasingly becoming dependent on use of energy. In the context of Tajikistan, watching television and using mobile phones are the most common ways to obtain information and communicate. Televisions are ubiquitous thanks to accessible imports from China. Mobile phones have also become ubiquitous and an essential part of everyday life. An assessment of electronic readiness in Tajikistan reported that mobile communication operators provide service to over 5.4 million customers, or 73% penetration level (Qosimov et al, 2010). Newspapers are not very popular and cost money to buy. Internet penetration is relatively low – between 9.3 and 31% by various estimates (Qosimov et al., 2010), but is increasingly gaining ground due its availability through mobile phones.

There is only one energy source that TV sets and mobile phones[11] run on – electric power. Access to electricity, therefore, is essential. In the survey, a great majority of households (n=344 or 89%) that are connected to the national electricity grid reported having a TV set (see Figure 43). There are a few households that are not connected but do own a TV set. These households may have access to alternative sources of electricity such as solar home systems or local mini-hydropower stations. Therefore, watching TV is one of the primary uses of electricity, and it takes up a large share of electricity use in rural areas. In addition, households also have CD/DVD players that they put on to watch their favorite music, shows and movies, as well as weddings and other celebrations recorded on digital media. The latter often contributes to maintaining ties with relatives who migrated abroad; thus, serving an important cultural function too.

**Figure 43: Access to TV sets vs. connectivity to electricity grid**

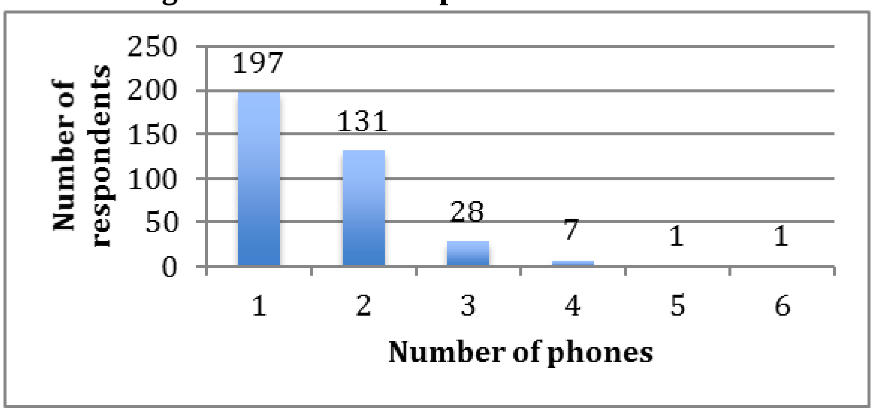



Source: Survey 2015.

[11] Note that phone batteries can be charged in cars and spare batteries can be used as backup when grid electricity is not available. Nonetheless, the charge is still electric regardless of the method.

A large number of households also reported having at least one phone. Of 386 respondents 364 or 95% reported having a phone, 11 (2.8%) not having a phone and 10 (2.6%) provided no information. Of those who reported having a phone, 358 or 98% said they have mobile phones, while only three have landline phones, and the remaining four did not specify their phone type. As shown in Figure 44, a majority of households have one phone (n=197 or 54%), but there is also a substantial number of households that have two phones (n=131 or 36%) in the household. Over two dozen have three phones; another seven households reported four phones.

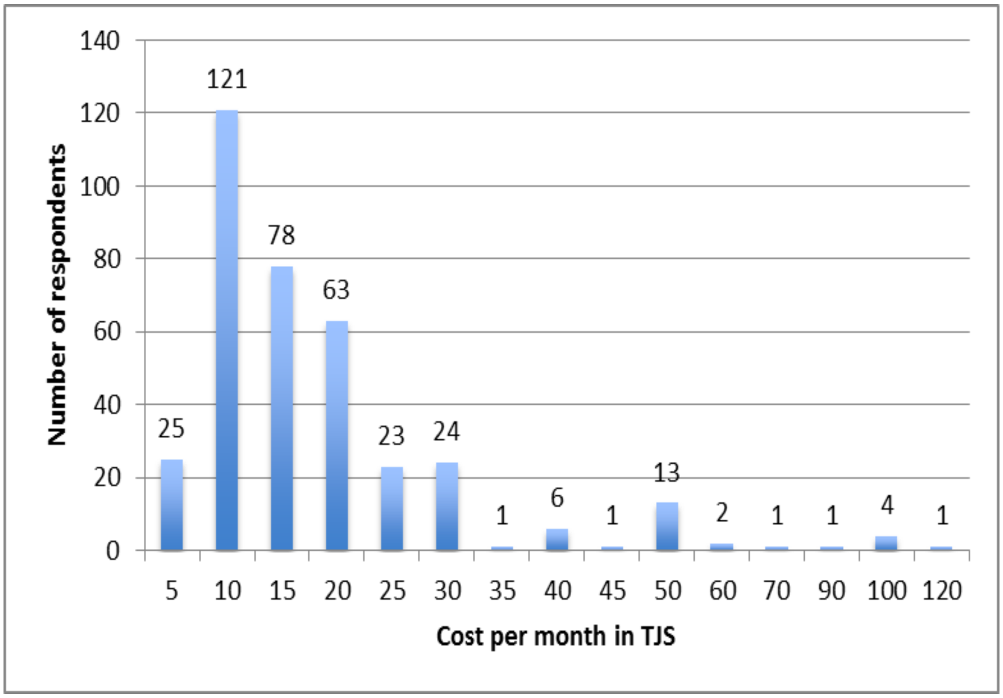
**Figure 44: Number of phones in a household**




Source: Survey 2015.

There is a cost to using mobile phones. In Tajikistan, people prefer prepaid plans because it allows them the flexibility to use their phones when they need it. Nevertheless, when asked to approximate how much they spend per month, respondents provided the answers on the spot. This suggests that they are keenly aware of their phone expenses. As shown in Figure 45, majority of respondents spend around 10 TJS per month (n=121 or 33%), while there are also many who spend 15 TJS (n=78 or 21%) and 20 TJS (n=63 or 17%) per month.

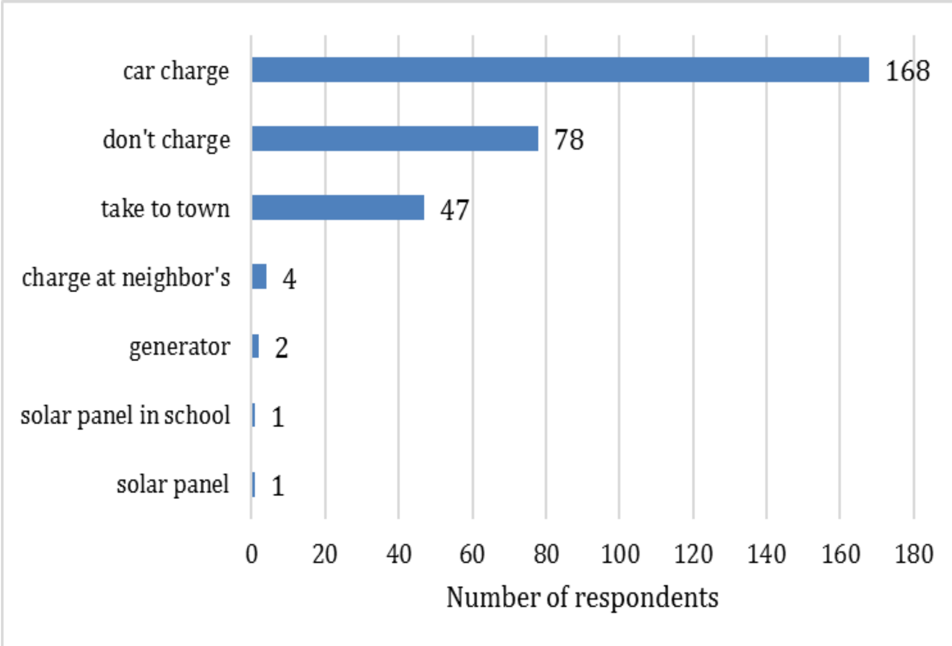
**Figure 45: Monthly expenditure on prepaid plan for mobile phones**




Source: Survey 2015.

In the absence of the electricity from the grid, which happens during the winter rationing and blackout period, respondents use a variety of strategies to charge their phones. The most popular method seems to be by using cars to charge their phones (see Figure 46). Some take the phones or batteries to town, but others do not charge their phones, presumably for not having access to any options. Since most of the reasons for using a phone were to talk with family members and friends, people may have to postpone such conversations until they have access to electricity to charge their phones, or seek other ways, including traveling to talk to the relatives in person.

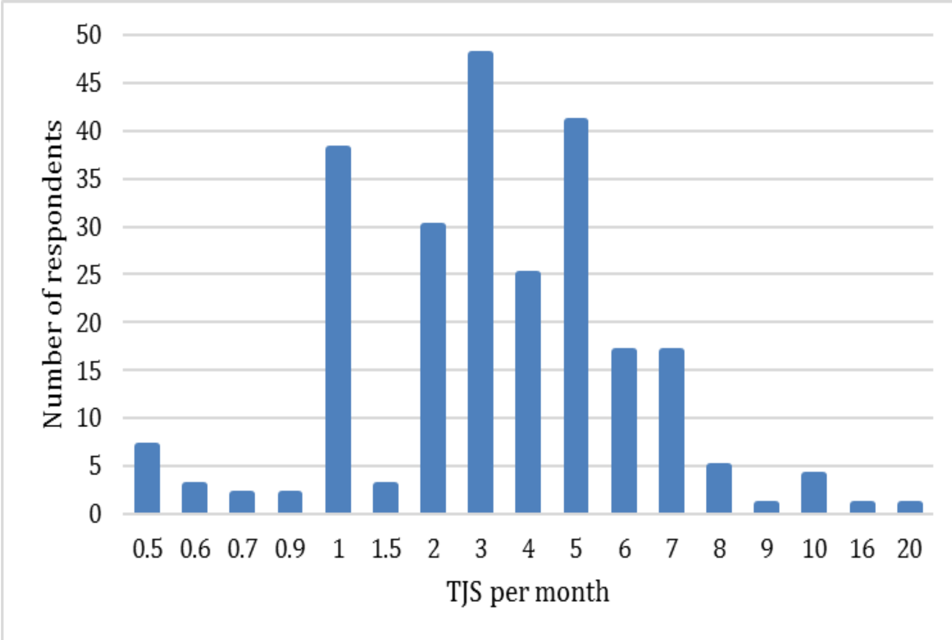
**Figure 46: Charging phone when no electricity**




Source: Survey 2015.

Given that access to electricity is essential to charging mobile phones, households were asked how much they would be willing to pay to have their phones charged. Overall, 245 or 63% of respondents expressed a willingness to pay (WTP) to have their phones charged when they do not have access to electricity. Their WTP ranged from 0.5 to 20 TJS (mean=3.7 TJS) per month, with a majority willing to pay between 1 and 5 TJS per month (see Figure 47). This finding suggests that there is potential for developing small businesses to offer mobile phone charging service. Solar panels are one option that could be used to satisfy this demand.

**Figure 47: Willingness to pay for charging phone**



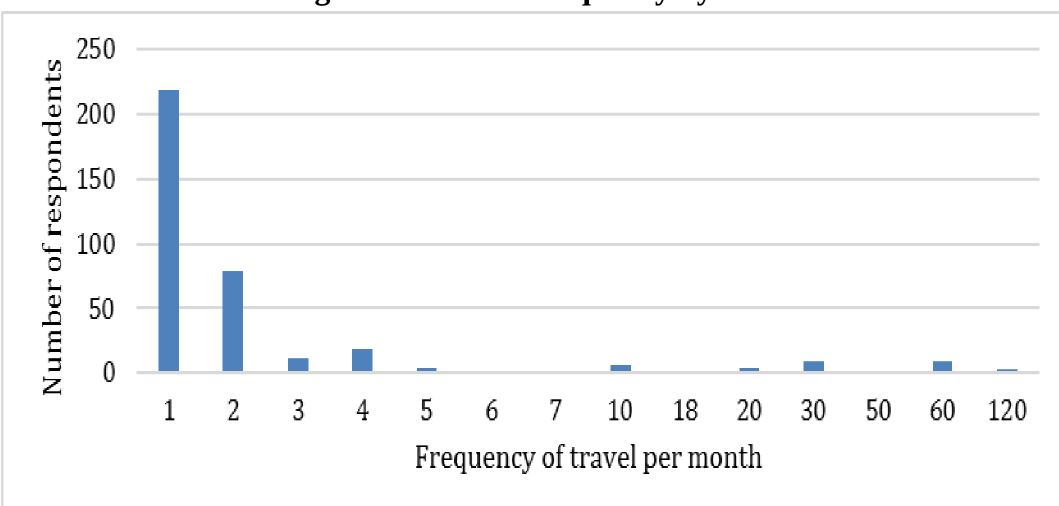

Source: Survey 2015.

### *4.7 Mobility*

A notable omission from the Practical Action's (2014) *energy services* framework is the *mobility* service. Ability to travel is important for rural households to access markets, health and education facilities beyond their village, and to relocate quickly during natural disasters. Similarly, local enterprises and community organizations need mobility to provide products and services to households more effectively. Therefore, in this study the mobility service was incorporated into a modified *energy services* approach to make it more comprehensive.

In the survey, most respondents (372 out of 386 or 96%) reported having access to a road, which allows driving. Five respondents lacked such access, and another nine did not provide any response. A majority of respondents travel one or two times per month by road. The main reasons reported for travel included visiting with extended family, going to markets, receiving medical treatment (or buying medicine), and addressing various matters that required going to government offices outside the village. Furthermore, some complained that poor road conditions makes travel dangerous, and high transport costs also deter them from traveling more frequently. There are a few who travel more frequently. The frequency of greater than 30 times per month means that they would travel more than once per day on the road. One reason for this could be going to work every day. It is hard to explain the frequency of 120 times per month or three times a day. For these respondents, driving might be part of their livelihood activities (e.g. taxi), other than once a day to and from work. Nonetheless, these greater frequencies are likely exceptional cases.

**Figure 48: Travel frequency by road**

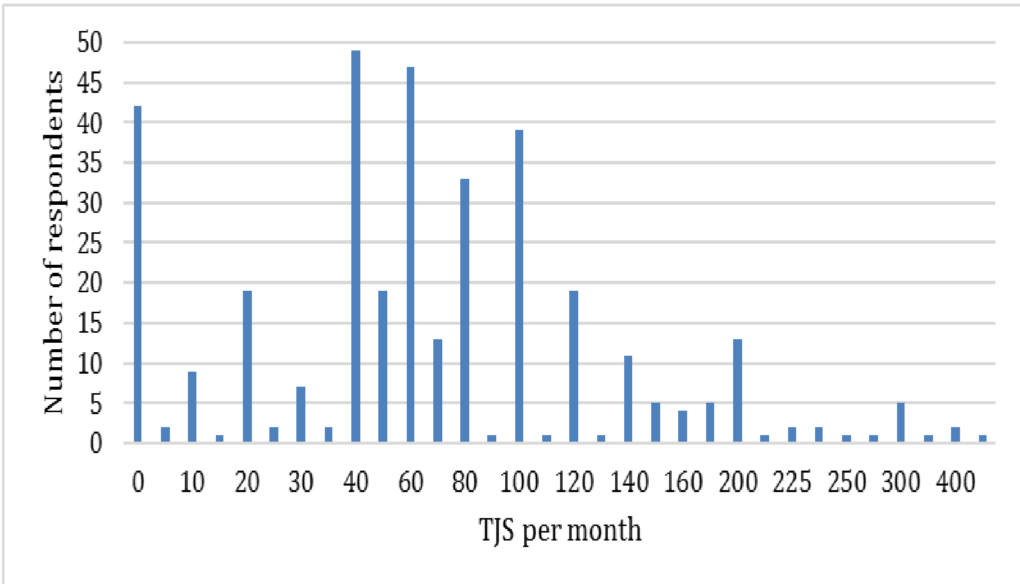



Source: Survey 2015.

The total cost of travel per month is quite variable from 0 to 600 TJS (mean=78 TJS or 88 TJS if zeros are removed). Most people spend 40 to 100 TJS on travel. It is also noteworthy that a large number of people reported zero monetary cost.

This could be because they walk on the road rather than drive or take a taxi. These findings suggest that households in rural areas also incur sizeable costs to travel.

**Figure 49: Travel cost per month**




Source: Survey 2015.

## *5. Discussion*

Important insights from this study are briefly summarized as follows. Households need energy for different purposes reflected in different service categories. Access to lighting after dark enables householders to enjoy their meals, socialize or engage in some productive activity. Although many households are connected to the electricity grid, reliability remains a challenge. Therefore, households use several sources (candles, kerosene, flashlights) to ensure sufficient lighting. Household income does not appear to have an impact on the number of sources used. It means that all households adopt a multiple source strategy. This is a reflection of unreliability of electricity. There is willingness to pay for electricity for lighting, albeit it is very low. Overall, households maintain access to a number of sources to stay resilient in the face of uncertainties, including in government provision of services. The experience of hardships during the civil war in 1990s and continuing energy shortages since then are further reasons to hedge the risks through diversity of energy sources. Beyond lighting, there are more reasons for multiple energy use, as discussed below for other energy services.

Households use electricity, liquefied petroleum gas, coal, wood, dung and straw to do the cooking, which is an indispensable energy service to prepare staple foods. Although some are edible in a raw form, most staples require cooking. Depending on cooking technique – boiling, steaming, stewing, smoking, roasting, frying, grilling, baking, etc. – different energy sources are used. Bread is baked in traditional clay ovens (tanoor), by mostly burning wood and/or dung. A combination of energy sources listed above is used to heat water, which is used for brewing tea, dishwashing, laundry, bathing and preparing animal feed. A lot of wood and dung is used to satisfy these services, and income has no effect on the type or amount of biomass used. The number of people switching away from biomass to using more electricity for cooking and bread baking is very low. Major reasons for not switching to electricity for cooking are: having access to cheap and abundant biomass, and finding electricity expensive and not reliable. In other words, cost and reliability are important considerations. There is some willingness to pay for electricity to bake bread, but it is very low. As will be discussed in Chapter 3, food culture plays a crucial role in using a certain energy source, particularly for bread baking.

Space heating is a critical energy service, especially during the long and cold winters. For this, rural households mostly use wood and dung to satisfy their heating needs. Such heating source differentiation is primarily due to the availability of energy sources with respect to location. Centralized heating systems are nonexistent. Facing fuel scarcity, households heat one room and often generate heat by cooking indoors using the same stove. Nonetheless, the amount of biomass used is considerable, and such combination is not always possible. Along with cooking, this high use of wood has critical implications for forest sustainability as well as soil fertility. Similar to other services mentioned above, there is no income effect, and willingness to switch to and pay for electricity is very low. Here again, having access to cheap and abundant biomass, and finding electricity expensive and unreliable are main reasons for not considering to switch.

Although usually perceived as being free in rural areas, households do pay for wood. The expense on wood is positively related to household income, indicating that households earning more may afford procuring more wood. Conversely, lower income households buy less, suggesting the households at the lower rungs may be collecting more to make up for the shortfall in the amount purchased. Overall, evidence showing that households are already paying for energy (wood), is a strong indication that they would be able, up to a certain cost, to afford better quality energy that is reliable. The implication is that rural households incur monetary costs beyond time and effort in wood collection, and therefore, access to cash is a critical factor in rural energy access. Such access is currently provided through remittances because employment opportunities in rural areas are limited. The latter is also a function of lack of energy access, for example, electricity to run small factories that process agricultural products. In the long term, improving access to energy would be very important to sustain the vitality of rural livelihoods. As suggested towards the end of this discussion section, one approach is through appropriate technologies.

Air conditioning is almost non-existent and refrigeration is very low in rural areas. Natural cooling is the only available means to keep comfortable temperatures. Since electricity is intermittent few households use a refrigerator. They mostly keep perishable food under cold water, tree shade or in underground wells. At this point, there is some willingness to pay for electricity for cold storage, but it is quite low.

Watching television and using mobile phones are the most common ways to obtain information and communicate in rural areas, and internet penetration is increasing due to its availability through mobile phones. There is a large ownership of TV sets and mobile phones, and households mostly watch TV/DVD, which, together with lighting, constitutes their major use of electricity. Willingness to pay for charging mobile phones indicates that there is demand for such service. In the absence of such service, households charge their phone batteries whenever they have electricity, by using their car chargers, by keeping several batteries as backup, or sometimes charging in the closest town or city. This indicates that information and communication services provided through mobile phones are very important to rural people and they go to great lengths to maintain access to these services. Therefore, setting up charging stations using solar panels could be another way to address this need. This small business would also provide a source of livelihood for some people, thereby helping families to be together and avoid migration.

Households do spend money to travel. It is clear that a part of this cost goes to transport fuel. Household members travel one or two times a month to go to markets, health clinics or visit with relatives. Poor road conditions and high transport costs are the main obstacles to travel.

Beyond satisfying the basic services, energy is important for improvement of quality of life. For example, evidence suggests that having access to electricity improves one’s educational and earning opportunities substantially. Studies of the Philippines found that household members with electricity were more likely to be literate (Porcaro & Takada, 2005), spend more time reading and studying, and attain two years more education (World Bank, 2002). Access to electricity also improved school attendance in Nicaragua (Masud et al., 2007) and Vietnam (Khandker at al., 2009).

Provision of reliable access to grid electricity, as one study notes, increases productivity as people mechanize agricultural activities such as milling and processing, run factories and shops with better lighting, and extend the life of products and vaccines through refrigeration (Larson & Kartha, 2000). In a similar manner, off-grid electricity generated at microhydro dams provides “mechanical energy for milling, husking, grinding, carpentry, spinning, and pump irrigation” (Sovacool et al., 2014, p. 40). Furthermore, as another study found, electrified households are 10.7 % more likely to run a home business, and once electrified, 25.5 % of non-electrified households will do the same (World Bank, 2002). In other words, provision of reliable access to energy can facilitate local job creation and thus, contribute to improved livelihoods.

Procuring energy also involves networks and supply chains, providing jobs and livelihoods for many people in the process. This is true also in the context of developing countries and their primary energy sources. For example, one study calculated the number of jobs in charcoal sector in the tens of millions worldwide, and estimated this to become the source of livelihoods for 12 million people in sub-Saharan Africa alone by 2030 (Mwampamba et al., 2013). Another study looking at battery production and recycling found that reconditioning of used batteries provided jobs for hundreds and potentially thousands of people in major cities of developing countries, and generated income in the millions of dollars (International Lead

Association, 2013). In terms of overall economic development, reliable energy access is correlated negatively with the level of poverty (defined at $1.25 per day, Karekezi et al., 2012) and positively with the gross domestic product (World Bank, 2011). Nonetheless, it is important to note, as Karekezi et al. (2012) do, that "provision of and access to modern, cleaner and affordable energy option *per se* does not, in itself, alleviate poverty … [but it] can play a key contributing role to reducing poverty … [and serve as] a means to facilitate development given that energy is an essential input for productive, household and social sectors" (p. 163).

It is clear, as the evidence above suggests, that expanding energy access entails tangible benefits in terms of the services it provides people in the developing world. The biggest question at both a household level and a national level, however, is how to expand access to energy. Sovacool et al. (2014) present a range of technological options that can be deployed to address energy poverty. As Table 23 illustrates these options are differentiated by scale and scope of coverage as well as required investment for each option. In rural areas of Khatlon region, a mix of technologies could be appropriate. Beyond provision through national electricity grid (which is unreliable and costly), complementary micro-grid and off-grid technologies mentioned in Table 23 need to be considered as well. The latter may be more appropriate to the needs of the rural communities and households. However, the authors caution that there is no one-size-fits-all solution to the problem of energy, and expanding access is a complex and context-dependent endeavor. They recognize that "there are an almost infinite number of ways an energy access program can result in failure, but only one (or perhaps a few) where they can result in success. So failure is inherently more common, and expected, than success” (p. 80).

**Table 23: Summary of technological options that expand energy access**

| | Conventional options | Grid electrification | Micro-grids | Off-grid technology |
|---|---|---|---|---|
| **Scale** | Community and household | National, regional, and even international | Community | Household |
| **Geographic radius** | < 30 $km^2$ | More than 50 $km^2$ | 1 to 49 $km^2$ | < 1 $km^2$ |
| **Number of customers** | Dozens to thousands | Thousands to millions | Dozen to hundreds | Usually a dozen or less |
| **Installed capacity** | Various | More than 10 MW | 20 kW to 10 MW | < 20 kW |
| **Technologies involved** | Woody biomass, candles, dry cell batteries, kerosene lanterns | Large-scale, centralized capital intensive | Medium-scale and small-scale | Very small-scale |
| **Investment required** | Hundreds to thousands of dollars | Billions of dollars | Millions of dollars to hundreds of thousands | Thousands of dollars |
| **Examples** | Fuelwood collection in rural areas, kerosene markets in Papua New Guinea, dry-cell battery charging stations in sub-Saharan Africa | The North China Grid, Electricité de France grid, the New England Independent System Operator (NE-ISO) grid | Community-scale solar PV systems in Bangladesh, micro-hydro networks in Nepal and Sri Lanka | Individual solar home systems, pico-hydro units, biogas digesters, cook stoves, residential wind turbines |

Source: Sovacool, B. K., Kryman, M., & Smith, T. C. (2014).

## *6. Conclusion and policy implications*

This study adapted the *energy services* approach of Practical Action (2014) to better understand the nature of energy use in rural areas of Khatlon region, Tajikistan. The approach complements the theoretical model of *energy stacking* and provides further insights into the multiple fuel strategy employed by many rural households. The alternative model of *energy ladder*, however, does not find support in this study.

The *energy services* approach adapted in this study is a key contribution of this study to the body of literature on energy poverty. It provides further insights into energy use in rural areas of the Khatlon region compared to a binary definition of energy poverty, as lack of connectivity to the electricity grid and reliance on solid biomass. Furthermore, although affordability and willingness to pay were important consideration, the study did not support the inverse relationship between household's income and energy use, as postulated by the *energy ladder* model. In fact, households use a variety of energy sources, including electricity, wood and dung to satisfy their various energy services, including lighting, cooking, heating, cooling, information and communication, and mobility. Indeed, the multiple use of fuels found in the study area suggests an *energy stacking* model is at work in rural areas. However, beyond this simple model, the *energy services* approach provides a more nuanced understanding of why households use multiple fuels. The main reason is that each fuel is used for a different purpose, such as cooking, cooling, information and communication, etc. Moreover, the use of fuel critically depends on the availability, affordability and reliability of energy sources. When any of these qualities is lacking, households adopt multiple energy sources to increase their options.

Although rural households do demonstrate resilience in the face of intermittent energy provision, their reliance on using biomass has repercussions for their quality of life. Beyond the concern on adverse health effects of burning biomass inside their homes, there are further implications for the sustainability of such an energy use strategy. As pressure on forests continues to grow, there is a risk to long-term availability of firewood. Apart from firewood, forests are also useful for gathering medicinal plants, grazing animals, hunting game and gathering hay. The forest is home to wild plants and animals whose survival may be increasingly threatened. Therefore, meaningful efforts are needed towards reforestation and providing alternative sources of energy to reduce the pressure on forest ecosystems.

Burning animal dung, instead of applying it in the fields, reduces soil fertility. It can mean that farmers risk losing their most important source of livelihood when nutrients are not returned to the field. Alternative strategies, such as biogas digesters, can provide a means to maximize the value of dung for both heating (gas) and fertilizer (sludge). However, given that the temperate zone and rocky substrate are major obstacles to deployment of such technology, some above-ground units have been experimented with varying degrees of success. In addition, such projects lack necessary financing to further refine the technologies to provide for households' thermal needs.

Overall, electricity is very flexible in that it can satisfy several needs. However, the challenge is that it is not directly available from nature because it is an energy carrier, and some other energy source needs to be converted first. Availability of conversion technologies at appropriate scale, such as solar panels and wind turbines, could potentially provide for the lighting, and information and communication needs. In this realm, there is potential for developing small businesses to offer mobile phone charging services, and solar panels can be an option to provide such service more reliably.

Beyond basic services, a close attention is needed to provide *energy for earning a living*. As Practical Action (2014) outlines, energy can be harnessed effectively to improve livelihoods through the following services: earning off the land, running micro and small-scale enterprises, expanding employment opportunities, and earning from supplying energy. Currently, empirical studies are lacking on productive energy use in Tajikistan. Rural households appear to have limited use of energy for productive purposes. Usually small shops use electricity for lighting and refrigeration. In agriculture, tractors are deployed to transport manure and seeds to the fields and plow the land. During harvest season, grain, produce and hay are transported from the fields to the house, but combine harvesters and electric threshers are rarely used due to exorbitant costs. With greater access to energy, through consideration of services and communities being closely involved, there is potential to alleviate energy poverty in rural areas. For this to begin to take shape, energy policy must look beyond one-size-fits-all approach of electrification, and into alternative technologies.

Of equal importance is *energy for community services.* Practical Action (2014) groups such services under four categories: (a) health care - hospitals, clinics and health posts; (b) education - schools, universities, and training centers; (c) public institutions - government offices, police stations, religious buildings, etc.; and (d) infrastructure services - water and street lighting. All of these are very relevant to improvement of quality of life in rural areas of Tajikistan. However, information is scarce on energy use for community services. In rural areas, health posts, schools, and government and community buildings are dependent on intermittent grid electricity, and wood and/or coal provided by the government for winter heating. Physical energy (manual labor) is used to haul water from water points. Street lighting is nonexistent. Similar to earning a living, attention to services and partnership with local communities are essential to adequate provision of community services.

Private sector development and engagement in energy provision should be elevated in the list of priorities in policies targeting energy poverty. Small-scale technologies that are appropriate to rural areas can be provided through private businesses. Some incentive structure is needed to set up the supply (value) chain for alternative technologies. Therefore, the government should step in to provide a clear policy directive supporting the proliferation of such technologies. More substantively, some form of financial incentive should be made available. This may include a tax break, or lifting of import tariffs for firms bringing technologies to local market, a direct subsidy or low-interest loan to households installing a technology, or some combination of these instruments. Importantly, funding should be made available to local developers that are already experimenting with adapting and improving technologies to local conditions. Furthermore, new lines of research should be encouraged and financed to pioneer locally designed technologies, such as improved cookstoves and biogas digesters.

Indeed, these avenues are not new to policymakers in Tajikistan. However, their relevance and significance can be amplified. This chapter is a first step towards raising the profile of energy poverty as an urgent challenge through analysis of the energy use patterns at the level of households. The detailed analysis of energy use provides empirical support to underscore the urgency of the problem. In light of this analysis, small-scale technologies through private sector engagement demonstrate appropriateness as a potentially powerful mechanism to alleviate, and eventually eradicate, energy poverty in Tajikistan. Moreover, these can be local, regional and national economic engines, generating income and jobs and improving wellbeing.

Overall, the findings from this study can inform energy policy in rural areas in that energy provision should be considered in terms of the services that it enables. Put simply, satisfaction of the needs should take precedence over a narrow focus on providing merely a source of energy (which is usually electrification). When the focus shifts from sources to services, alternative technologies and options can be evaluated in their effectiveness to provide the needed services. A package of reinforcing measures to address the challenge of energy access may also include improvements in efficiency, reduction in demand, and expansion of supply of electricity through grid. Ignoring the services would jeopardize the hopes of alleviating energy poverty in rural areas. Ultimately, the role of households and their communities should not be overlooked in addressing their energy challenges.

# CHAPTER 3: ENERGY SOVEREIGNTY: UNDERSTANDING DECISION-MAKING AND EMPOWERMENT IN TAJIKISTAN


***Abstract***

*Energy sovereignty* is concerned with decision-making and locally driven, culturally relevant and ecologically sustainable energy systems. Using a survey of 386 households along with interviews and focus groups, this chapter reveals a complex process of energy decision-making influenced by cultural values, financial wherewithal, technological capability, and ecological foundation of households. Cultural norms affect household energy choice. Women and children are expected to engage in biomass collection and cooking because it is considered their responsibility. Food preference is another factor. For example, bread – a staple food – is baked in traditional *tanoors* (vertically installed clay ovens) in which wood or dung is burned. Many types of bread baked in these *tanoors* are difficult to bake in an electric oven. Efforts to eliminate energy poverty and improve energy security, therefore, would need to take cultural factors into account in addition to efficiency, cost-effectiveness, and health and environmental considerations. Local people should be involved in all stages of energy access projects because it is crucial to improving their livelihoods.

## *1. Introduction*

Households use different energy sources for different purposes, as Chapter 2 discussed in great detail. Energy use patterns in households are shaped by the context in which households operate. People make certain decisions about which energy source to use and for what purpose. These decisions can, in turn, be influenced by a variety of factors. Therefore, this chapter sets out to answer the following research question: What factors influence household decisions about their use of energy sources? Understanding the factors that affect household decisions is important because it can inform ways of improving access to energy by encouraging the factors that have a positive influence and hindering the ones that have a negative influence. This chapter will explore the role of local people within their energy system through the lens of *energy sovereignty*.

The rest of the chapter is organized in the following way. First, the root of the concept of energy sovereignty is traced. Next, the significance of decision making to energy sovereignty is highlighted with reference to factors that influence energy choices. Then, the methods of the study are explained, followed by presentation of the study results. Finally, the study results are discussed in detail, and important implications are drawn at the end.

## *2. Emergence of energy sovereignty in food security-sovereignty dialogue*

Before one can conceptualize *energy sovereignty*, it is important to first understand an older concept, that of *food sovereignty* that emerged in *food security* discourse. The *food security* and *sovereignty* debate provides a relevant platform for this research study to draw upon for the conceptualization of the concepts of security and sovereignty in the energy context.

The *food security* approach focuses on securing food as consumable product whereas *food sovereignty* is more concerned with the production process. The former problematizes hunger and poverty as the lack of food, and the solution it seeks is through ensuring availability, accessibility and affordability of food (FAO, 2006; Pinstrup-Andersen, 2009). The latter sets out to problematize hunger and poverty in terms of lack of rights, capacity and control over resources by people to meet their various needs for food, and the solution it seeks is through empowering the people to determine their own ways of meeting their needs (Indigenous Peoples' Consultation on the Right to Food, 2002; Forum for Food Sovereignty, 2007; Patel, 2009). While the former seeks to secure food supply through guaranteed imports and increased incomes, the latter seeks to place the resources under the control of the people so that they make their own decisions, as appropriate to their needs and context. By following the former, the lack of food is solved by making more of it available from outside to be paid for by local people's earned income. By following the latter, people's right to determine their food systems is recognized; they can make their own food choices; they have the capacity (knowledge, money, technology) to exercise their rights and make choices; and they can control the means of production based on ecological possibilities (Cohn et al, 2006; Ruelle, Morreale, & Kassam, 2011;  Cattelino, 2008; Via Campesina, 1996).

Along with food sovereignty, the development of the concept of *energy sovereignty* appears to be shaped by indigenous peoples from the Americas and also by the social movements in the Global South in an effort to “tackle ecological crisis and social inequalities and to address the root causes of global warming and fossil fuel depletion” (Moreno & Mittal, 2008, p. 27). In a recent energy development report for the Seneca Nation of Indians in the US[12] an “exercise [of] energy sovereignty” was described as an effort to “control and manage their natural resource assets – i.e. develop their own energy resources, meet the current and projected energy needs of their community, and “sit at the table” with other regional energy providers to deal with issues on a peer-to-peer basis” (Paradis, Yokey, & LeBeau, 2009, p. 2). The idea of ‘control’ is also repeatedly emphasized in the Abuja Declaration for Energy Sovereignty[13] (2006), particularly the “democratic control of natural resources” and “local community control of energy along with the protection of the environment and local livelihoods from corporate and state abuse” (FoEI, 2006). Furthermore, the Abuja Declaration for Energy Sovereignty calls for greater involvement of women in issues pertaining to energy. Similarly, the signatories of the Brazilian Declaration for Food and Energy Sovereignty “affirm the principle of popular sovereignty over territory and its destiny” and recognize “food and energy sovereignty [as] people’s right to produce and control food and energy to take care of their needs” (Moreno & Mittal, 2008, p. 32).

[12] Although this definition is dated later than the ones that follow, it should be noted that the movement to sovereignty by the indigenous peoples in North America predates those of South America.
[13] It is a resolution of the Friends of the Earth International Conference on Climate Change held in September 28-29, 2006 in Abuja, Nigeria.

The above treatment of differences between *food security* and *food sovereignty* is also informative in the discussion of *energy security* and *energy sovereignty*. *Energy security* is commonly distinguished by its focus on reliability of energy supply and reasonableness of energy price. Unlike this market-based formulation, *energy sovereignty* emphasizes the role of local people in determining their energy systems in ways that are culturally relevant and ecologically sustainable. More specifically, energy sovereignty is conceptualized as a framework that recognizes the individual, community or nation's rights, and strengthens their abilities to exercise choice within all components of energy systems, including sources, means of harnessing and uses of energy, in order to satisfy their needs for energy.

To illustrate some of the differences, the problem of lack of energy in rural communities can be used as an example. The supporters of conventional energy security would describe the problem in terms of energy deficit that is a function of chronic shortage of energy supply due to low generation capacity (i.e. lack of energy resources) and/or unaffordability of price for most households. To eliminate the energy deficit, they would advocate policy measures to (a) increase the capacity, e.g. by building a power plant, and/or (b) address the price differential, e.g. through government subsidies. Local people play little or no role in such policy discussions, because the measures are devised at the national (or regional or international) levels.

In contrast, the proponents of energy sovereignty would view the problem through the prism of local people's needs and preferences. They would underscore people's rights, knowledge and technological capacities, as well as local ecological possibilities to determine which potential energy resources will need to be harnessed, for what purpose, by whom and how. In a hypothetical village, for example, to satisfy the need for home lighting, a micro-hydropower plant on a small stream could potentially power several homes. Alternatively, or complementarily, solar panels and/or wind turbines could produce electricity for home lighting. However, the potentialities can be realized only if people have legal rights as well as capacity (knowledge, technology and finances) to build, install and use adequate technologies. Whether one or more options are viable is a decision that local people have the authority to make.

### *3. Significance of decision making to energy sovereignty*

The act of exercising energy sovereignty can be better understood by exploring the decisions that people make in the process of meeting their energy needs. For this purpose, the literature on household energy decision making (or choice) is very relevant. It looks at the factors that are associated with particular energy use patterns. Understanding the factors that enable or prevent certain energy uses can help gain insight into the motivations behind certain decisions. Using this information, we can then design and deploy targeted measures to eliminate energy poverty and achieve energy security.

Household energy decision-making is a very complex process, and the literature reviewed provides important explanations about the determinants of energy choice. As extensively discussed in Chapter 2, the “energy ladder” model with income as its primary determining variable provides a compelling explanation. However, an alternative model of “energy stacking” is challenging this perspective by bringing empirical evidence that households actually use a number of fuels for different purposes at the same time, as opposed to transitioning completely from lower to higher efficiency fuels with increase in their income. Moreover, there are many other variables that exert important influence on household energy choice, such as age, gender, culture, habituation, taste preferences and cooking habits.

Many studies found that household income is the most common factor in energy decision making. More income, particularly for urban households, is associated with a shift away from firewood towards greater use of commercial fuels, such as charcoal, kerosene, LPG, and electricity (Fitzgerald, Barnes, and McGranahan, 1990; Heltberg, 2005; Mensah and Abu, 2013). In rural areas better-off households tend to use more kerosene (Nnaji, Ukwueze, and Chukwu, 2012), whereas households in the lowest income quintiles use crop residue (Mensah and Abu, 2012). Regardless of income levels, however, rural households continue to rely on firewood for their thermal needs (Heltberg, 2005; Mensah and Abu, 2013). As for lighting needs, with increasing income levels households use less kerosene and more electricity, where electricity is accessible (Fitzgerald, Barnes, and McGranahan, 1990).

Fuel price is another economic indicator of fuel choice. Higher prices of LPG confine households into using more wood; yet, higher wood price leads to using less wood (Fitzgerald, Barnes, and McGranahan, 1990; Heltberg, 2005). Similarly, higher kerosene price is negatively related to its use for cooking (Fitzgerald, Barnes, and

McGranahan, 1990). However, the reverse is true for price and use of kerosene for lighting. This is explained partially by additional costs of transporting kerosene to remote areas, and partially, by the habits of purchasing kerosene frequently and in small quantities (Fitzgerald, Barnes, and McGranahan, 1990).

Reliable supply of energy also determines its use. Households with reliable access to LPG are more likely to adopt LPG and less likely to use crop residue and firewood. Conversely, with erratic or no access to LPG, but reliable access to firewood source, households tend to use less LPG and more firewood (Fitzgerald, Barnes, and McGranahan, 1990; Mensah and Abu, 2013).

Demographic characteristics also determine household energy use to some extent. Larger households use more of fuels, reflecting their overall energy demand as well as availability of additional labor to procure firewood and affordability of cooking for many people (Heltberg, 2005; Nnaji, Ukwueze, and Chukwu, 2012). Furthermore, larger households are more likely to use firewood and less likely to use LPG as "the associated economic burden of increasing family size affects households' ability to switch to cleaner fuels" (Mensah and Abu, 2013).

Age and gender are also important indicators of household energy choice. Older heads of household are found less likely to use modern fuels like LPG (Mensah and Abu, 2013). Similarly, male-headed households are more likely to use firewood and crop residue (Mensah and Abu, 2013). Contrary to the expectation that loyalty is developed over time to using firewood, older women used more charcoal in Enugu State, Nigeria (Nnaji, Ukwueze, and Chukwu, 2012). It can be explained by the elderly's lack of strength to collect wood. A negative relationship between age of the wife and use of charcoal and kerosene was found, but was not statistically significant, as mean age in the sample was 33.5 years (Pundo and Fraser, 2006). Households with more females are found to use more wood, which is explained by women's responsibility for wood collection and cooking (Heltberg, 2005).

More years of education of household members is associated with less wood and more LPG use, and thus, education is considered a strong determinant of fuel switching (Heltberg, 2005; Mensah and Abu, 2013). This is related to greater awareness of pros and cons of using biomass and commercial fuels. Education provides opportunities for better income; thus, households devote less time to procuring biomass and more time to earning income, a part of which they use to purchase commercial fuels. Women with secondary education or higher are found to use more charcoal as they engage in other income-generating activities and lack time for wood collection (Nnaji, Ukwueze, and Chukwu, 2012). On the contrary, Pundo and Fraser (2006) find that increase in the level of education of the wife is negatively correlated with the use of charcoal. The authors offer two explanations: (a) alternative fuels are not accessible, therefore, everyone uses firewood; (b) female servants may do wood collection and cooking (though such services are rare in rural areas).

Occupation can be a factor in energy choice by households. Women engaged in white-collar jobs use more charcoal and kerosene as opposed to firewood, which reflects their higher incomes and social status (Nnaji, Ukwueze, and Chukwu, 2012). However, in an earlier study this relationship did not hold true, possibly because women were underpaid and/or societal expectation of cooking with firewood prevailed (Pundo and Fraser, 2006).

Dwelling characteristics of households is indicative of energy use patterns. More rooms in a dwelling unit means less wood and more LPG use, which is paradoxical, but can be due to wealth affect, i.e. larger dwelling units usually belong to more affluent households who can afford commercial fuels (Heltberg, 2005). The assumption that households living in modern type dwelling units are likely to use firewood alternatives proved unsubstantiated in case of Kisumu district in Kenya (Pundo and Fraser, 2006). Richer households may prefer cleaner houses, but continue to use firewood because extra money is spent on priority needs, or there is a separate designated place for cooking (Pundo and Fraser, 2006). Relatedly, existence of internal cooking facilities was found to be associated with more charcoal and kerosene use in Enugu State, Nigeria (Nnaji, Ukwueze, and Chukwu, 2012). It could be explained by the characteristic that these energy carriers emit less smoke and thus, are better suited for use inside the house. Related to this smoke effect, Pundo and Fraser (2006) find that households renting the dwelling unit are likely to use charcoal or kerosene in order to avoid staining the walls and roofs. Another explanation is that households living in a shared dwelling unit are more likely to use LPG because of space constraints for storing firewood (Mensah and Abu, 2013).

Cultural factors influence household energy choice. Such factors as taste preferences and cooking habits, are difficult to capture theoretically and assess quantitatively (Heltberg, 2005). Nonetheless, some proxy indicators can be useful in revealing the effect of culture on energy use. Cooking practices matter for fuel choice. Households in urban Java, Indonesia consuming more steamed rice are found to use more energy (specifically, kerosene) compared to those boiling their rice (Fitzgerald, Barnes, and McGranahan, 1990). Cooking time is also an important indicator of fuel choice in that meals taking longer time to cook are cooked using firewood, whereas those taking shorter time are cooked using either charcoal or kerosene. This choice is partly motivated by higher prices of the latter fuels, which makes them more expensive for longer time cooking (Pundo and Fraser, 2006). Even in relatively well-off households "cultural beliefs may keep working women to a common culture and societal life style of using firewood" (Pundo and Fraser, 2006).

Many of the factors discussed above are applicable to the context of rural households in Tajikistan that are the unit of analysis for the present study. As far as economic factors are concerned, rural households do not have many income generating options; so they find it difficult to afford electricity for their cooking or heating needs. It is likely that they are spending a larger share of their income on energy sources. There is a culture of bread baking in traditional *tanoors* (vertically installed clay ovens of cylindrical shape) in which wood or dung is burned. The different types of bread baked in these *tanoors* are impossible to bake in an electric oven. Other factors may influence the decisions of households to follow certain energy use patterns. This study sets out to identify all the relevant factors and assess the level of control that households have over such factors. The extent to which households have control over these factors, then, is an indication of their energy sovereignty.

### *4. Methods*

A survey of 386 households was conducted in mountain areas of Khatlon region of Tajikistan from February to March 2015. The details of the survey design and implementation are provided under the Methods section of Chapter 2. The survey questionnaire asked participants to provide information on important factors influencing their energy use. Such information included demographic characteristics, such as age and gender; economic variables, such as income, assets, occupation, and energy cost; farming activities, such as ownership of land and livestock; as well as other variables including education, dwelling characteristics and cooking and heating preferences. These variables serve the basis for the analysis of results that follows in the next section. Similar to Chapter 2, the analysis used statistical and visual representation tools, including simple and multiple linear and logistic regressions, least square means comparison, boxplot, barchart, histogram, scatterplot, etc., which will be specified in the notes under the visuals, wherever relevant.

### *5. Results*

In rural areas of Khatlon region, households predominantly use wood and dung for their thermal needs. The use of these sources makes up the bulk of energy consumption of households. Therefore, wood and dung are regressed against a number of variables to assess the influence of the latter on the former. The choice of variables, shown in Table 24, Table 25 and Table 27, is informed by the literature, as well as interviews with study participants in the Khatlon region. In this section, the results of the analysis along with explanations are provided for each variable.

### Table 24: Summary of variables used in the analysis

| Variable | Mean | Min | Max | n |
|---|---|---|---|---|
| Wood per day (kg) | 37 | 3 | 130 | 380 |
| Dung per day (kg) | 23 | 3 | 75 | 357 |
| Income in cash (TJS) | 8,387 | 100 | 47,124 | 282 |
| Number of household assets (#) | 5 | 1 | 9 | 385 |
| Land area (ha) | 2 | 0.04 | 52 | 385 |
| Number of cows (#) | 4 | 1 | 20 | 332 |
| Number of sheep and goats (#) | 9 | 1 | 80 | 252 |
| Number of poultry (#) | 7 | 1 | 66 | 233 |
| Number of horses and donkeys (#) | 2 | 1 | 16 | 275 |
| Annual cost of energy (TJS) | 412 | 6 | 3,091 | 367 |
| Annual cost of wood (TJS) | 936 | 30 | 3,000 | 150 |
| Income spent on food (%) | 70 | 0 | 100 | 377 |
| Household size (# of people) | 8 | 1 | 15 | 386 |
| Head of household's age (year) | 51 | 22 | 85 | 386 |
| Children up to age 17 (#) | 3 | 0 | 8 | 386 |
| Adults ages 18 to 65 (#) | 4 | 0 | 11 | 386 |
| Elderly ages 66 & above (#) | 0.2 | 0 | 2 | 386 |
| Female in household (#) | 4 | 1 | 9 | 386 |
| Members with secondary education (#) | 12 | 1 | 27 | 386 |
| Number of rooms in dwelling (#) | 3 | 1 | 6 | 386 |
| | Yes | No | | n |
| Connected to grid (yes/no) | 351 | 31 | | 382 |
| Double-glazed window (yes/no) | 14 | 371 | | 385 |
| Insulation (yes/no) | 5 | 377 | | 382 |
| | Female | Male | | n |
| Head of household's sex | 21 | 365 | | 386 |

Source: Survey 2015.

### Table 25: Summary of education variable

| Variable | No education | Incomplete primary | Primary school | Middle school | Secondary school | Technical school | College student | College education |
|---|---|---|---|---|---|---|---|---|
| Head of household's education - % (n) | 1.05 (4) | 0.52 (2) | 2.09 (8) | 4.97 (19) | 41.62 (159) | 24.87 (95) | 7.85 (30) | 17.02 (65) |
| Head of household's wife's education - % (n) | 0.84 (3) | 1.39 (5) | 4.75 (17) | 12.85 (46) | 74.02 (265) | 3.91 (14) | 0.84 (3) | 1.12 (4) |

Source: Survey 2015.

Household members identified over 40 types of occupations. Three occupations were removed, as they were not associated with any income generating activity: primary and secondary grades students and young adults serving in the army (who receive token salary that they do not send home). The rest of occupations were grouped under nine categories as below:

**Table 26: Grouping of occupations by category**

| Category | Occupation |
|---|---|
| Agriculture | Farmer, farm laborer, shepherd, dekhkan farm member, veterinarian, agronomist, forester, casual laborer |
| Transport, communication, construction | Road maintenance, driver, telecom, bill collector, construction, geology (mining) |
| Trade, business | Merchant, artisan, accountant/banker, NGO employee, non-salaried other business |
| Civil service | Civil servant, military/police, conservation employee |
| Education & health | Teacher, librarian, education worker, doctor/nurse, lab worker |
| Other utilities, services | Guard/security, firefighter, school caretaker, janitor/cleaner, emergency worker, culture |
| Migrant work | Migrant worker |
| Pension | Pensioner |
| Irregular employment | Temporary work in any of the above categories |

Source: Survey 2015. Note: In reference to OKVED (Russian Classification of Economic Activities) which is also used in Tajikistan.

**Table 27: Summary of occupation variable**

| Variable | Agriculture | Transport, communication, construction | Trade, business | Civil service | Education & health | Other utilities, services | Migrant work | Pension | Irregular employment |
|---|---|---|---|---|---|---|---|---|---|
| Head of household's occupation | 15.80 (61) | 4.15 (16) | 13.47 (52) | 4.92 (19) | 11.66 (45) | 1.81 (7) | 2.85 (11) | 16.32 (63) | 29.02 (112) |

Source: Survey 2015.

### *5.1 Income*

Household income is measured in several ways. For the members who reported a cash earning activity, including a salary, pension or some business activity, they were asked to provide the best estimate of their earning for a month. This estimate was then converted to annual income, taking into account the number of months the income was earned (particularly for irregular sources of income). For those engaged in agricultural activity, they were asked to provide an estimate of how much cash they earned by selling of their farming produce, including fruits, dairy products, eggs, honey, etc. These estimates were reported for a year. The two estimates were then combined to represent household's annual cash income from all sources (CASHALL).

The annual cash income of households (in TJS) is positively associated with the amount of wood (in kg) used for all thermal needs (see Table 28). However, this association is neither statistically significant, nor of notable magnitude. Dung use is also positively related to income, and the association is statistically significant at $p<0.05$ (see Table 28). But the magnitude is rather small: for 1 TJS increase in annual income an increase of only 0.18 grams can be expected in daily use of dung. Nonetheless, the positive association between income and biomass seems to suggest that with improvement in economic wellbeing of household greater use of wood and dung can be expected. The causality direction can go either way: better-off households can afford to procure more biomass, or those who have access to cheap (or free) biomass incur little monetary costs, thereby saving more money.

**Table 28: Effect of cash income on wood and dung use**

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| Wood | | | | |
| (Intercept) | 3.683e+01 | 1.455e+00 | 25.310 | <2e-16 *** |
| CASHALL | 1.073e-04 | 1.315e-04 | 0.816 | 0.415 |
| Dung | | | | |
| (Intercept) | 2.098e+01 | 9.610e-01 | 21.829 | <2e-16 *** |
| CASHALL | 1.817e-04 | 8.648e-05 | 2.101 | 0.0366 * |

Source: Survey 2015. Note: The table shows two separate simple linear regression models ("lm" function in R). Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

### *5.2 Assets*

The number of assets owned by household – another indicator of economic wellbeing – positively affects the use of biomass as fuel. The assets include home, motorbike, truck, tractor, TV, DVD-player, satellite dish, washing machine, sewing machine, computer, internet, etc. Ownership of more assets can be viewed as a proxy to a better socio-economic status of household. Under such an assumption, and as the *energy ladder* would predict, the use of biomass should decrease because better-off households would be able to afford more efficient and expensive fuels, such as electricity or natural gas. However, this relationship was not observed in the context of Khatlon region. To the contrary, as shown in Table 29, with an additional asset a household can be expected to increase its wood use by about 2.2 kg and dung use by 1.4 kg (both are statistically significant at $p<0.001$). It could be inferred that the amount of biomass use is currently insufficient, and therefore, better-off households tend to use more of the same. The lack of adequate access to electricity or other fuels could be another reason for reliance on biomass.

**Table 29: Effect of household asset ownership on wood and dung use**

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| Wood | | | | |
| (Intercept) | 27.3472 | 2.7451 | 9.962 | < 2e-16 *** |
| AssetSUM | 2.1738 | 0.5808 | 3.743 | 0.00021 *** |
| Dung | | | | |
| (Intercept) | 16.2130 | 1.9495 | 8.317 | 1.97e-15 *** |
| AssetSUM | 1.4164 | 0.4099 | 3.456 | 0.000616 *** |

Source: Survey 2015. Note: The table shows two separate simple linear regression models ("lm" function in R). Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

### *5.3 Land and livestock*

Availability of land and livestock can also impact biomass use as fuel. Land requires fertilizer to cultivate crops, thus, competing with alternative use of dung as fuel. To the contrary, more land means more fodder (crop residue: stems, leaves, etc.) that can sustain more livestock and, therefore, make more dung available, that in turn can be used both as fertilizer and fuel for burning. More land can generate more money – either by selling harvested crops, or spending less cash on food. Availability of livestock can have a similar effect on household income. The additional money can be used, among other things, to purchase wood (or other energy sources); thus, resulting in less use of dung as fuel. Other animals such as horses and donkeys are important means of transport, including for bringing wood from distant locations.

As shown in Table 30, owning a cow affects household's wood use positively in that a household with an additional cow is expected to use about 5 kg more of wood daily ($p<0.01$). However, the addition of a hectare of land and a cow together reduce the quantity of wood use by about 0.8 kg ($p<0.05$). Furthermore, addition of a cow and poultry (chicken, turkey or duck) together influence a reduction of 0.3 kg in wood use ($p<0.01$). Similarly, adding one more sheep or goat and a horse or a donkey can translate into 0.3kg reduction in wood use ($p<0.1$).

**Table 30: Effects of ownership of land and livestock on wood use**

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| (Intercept) | 23.94898 | 6.10946 | 3.920 | 0.000148 *** |
| LandAll | 0.45152 | 2.08126 | 0.217 | 0.828622 |
| Cow | 4.93040 | 1.80436 | 2.732 | 0.007244 ** |
| SheepGoat | 0.02102 | 0.64717 | 0.032 | 0.974147 |
| Poultry | 0.08688 | 0.52315 | 0.166 | 0.868379 |
| HorsDonk | 1.96037 | 2.80727 | 0.698 | 0.486342 |
| LandAll:Cow | -0.78443 | 0.33924 | -2.312 | 0.022479 * |
| LandAll:SheepGoat | 0.01019 | 0.11414 | 0.089 | 0.929024 |
| LandAll:Poultry | 0.18717 | 0.15844 | 1.181 | 0.239808 |
| LandAll:HorseDonkey | -0.20892 | 0.50313 | -0.415 | 0.678709 |
| Cow:SheepGoat | 0.03596 | 0.04142 | 0.868 | 0.387002 |
| Cow:Poultry | -0.31250 | 0.11436 | -2.733 | 0.007243 ** |
| Cow:HorseDonkey | 0.20168 | 0.44581 | 0.452 | 0.651809 |
| SheepGoat:Poultry | 0.06409 | 0.05196 | 1.233 | 0.219901 |
| SheepGoat:HorseDonkey | -0.32060 | 0.18514 | -1.732 | 0.085935 . |
| Poultry:HorseDonkey | 0.09220 | 0.18324 | 0.503 | 0.615771 |

Source: Survey 2015. Note: Multiple linear regression with interactions (“lm” function in R). Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1.

Therefore, it could be argued that with an increase in area of land, along with an increase in number of animals the cost of tending to the same would also increase, thus leaving less spare money to be spent on purchasing and/or less spare time (and labor) to collect wood. Nonetheless, reduced wood use does not necessarily indicate inadequate energy access because households may use more dung to cover the shortfall. An important implication of wood use increasing with cow ownership and decreasing with addition of land and poultry is that different elements in the agropastoral system can exert contradictory influences on energy use. Therefore, the system as a whole should be considered to make better sense of rural energy use.

As for dung, shown in Table 31, an increase in the number of sheep or goats is associated with 1.6 kg increase in the use of dung ($p<0.01$). It is difficult to explain this finding, especially as sheep/goat dung is not used as fuel. Nonetheless, it can be inferred that, regardless of its sources, more dung is used as fuel because households owning more sheep/goats have more dung available to be used as fertilizer. Enlarging the land by one more hectare and adding another horse or donkey together translate into about 0.7 kg more of dung use as fuel per day ($p<0.1$). This finding contradicts the negative individual effect of land and draught animals on dung use. Perhaps, households having a combination of the two have more dung available or their current use has not reached the threshold beyond which income or substitution effects take hold. Addition of a cow and a sheep or a goat is expected to reduce the amount of dung use, though by a small amount of 0.06 kg per day ($p<0.1$). This finding appears contradictory because more cows and sheep/goat should yield more dung, which should lead to more dung use as fuel. However, the use of dung as fertilizer may be a higher priority for farming households. Moreover, the income effect of having more animals could be larger, translating into procuring more wood – thus, resulting in the substitution effect in the opposition direction, i.e. wood for dung. Overall, the push and pull factors further point to the need to consider the agropastoral system as a whole for energy use decisions.

**Table 31: Effects of ownership of land and livestock on dung use**

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| (Intercept) | 21.07389 | 4.89339 | 4.307 | 3.49e-05 *** |
| LandAll | -2.41765 | 1.63307 | -1.480 | 0.1415 |
| Cow | -0.57025 | 1.35107 | -0.422 | 0.6738 |
| SheepGoat | 1.64880 | 0.50374 | 3.273 | 0.0014 ** |
| Poultry | -0.05356 | 0.40769 | -0.131 | 0.8957 |
| HorseDonkey | -3.19732 | 2.21861 | -1.441 | 0.1522 |
| LandAll:Cow | 0.05371 | 0.25793 | 0.208 | 0.8354 |
| LandAll:SheepGoat | -0.02573 | 0.08838 | -0.291 | 0.7715 |
| LandAll:Poultry | 0.09284 | 0.12307 | 0.754 | 0.4521 |
| LandAll:HorseDonkey | 0.68506 | 0.39435 | 1.737 | 0.0850 . |
| Cow:SheepGoat | -0.06091 | 0.03213 | -1.896 | 0.0605 . |
| Cow:Poultry | 0.08382 | 0.08763 | 0.957 | 0.3408 |
| Cow:HorseDonkey | 0.55327 | 0.34221 | 1.617 | 0.1086 |
| SheepGoat:Poultry | -0.05798 | 0.04030 | -1.439 | 0.1529 |
| SheepGoat:HorseDonkey | -0.11712 | 0.14400 | -0.813 | 0.4177 |
| Poultry:HorseDonkey | -0.17877 | 0.13972 | -1.280 | 0.2033 |

Source: Survey 2015. Note: Multiple linear regression with interactions (“lm” function in R). Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1.

## *5.4 Energy cost*

The cost of energy is a combination of purchasing cost of wood, electricity, LPG, kerosene, batteries, and candles. This cost is aggregated for a year. As shown in Table 32, the aggregated energy cost for a year is positively associated with wood use; however, the relationship is not statistically significant, and the magnitude is very low.

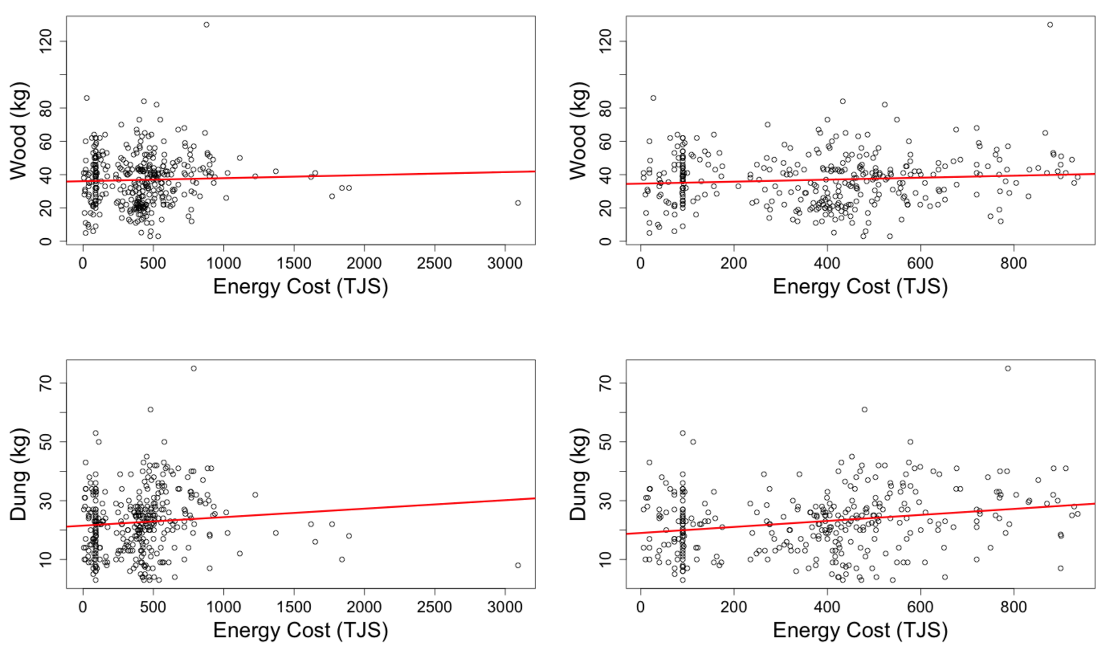
**Table 32: Effect of energy cost on wood and dung use**

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| Wood | | | | |
| (Intercept) | 36.066223 | 1.312271 | 27.484 | <2e-16 *** |
| EnergYrCost | 0.001832 | 0.002481 | 0.738 | 0.461 |
| Dung | | | | |
| (Intercept) | 21.502637 | 0.909767 | 23.64 | <2e-16 *** |
| EnergYrCost | 0.002896 | 0.001714 | 1.69 | 0.092 . |
| | | | | |
| Wood | | | | |
| (Intercept) | 34.595491 | 1.574835 | 21.968 | <2e-16 *** |
| EnergYrCost <1000 | 0.006008 | 0.003538 | 1.698 | 0.0904 . |
| Dung | | | | |
| (Intercept) | 19.014512 | 1.068400 | 17.80 | < 2e-16 *** |
| EnergYrCost <1000 | 0.010255 | 0.002419 | 4.24 | 2.92e-05 *** |

Source: Survey 2015. Note: Four simple linear regression models (“lm” function in R). Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1.

As for dung, the correlation is also positive and slightly significant ($p<0.1$). After removing the likely outliers beyond 1000 TJS (lower part of Table 32; also shown on the right panel of Figure 50), the correlation becomes slightly significant with wood ($p<0.1$), and highly significant with dung ($p<0.001$), and the magnitude of the effects increases as well. In particular, the amount of increase in use of dung that is associated with an increase by 1 TJS in annual energy cost is about 10 grams per day, which is very small. The positive correlation with both wood and dung indicates that households are procuring these energy sources even though the overall cost of energy increases. This could be due to the need for energy as a basic good, the price elasticity of demand for which seems to be inelastic. In other words, households need a certain amount of energy for survival, and they continue to bear the costs until such a point where an additional unit of energy is no longer crucial for survival. It seems from the analysis that households in Khatlon region have yet to cross that threshold. Nonetheless, it should be noted that the correlations are very weak (see right panel of Figure 50) and overall magnitude of effects is very small. Therefore, these findings should be treated with caution.

**Figure 50: Effect of energy cost on wood and dung use**




Source: Survey 2015. Note: Red line is a simple linear regression line.

## *5.5 Food expenditure*

Food is a basic need, but is more important for survival than household energy. When food and energy compete for scarce household budget, it is expected that food should get priority. Indeed, as Table 33 shows, the percentage of household income spent on food is negatively associated with the amount of wood and dung use. In particular, a 1% increase in monthly food expenditure can translate into about 0.12 kg reduction in daily use of both wood ($p<0.05$) and dung ($p<0.01$) use respectively. In other words, food takes precedence over fuel; therefore, with less energy either less cooked food would be consumed or home heating would be reduced or both. Either situation further confirms households being trapped in poverty. This is because lack of adequate access to food and energy has adverse impacts on health and educational attainments, and therefore, households are unlikely to improve their socio-economic wellbeing. Put simply, all efforts are devoted to ensuring these two basic needs, the demand for which is inelastic; thus, not leaving much to be devoted elsewhere.

**Table 33: Effect of food expenditure on wood and dung use**

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| Wood | | | | |
| (Intercept) | 45.96747 | 4.34125 | 10.589 | <2e-16 *** |
| FoodExpendPercent | -0.12323 | 0.06058 | -2.034 | 0.0427 * |
| Dung | | | | |
| (Intercept) | 30.85994 | 3.01011 | 10.252 | < 2e-16 *** |
| FoodExpendPercent | -0.11514 | 0.04193 | -2.746 | 0.00634 ** |

Source: Survey 2015. Note: Two simple linear regression models. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

The cost of energy can also impact how much is spent on food. The relationship is negative, as shown in Table 34, in that 1 TJS increase in the annual cost of energy can result in 0.007% reduction in monthly food expenditure ($p<0.05$). This is a very small fraction, which suggests that food is still more important. In fact, over 70% of household income is spent on food (see the intercept). Perhaps, because the percentage of income spent of food is so high, that a fraction of it can be devoted to energy, if the cost of the latter increases. In fact, as the analysis above (Table 32) revealed households continue to consume energy in the face of rising costs up to the point where it serves a basic survival need. Nonetheless, the tension between food and energy is an important factor in household decisions on resource allocation. This tension supports a situation of energy poverty among rural households in Tajikistan.

**Table 34: Food expenditure vs energy cost**

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| (Intercept) | 72.560304 | 1.326441 | 54.703 | <2e-16 *** |
| EnergYrCost <1000 | -0.006593 | 0.003005 | -2.194 | 0.0289 * |

Source: Survey 2015. Note: Simple linear regression model. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

### *5.6 Connectivity to electricity grid*

Electricity is a flexible energy source that can be put to variety of uses to satisfy lighting and thermal, as well as information and communication needs. It is also a much cleaner and efficient source than biomass, although it may cost more. Therefore, it can be expected that with access to electricity, households will use more of it, if the cost is affordable. Conversely, a reduction in use of biomass can be expected as a result. However, it is also possible that households will continue to use biomass along with electricity because each energy source satisfies a different energy need.

In case of the Khatlon region, households connected to the electricity grid do not seem to differ in their wood use compared to those not connected to the grid (as the association is not statistically significant; see Table 35). As for dung, there is a statistically significant difference ($p<0.05$) in household use of dung, namely, connected households use about 5 kg more. The positive correlation between connectivity to the electricity grid and wood and dung use suggests that households increase their biomass use when they have electricity. This finding is a further evidence to reject the *energy ladder* model, discussed in Chapter 2, because it contradicts the logic that with access to electricity (clean, efficient) the use of biomass can be expected to decrease. A possible explanation is that households connected to the grid substitute biomass for electricity when the latter is not reliable and/or expensive. In other words, due to connectivity they use more energy because they put energy to more uses. When electricity is not available (rationed), they end up satisfying their needs with greater use of biomass. Another explanation could be that households connected to the grid can afford to use more energy. As Table 36 shows, connected households earn more income compared to those not connected to the grid, although the difference is not statistically significant. Nonetheless, a key message from this analysis is that connectivity to electricity may lead to increasing use of biomass that could be due to increasing demand for energy that electricity seems to encourage. However, a reduction in biomass use may occur if electricity supply becomes reliable and also affordable.

**Table 35: Effect of connectivity to electricity grid on wood and dung use**

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| Wood | | | | |
| (Intercept) | 36.283 | 2.800 | 12.957 | <2e-16 *** |
| GridConnect | 1.171 | 2.919 | 0.401 | 0.689 |
| Dung | | | | |
| (Intercept) | 18.446 | 1.960 | 9.410 | <2e-16 *** |
| GridConnect | 4.569 | 2.043 | 2.236 | 0.026 * |

Source: Survey 2015. Note: Two simple linear regression models. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

**Table 36: Household income vs connectivity to electricity**

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| (Intercept) | 6145 | 1584 | 3.878 | 0.000131 *** |
| GridConnect | 2476 | 1648 | 1.502 | 0.134201 |

Source: Survey 2015. Note: Simple linear regression model. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

### *5.7 Household size*

Demand for energy can also increase as a response to increase in household size. A larger household would need more energy to satisfy the needs of all members compared to a smaller household. However, as shown in Table 37, household size does not seem to significantly influence the quantity of wood or dung used daily. In other words, regardless of the number of members, the amount of biomass use remains about the same for everyone. A possible explanation is that houses are built in the same way, and of approximately the same size, so the overall demand for heating energy is about the same. Moreover, households conserve energy by combining heating, cooking and water heating using one stove, and not heating other rooms in winter. Another explanation, which was pointed out earlier as well, is that demand for energy is inelastic when it satisfies basic needs. Therefore, small and large households end up using about the same amount.

**Table 37: Effect of household size on wood and dung use**

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| *Wood* | | | | |
| (Intercept) | 36.0044 | 2.4282 | 14.828 | <2e-16 *** |
| HSIZE | 0.1536 | 0.3025 | 0.508 | 0.612 |
| *Dung* | | | | |
| (Intercept) | 23.9160 | 1.7377 | 13.763 | <2e-16 *** |
| HSIZE | -0.1617 | 0.2157 | -0.749 | 0.454 |

Source: Survey 2015. Note: Two simple linear regression models. Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1.

## *5.8 Age*

The age of the head of household is another important demographic characteristic that can influence energy use. As Table 38 shows, however, in case of mountain communities in Khatlon region, the quantity of biomass use does not differ by how old (or young) the head of household is. In other words, the age of the head of household does not factor significantly in the decisions on biomass use as fuel.

**Table 38: Effect of age of head of household on wood and dung use**

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| *Wood* | | | | |
| (Intercept) | 38.30358 | 3.41846 | 11.205 | <2e-16 *** |
| HHHeadAge | -0.02237 | 0.06566 | -0.341 | 0.733 |
| *Dung* | | | | |
| (Intercept) | 21.90971 | 2.40834 | 9.097 | <2e-16 *** |
| HHHeadAge | 0.01526 | 0.04629 | 0.330 | 0.742 |

Source: Survey 2015. Note: Two simple linear regression models. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

Similarly, in terms of the number of household members that fall within three age groups of children (less than 17), adults (18 to 65) and the elderly (66 and above), there is no significant association with the amount of wood used on a daily basis (see Table 39). In other words, the age composition of household does not seem to influence wood use either. As indicated above other reasons, such as house design, energy conservation, and inelasticity of energy demand could be more influential that age or number of household members.

**Table 39: Effect of number of household members by age group on wood use**

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| (Intercept) | 36.91772 | 1.58302 | 23.321 | <2e-16 *** |
| AGE0to17 | 0.08004 | 0.43480 | 0.184 | 0.854 |
| (Intercept) | 36.2210 | 1.8161 | 19.94 | <2e-16 *** |
| AGE18to65 | 0.2253 | 0.3882 | 0.58 | 0.562 |
| (Intercept) | 37.2827 | 0.8630 | 43.203 | <2e-16 *** |
| AGE66up | -0.5028 | 1.5552 | -0.323 | 0.747 |

Source: Survey 2015. Note: Three simple linear regression models. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

As Table 40 shows, similar to wood use, the effect of two age groups, namely children and adults, is not significantly associated with dung use. However, the elderly group does have a statistically significant association with dung use ($p<0.01$). The association is positive, meaning that for every addition of a household member entering into the elderly age category there is a 2.95 kg increase in the amount of daily dung use in the same household. Put simply, households with more elderly members tend to use more dung. A possible explanation is that elderly members may be looking after livestock and making dungcakes more so than being physically able to fetch firewood from distant locations, or chop wood into smaller pieces to fit in woodstoves. Notably, the ownership of cows (main contributors of dung) is positively associated with the number of elderly in the household, although the relationship is not statistically significant (see Table 41). Another reason could be that older people may need to keep the house warmer, and therefore, burn more dung overall.

**Table 40: Effect of number of household members by age group on dung use**

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| (Intercept) | 23.7038 | 1.1025 | 21.501 | <2e-16 *** |
| AGE0to17 | -0.3263 | 0.3043 | -1.072 | 0.284 |
| (Intercept) | 23.5355 | 1.3125 | 17.931 | <2e-16 *** |
| AGE18to65 | -0.2000 | 0.2788 | -0.717 | 0.474 |
| (Intercept) | 21.9961 | 0.6021 | 36.530 | <2e-16 *** |
| AGE66up | 2.9507 | 1.0609 | 2.781 | 0.0057 ** |

Source: Survey 2015. Note: Three simple linear regression models. Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1.

**Table 41: Number of cows owned vs number of elderly in the household**

<table>
<tr><th></th><th>Estimate</th><th>Std. Error</th><th>t value</th><th>Pr(>|t|)</th></tr>
<tr><td>(Intercept)</td><td>3.4824</td><td>0.1802</td><td>19.324</td><td><2e-16 ***</td></tr>
<tr><td>AGE66up</td><td>0.3475</td><td>0.3062</td><td>1.135</td><td>0.257</td></tr>
</table>

Source: Survey 2015. Note: Simple linear regression model. Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1.

### *5.9 Gender*

The head of household’s gender can be another factor that impacts energy use. Similar to age, however, the gender effect is not statistically significant (see Table 42). Moreover, the number of females in a household does not seem to influence use of wood or dung either (see Table 43). In other words, there does not appear to be any gender bias as reported in the daily use of wood and dung. However, there are important socio-cultural expectations of women’s role in cooking that are discussed in sub-section 5.15.

**Table 42: Effect of gender of head of household on wood and dung use**

<table>
<tr><th></th><th>Estimate</th><th>Std. Error</th><th>t value</th><th>Pr(>|t|)</th></tr>
<tr><td>Wood</td><td></td><td></td><td></td><td></td></tr>
<tr><td>(Intercept)</td><td>37.1357</td><td>0.8126</td><td>45.701</td><td><2e-16 ***</td></tr>
<tr><td>HHHeadSex</td><td>0.6263</td><td>3.4566</td><td>0.181</td><td>0.856</td></tr>
<tr><td>Dung</td><td></td><td></td><td></td><td></td></tr>
<tr><td>(Intercept)</td><td>22.729</td><td>0.568</td><td>40.015</td><td><2e-16 ***</td></tr>
<tr><td>HHHeadSex</td><td>-1.041</td><td>2.683</td><td>-0.388</td><td>0.698</td></tr>
</table>

Source: Survey 2015. Note: Two simple linear regression models. Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1.

**Table 43: Effect of number of females in a household on wood and dung use**

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| *Wood* | | | | |
| (Intercept) | 35.8387 | 1.8808 | 19.05 | <2e-16 *** |
| FEMALE | 0.3707 | 0.4753 | 0.78 | 0.436 |
| *Dung* | | | | |
| (Intercept) | 24.1818 | 1.3263 | 18.232 | <2e-16 *** |
| FEMALE | -0.4141 | 0.3327 | -1.245 | 0.214 |

Source: Survey 2015. Note: Two simple linear regression models. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

### *5.10 Interaction of age and gender*

When accounted for together, the age and gender of the head of household showed a slightly significant association with wood use ($p<0.1$). As shown in Table 44, with one year increase in the age of a female head of the household there is an associated decrease of 0.59 kg in the amount of daily wood use. In other words, one could expect a household run by an older woman to use less wood, compared with one run by an older man.

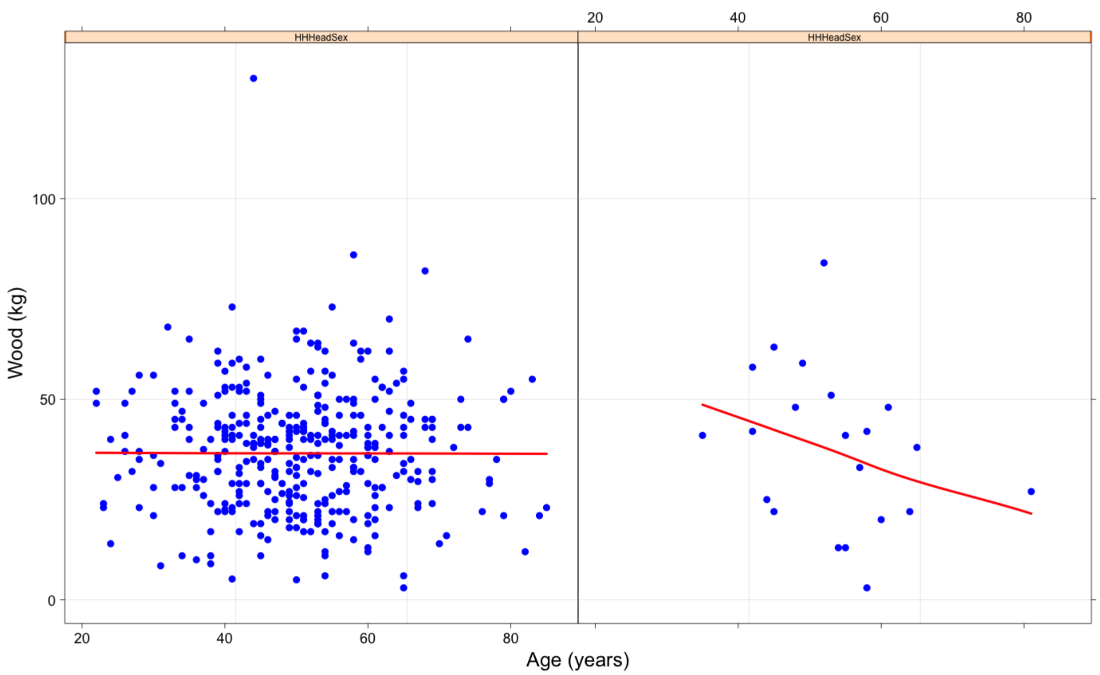
**Table 44: Effect of age and gender of household head on wood use**

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| (Intercept) | 37.1761861 | 3.4759030 | 10.695 | <2e-16 *** |
| HHeadAge | -0.0008028 | 0.0669447 | -0.012 | 0.9904 |
| HHeadSex | 32.5429430 | 18.7929183 | 1.732 | 0.0842 . |
| HHeadAge:HHeadSex | -0.5967944 | 0.3461519 | -1.724 | 0.0855 . |

Source: Survey 2015. Note: Multiple linear regression model with interactions. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

This relationship is graphically illustrated in Figure 51 (see right panel for female). This finding is in line with the elderly using less wood and more dung (see Table 39 and Table 40). No statistically significant difference was found between interaction of age and gender for dung use.

**Figure 51: Effect of age and gender of household head on wood use**



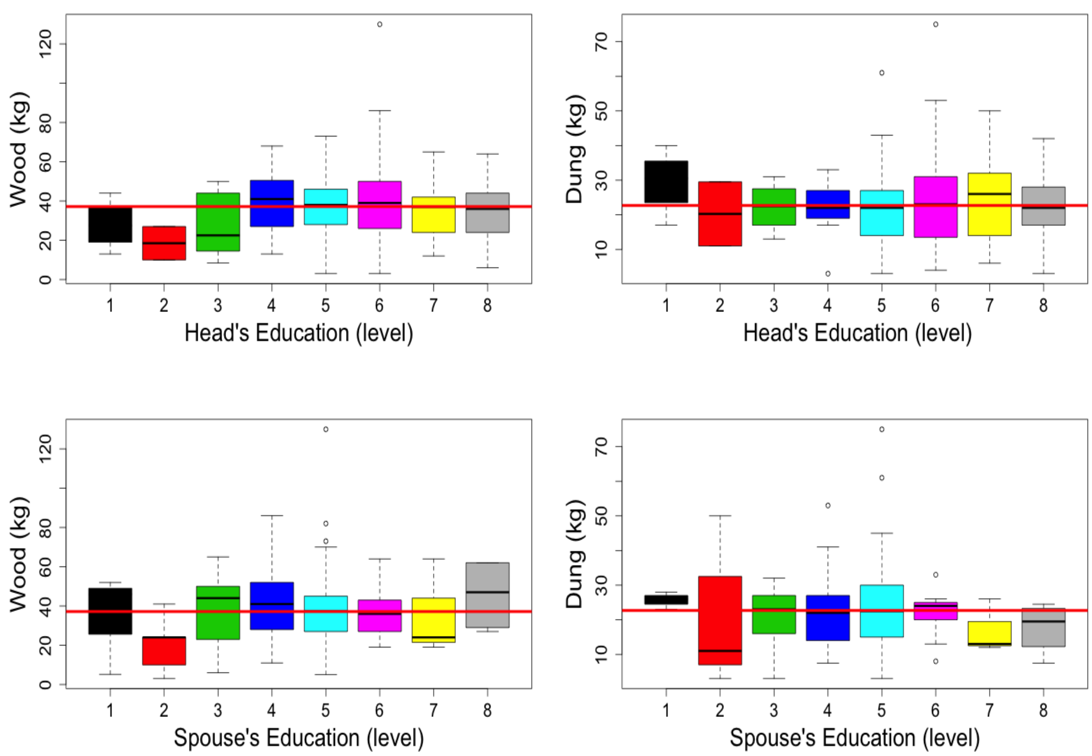

Source: Survey 2015. Note: Multiple linear regression model with interaction. Left panel for male, right panel for female. Red line is regression line.

### 5.11 *Education*

The level of education of household members can be an indicator of household energy use patterns. With better education household members are more likely to recognize the adverse impact of burning biomass on their health. Further, with higher education they can earn more money, and thus, afford cleaner sources of energy such as electricity. Taken together, the use of biomass can be expected to decrease in households with members attaining a higher level of education. However, as was discussed earlier, other factors also influence energy decisions.

The use of wood and dung, shown in Figure 52, may seem to vary by the education level of the head of household (upper panel) and her/his spouse (lower panel). However, comparisons of means (not shown) among pairs of education levels did not provide any statistically significant differences.

**Figure 52: Effect of education level of household head's and her/his spouse on wood and dung use**




Source: Survey 2015. Note: 1=No Education; 2=Incomplete primary; 3=Primary school; 4=Middle school; 5=Secondary school; 6=Technical school; 7=College student; 8=College education. Red line shows the mean wood/dung (kg). 'Head's Education' means household head's education, and 'Spouse's Education' means the education level of the head's spouse.

As for the rest of the household members, the number of those with secondary education or higher does not significantly affect wood or dung use either (see Table

45). It may seem unusual that education does not influence wood or dung use in Khatlon region. Two possible explanations can be offered. One is that access to alternative sources of energy, particularly electricity, is erratic. Second is that there are very few jobs in the villages, and even then, these jobs provide minuscule salaries that fall far short of satisfying household needs. Therefore, taken together, people will not be able to reduce their consumption of biomass even if they recognize its negative effects. This is yet another indication of households remaining in poverty.

**Table 45: Effect of higher education on wood and dung use**

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| *Wood* | | | | |
| (Intercept) | 37.153736 | 2.156211 | 17.231 | <2e-16 *** |
| SecEduOrMore | 0.001431 | 0.173669 | 0.008 | 0.993 |
| *Dung* | | | | |
| (Intercept) | 24.1638 | 1.5100 | 16.003 | <2e-16 *** |
| SecEduOrMore | -0.1280 | 0.1214 | -1.055 | 0.292 |

Source: Survey 2015. Note: Two simple linear regression models. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

### *5.12 Occupation*

Household members' occupation may affect the sources of energy used to satisfy household needs. Those engaged in formal jobs may not have time to collect wood or make dungcakes. They may also earn sufficient money to purchase wood as opposed to collecting it, and use less dung because they do not have time to prepare dungcakes. They can also buy a more clean and efficient source, such as electricity or

LPG. Depending on the type of occupation, then, households may follow different energy use patterns.

As shown in Table 46, daily wood use ranges between 33 and 54 kg, depending on the occupation of the household head. Comparison of means between different pairs (using Tukey method with Bonferroni correction) of occupations does show significance ($p<0.05$ and $p<0.1$) for four out of eleven pairs. It should be noted that Table 44 shows only the significant differences of largest magnitude among pairs.

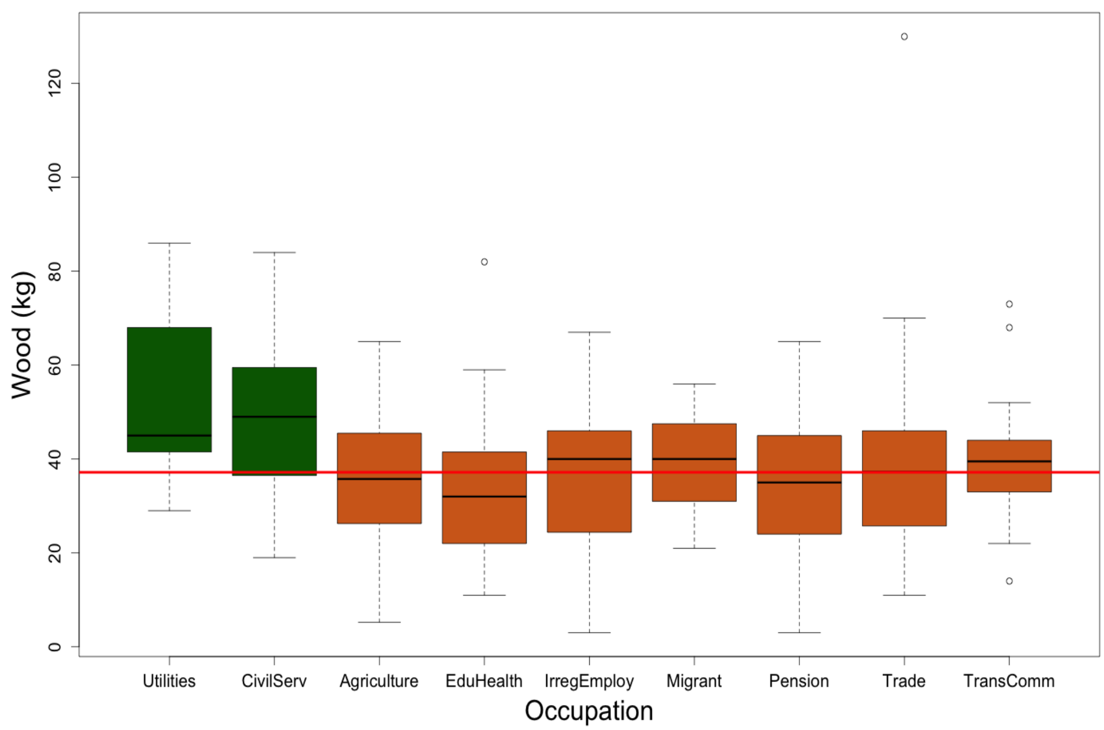
**Table 46: Daily wood use (in kg) by household head's occupation**

| Occupation | Mean (SE) wood use (kg) | | Comparisons by pairs (for >10kg only) | Mean (SE) difference of wood use in pairs (kg) | p-value |
|---|---|---|---|---|---|
| Agriculture | 36.11 (1.94) | | Utilities – Agriculture | 18.03 (6.02) | 0.0716 . |
| Transport, communication, construction | 40.38 (3.77) | | Utilities – EduHealth | 20.89 (6.15) | 0.0211 * |
| Trade, business | 38.50 (2.09) | | Utilities – Pension | 18.69 (6.01) | 0.0514 . |
| Civil Service | 47.11 (3.45) | | Utilities – IrregEmploy | 17.99 (5.88) | 0.0596 . |
| Education & Health | 33.24 (2.29) | | CivilServ – EduHealth | 13.86 (4.15) | 0.0259 * |
| Other utilities, services | 54.14 (5.70) | | CivilServ – Pension | 11.65 (3.95) | 0.0801 . |
| Migrant work | 39.27 (4.55) | | CivilServ – IrregEmploy | 10.95 (3.75) | 0.0872 . |
| Pension | 35.45 (1.90) | | | | |
| Irregular employment | 36.16 (1.44) | | | | |

Source: Survey 2015. Note: Pairwise comparison of means using Tukey method with Bonferroni correction. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

It is remarkable that the other utilities/services category is different from most of the other categories, and such differences range from about 18 to 21 kg, which is substantial. In other words, people employed in other utilities/services category use substantially more wood than those employed in other jobs. Other significant differences are between the civil service category and the categories of education and health, pension and irregular employment. The former uses more wood than all the latter categories, although the magnitudes are lower (about 14, 12 and 11 kg respectively). The graphical representation in Figure 53 (showing all categories) helps to illustrate the differences visually.

**Figure 53: Daily wood use (in kg) by household head's occupation**

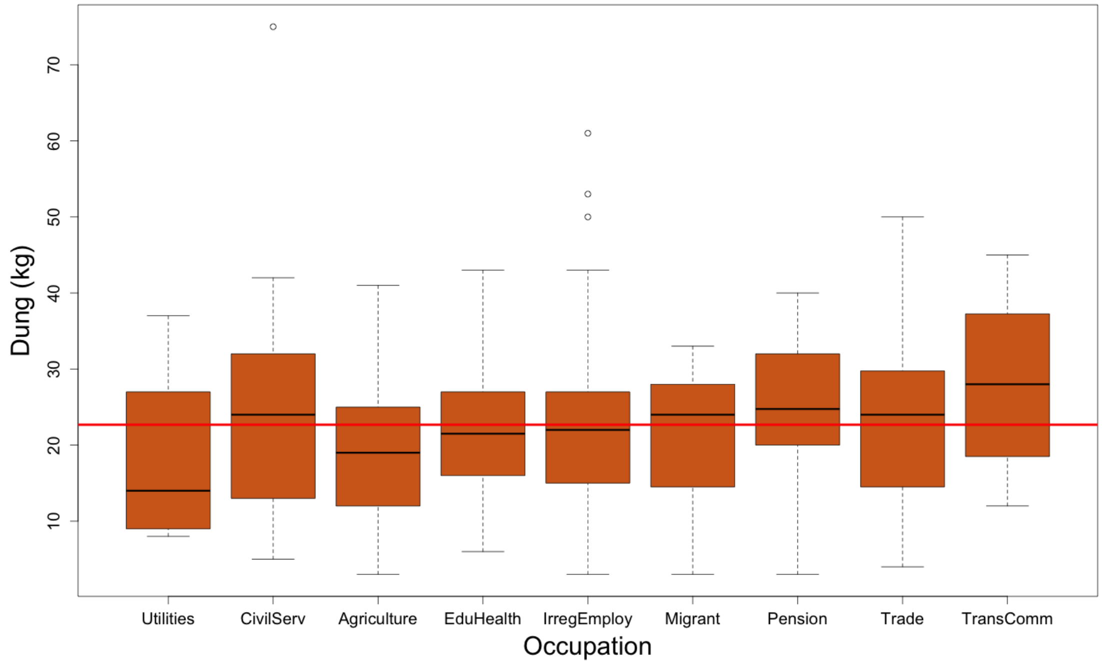



Source: Survey 2015. Note: Green color shows the two categories that are significantly different from others. Red line is overall mean (kg).

Overall, household heads employed in some sort of cash earning jobs tend to use more wood. This finding confirms the assumption that such households are likely to afford purchasing wood as opposed to relying on dungcakes for their source of fuel. Put simply, the opportunity cost of their time engaging in their occupations is higher than tending to livestock. For example, the civil service requires an employee to work full time; thus, leaving very little spare time for other activities, including agriculture. However, civil service cannot employ everyone; so majority of people in rural areas have few options to diversify their household income.

As for dung use per day, there is only one difference – between agriculture and transportation/communication/construction categories – that is statistically significant ($p<0.1$). It is interesting to note that the latter uses more dung (about 9 kg more). This could be because the jobs in this category tend to be seasonal and therefore, yield insufficient income to purchase more wood. It is notable that the magnitude of differences by pairs is substantially lower (ranging from 19 to 28 kg) compared to those in wood use (ranging from 33 to 54 kg; see Table 46). It can be inferred that households use about the same quantity of dung, regardless of the occupation of their household head. It is likely that because households do not incur monetary costs to produce dung, the influence of occupation is not so strong. This can be seen in Figure 54 as well.

**Figure 54: Daily dung use (in kg) by household head's occupation**




Source: Survey 2015. Note: Red line is overall mean (kg).

### *5.13 Interaction between occupation, cost of wood and income*

The differences in wood use observed among occupations could be due to the opportunity cost of procuring wood in terms of spending time or money. In effect, household heads may trade off their time and money as they see fit when they decide whether to collect/purchase wood or go about their jobs (thus earning money to pay for wood). Since wood is a tradable item in the villages, this relationship may be plausible. Therefore, this relationship is explored below by looking into household spending on wood purchase by occupation of the household head.

When comparing the annual cost of wood between the pairs (using Tukey method with Bonferroni correction; not shown), the relationship does not hold because no statistically significant difference is evident. It is possible that cost of wood in itself does not always impact its use when the role of household head's occupation is taken into account. Households with different occupations may use significantly different quantities of wood on a daily basis (as shown in Table 46) but pay similar prices to obtain wood in the first place. Three explanations are possible: a) the cost of wood is small enough that everyone can afford it; b) not everyone purchases a similar share of their individual annual wood stock; or c) relationships between households influence the price of wood (keeping it low) when vendors are neighbors to customers.

It should be noted that the household head may not always be the sole income earner in the household. Thus, it is also worth looking into income earned in the entire household to account for diverse sources of income by different household members. Table 47 shows the differences between pairs of occupations on their annual income that are statistically significant. Household income differs significantly for those household heads who work for civil service, agriculture, trade and business, education and health, transport, communication and construction or have irregular employment. This comparison helps only to explain the difference in wood use between the civil service and the irregular employment categories. The rest of income differences do not match up to the differences in use among the categories shown in Table 46. Therefore, it can be inferred that the household income does not much differ by the occupation of household head when it comes to wood use. Several implications arise from this finding: a) making more money is not necessarily positively correlated with using more wood; b) the type of occupation may influence wood use more than income (e.g. in terms of spare time after work); c) those who earn more spend it on something else, but not wood; or d) only a certain amount of wood stock is purchased for which all households have sufficient cash. Ultimately, the interactions among occupation, cost of wood, and income are not as simple as they appear in the first instance, and therefore, need further scrutiny to better understand the relationships.

**Table 47: Annual income by household head's occupation**

| Occupation | Mean (SE) income (TJS) | | Comparisons by pairs | Mean (SE) difference of income in pairs (TJS) | p-value |
|---|---|---|---|---|---|
| Agriculture | 6689 (1129) | | CivilServ – Agriculture | 6776 (2031) | 0.0266 * |
| Transport, communication, construction | 10779 (1740) | | CivilServ – IrregEmploy | 8342 (1919) | 0.0007 *** |
| Trade, business | 9914 (1177) | | IrregEmploy – Trade | -4791 (1489) | 0.0385 * |
| Civil Service | 13464 (1688) | | IrregEmploy – TransComm | -5657 (1966) | 0.0987 . |
| Education & Health | 10305 (1038) | | IrregEmploy – EduHealth | -5182 (1383) | 0.0067 ** |
| Other utilities, services | 8329 (2630) | | | | |
| Migrant work | 7130 (2201) | | | | |
| Pension | 8429 (930) | | | | |
| Irregular employment | 5123 (914) | | | | |

Source: Survey 2015. Note: Pairwise comparison of means using Tukey method with Bonferroni correction. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

## *5.14 Dwelling characteristics*

The size and property of houses can affect household's energy use, particularly for heating. A larger house requires more energy to bring up and maintain the temperature, compared to a smaller house. Whether or not a house is insulated is another important factor in heat retention.

The number of rooms in a dwelling appears to make a significant difference for wood use, but not for dung use. As shown in Table 48, for an additional room in a house there is an associated 2 kg more of wood use. This additional wood use could be due to the need to heat additional rooms.

**Table 48: Effect of number of rooms on wood and dung use**

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| *Wood* | | | | |
| (Intercept) | 30.5522 | 2.9799 | 10.253 | <2e-16 *** |
| NumRooms | 2.0103 | 0.8733 | 2.302 | 0.0219 * |
| *Dung* | | | | |
| (Intercept) | 20.9083 | 2.1664 | 9.651 | <2e-16 *** |
| NumRooms | 0.5362 | 0.6330 | 0.847 | 0.398 |

Source: Survey 2015. Note: Two simple linear regression models. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

Furthermore, the reason for wood use showing significance could be that it is better-off households that own larger houses (with more rooms). As indicated with wood use in relation to several variables above, these households may afford to buy wood, and thus use more of it compared to those who have smaller houses (with fewer rooms). It is also possible that smaller households live in larger houses and vice versa, which could influence their wood use. However, exploring the interactions among the variables shows a mixed picture (Table 49). The main effect of household cash income is negatively associated with wood use ($p<0.01$), meaning better-off households use less wood. Albeit the magnitude is very small: for 1 TJS increase in income 5.3 grams reduction in daily wood consumption is expected. But better-off households with larger houses (with more rooms) increase their daily wood use by 1.5 grams with an increase by 1 TJS of income and addition of a room. Larger households that are better off are also expected to use more wood, albeit by a very small amount. On the contrary, larger and better-off households living in bigger houses reduce their daily wood consumption. These mixed outcomes may indicate that there is tremendous diversity among households and therefore, it impacts their energy usage. Nonetheless, it should be noted that the magnitude of the effects of the variables is very small. In other words, the effects could change direction if circumstances change. This is another indication that flexibility in energy use is associated with diversity of livelihoods in rural areas.

**Table 49: Interaction of number of rooms, income and household size on wood use**

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| (Intercept) | 42.2200 | 17.3300 | 2.436 | 0.01549 * |
| NumRooms | -0.7302 | 5.1150 | -0.143 | 0.88659 |
| CASHALL | -0.0053 | 0.0018 | -2.856 | 0.00462 ** |
| HHSIZE | -1.0010 | 2.1780 | -0.460 | 0.64619 |
| NumRooms:CASHALL | 0.0015 | 0.0005 | 2.876 | 0.00434 ** |
| NumRooms:HHSIZE | 0.2417 | 0.6123 | 0.395 | 0.6332 |
| CASHALL:HHSIZE | 0.0005 | 0.0002 | 2.527 | 0.01207 * |
| NumRooms:CASHALL:HHSIZE | -0.0002 | 0.0001 | -2.571 | 0.01067 * |

Source: Survey 2015. Note: Multiple linear regression with interactions. Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1.

Installation of snug doors and double-glazed windows, as well as some sort of thermal insulation, can increase heat retention, and thus, reduce energy use. In Khatlon region, no snug doors were reported. As for the double-glazed windows, households having installed them use significantly more wood and dung ($p<0.05$), as shown in Table 50. The magnitudes of the difference from those without such windows are staggeringly high: about 59 and 41 kg more for wood and dung respectively. In contrast, the interaction of windows and number of rooms shows significant reductions in wood and dung use by about 15 and 12 kg respectively ($p<0.05$). In other words, households with double-glazed windows and larger houses use less biomass. Interactions with household income and size did not show any statistically significant associations with either wood or dung use. Nonetheless, these findings should be taken with caution because there are only 14 households with double-glazed windows in the survey (371 without such windows).

**Table 50: Effect of double-glazed windows and number of rooms on wood and dung use**

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| *Wood* | | | | |
| (Intercept) | 29.168 | 3.014 | 9.678 | < 2e-16 *** |
| Window | 58.779 | 23.825 | 2.467 | 0.01407 * |
| NumRooms | 2.398 | 0.888 | 2.701 | 0.00723 ** |
| Window:NumRooms | -15.254 | 6.579 | -2.318 | 0.02097 * |
| *Dung* | | | | |
| (Intercept) | 20.1865 | 2.1986 | 9.181 | <2e-16 *** |
| Window | 41.3135 | 18.0985 | 2.283 | 0.0230 * |
| NumRooms | 0.7739 | 0.6465 | 1.197 | 0.2320 |
| Window:NumRooms | -11.7739 | 4.8731 | -2.416 | 0.0162 * |

Source: Survey 2015. Note: Two multiple linear regression models with interactions. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

The association between house insulation and wood and dung use is negative, and statistically significant for dung use ($p<0.05$), as shown in Table 51. Households that have some type of house insulation use less wood and dung than those that do not have any insulation. The magnitudes of difference are large: about 31 and 50 kg less for wood and dung respectively. In contrast, when a household has some thermal insulation and more rooms, it uses about 7 kg more wood and 19 kg more dung per day – the latter being statistically significant ($p<0.01$). But no statistically significant associations were found between wood or dung use in interactions with household income and size.  Here again, the differences should be treated cautiously because the number of households with insulation was only five in the survey.

**Table 51: Effect of house insulation and number of rooms on wood and dung use**

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| *Wood* | | | | |
| (Intercept) | 30.1983 | 3.0338 | 9.954 | <2e-16 *** |
| Insulation | -30.8412 | 30.1586 | -1.023 | 0.3071 |
| NumRooms | 2.1597 | 0.8901 | 2.426 | 0.0157 * |
| Insulation:NumRooms | 7.4475 | 9.1737 | 0.812 | 0.4174 |
| *Dung* | | | | |
| (Intercept) | 21.5761 | 2.1718 | 9.935 | < 2e-16 *** |
| Insulation | -49.5761 | 20.3207 | -2.440 | 0.01520 * |
| NumRooms | 0.2920 | 0.6353 | 0.460 | 0.64611 |
| Insulation:NumRooms | 19.2080 | 6.1807 | 3.108 | 0.00204 ** |

Source: Survey 2015. Note: Two multiple linear regression models with interactions. Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1.

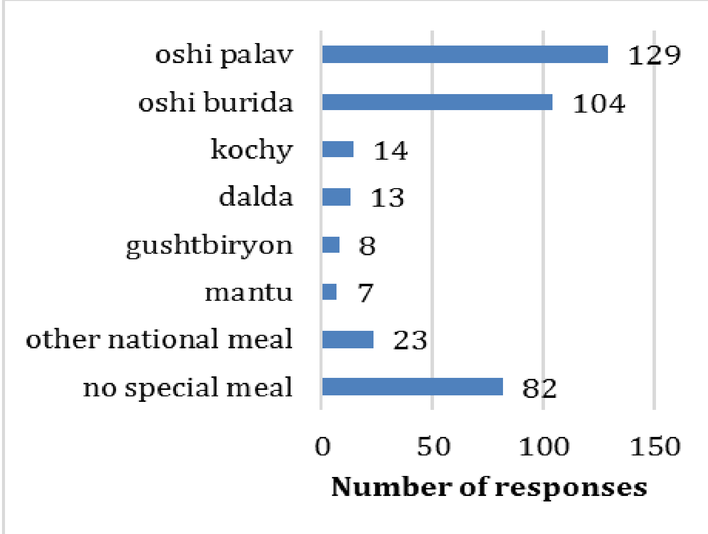
Overall, it can be inferred that dwelling characteristics exert a mix of influence on households’ energy use. There is heterogeneity in wood and dung use among households with different house and household sizes, income, and insulation. Small number of observations for double-glazed windows and house insulation suggests that these methods of energy conservation are very rare. Yet, going forward, these techniques may require a closer attention before wider application in rural areas, especially as associations of these variables with wood or dung use were shown to be mixed in case of Khatlon region.

### *5.15 Cooking and heating preferences*

Cultural preferences and social norms of a community can influence household energy decisions. Certain traditional meals are prepared using biomass, and local stoves that are more conducive than other forms of energy or other types of stoves. The important differences are in the techniques of food preparation as well as the perceived taste of food. Gender roles in food preparation are also important because social norms set expectations for division of labor. Therefore, socio-cultural factors should be considered in the analysis of energy use patterns.

In Khatlon region, a number of traditional meals are prepared using wood and/or dung. As Figure 55 shows, two meals – *oshi palav* (fried rice and meat) and *oshi burida* (homemade noodles) – are reported by majority of respondents to be cooked using only wood and/or dung. Both of these dishes are usually prepared in a big cauldron on open fire (see Figure 56).

**Figure 55: Special meals cooked using only wood and/or dung**



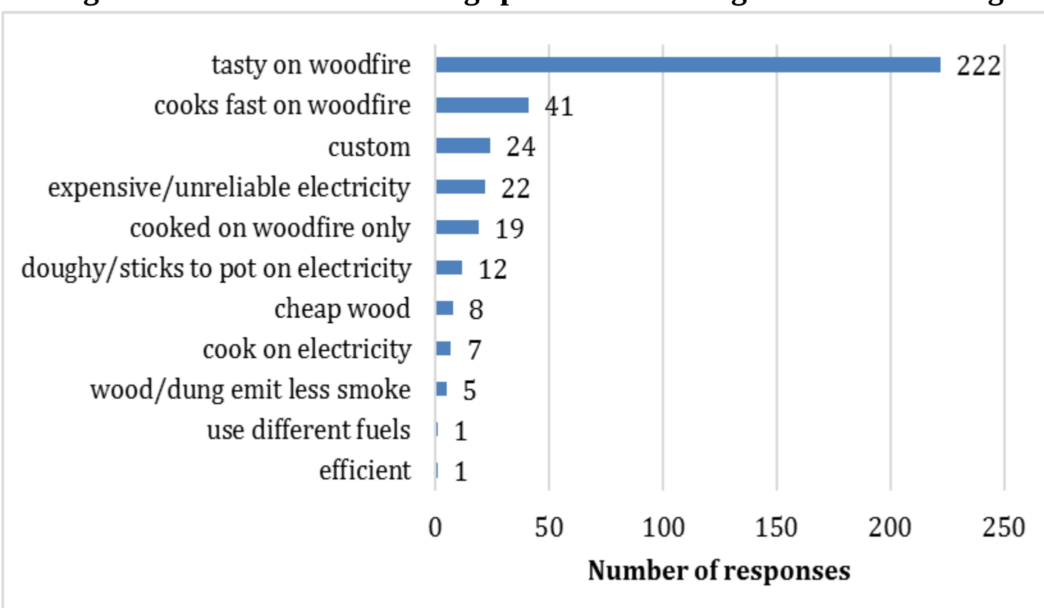

Source: Survey 2015.

**Figure 56: Cooking *oshi burida***

Source: Laldjebaev M. 2013.

The survey participants reported that these special meals must be cooked on open fire for several important reasons. As shown in Figure 57, the most common reason is taste of food. The participants shared that the meals cooked on open fire are tastier than if they were cooked using electricity. Moreover, cooking on open fire is more expedient. Another important reason is local customs of cooking meals on open fire. Apart from daily cooking, *oshi palav* is also cooked during various culturally significant events, such as weddings and funerals. When asked about why the special meals are not cooked using electricity, three main responses were provided: a) cooking these meals requires a lot of energy and time; thus, it becomes very expensive to use electricity; b) these meals are cooked solely on open fire; hence, electricity is not even considered; and c) the main ingredients stick to the bottom of the cauldron (pot) or become "doughy" (i.e. lose their consistency) if cooked on an electric stove. These reasons indicate practical challenges in food preparation when alternative sources of energy (in this case electricity) are used.

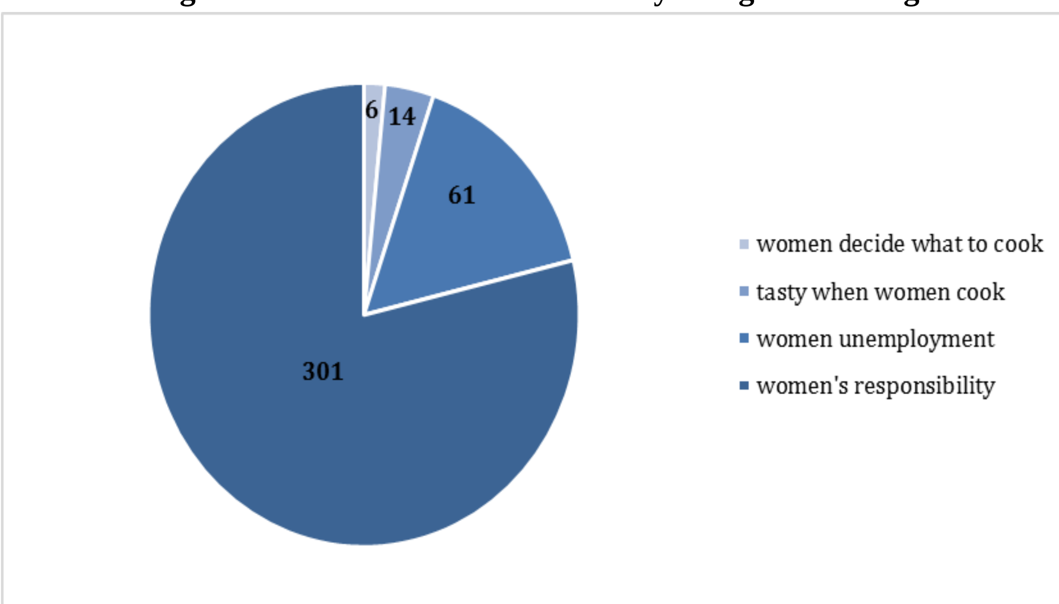
**Figure 57: Reasons for cooking special meals using wood and/or dung**




Source: Survey 2015.

It is also important to consider who does the cooking in the household. In Khatlon region, it is mainly women's responsibility, as shown in Figure 58. In other words, the social expectation is that women prepare daily meals for the households. It should be noted, however, that during cultural events usually men prepare *oshi palav*. On the other hand, *oshi burida* is prepared exclusively by women. Therefore, there is a differentiation in the roles of men and women in cooking that depends on the occasion as well as the type of meal. Furthermore, a large number of participants indicated that the main reason for women doing the cooking is that they do not have an outside job to go to. Whether or not this is taken for granted, the implication is that employment may be a significant factor in gender roles in cooking. Nonetheless, this factor is likely to challenge the current social expectations of who should be responsible for cooking if more employment opportunities for women become available. Notably, the reproductive role of women and looking after children may be an obstacle to their engagement in formal employment or other productive activities.

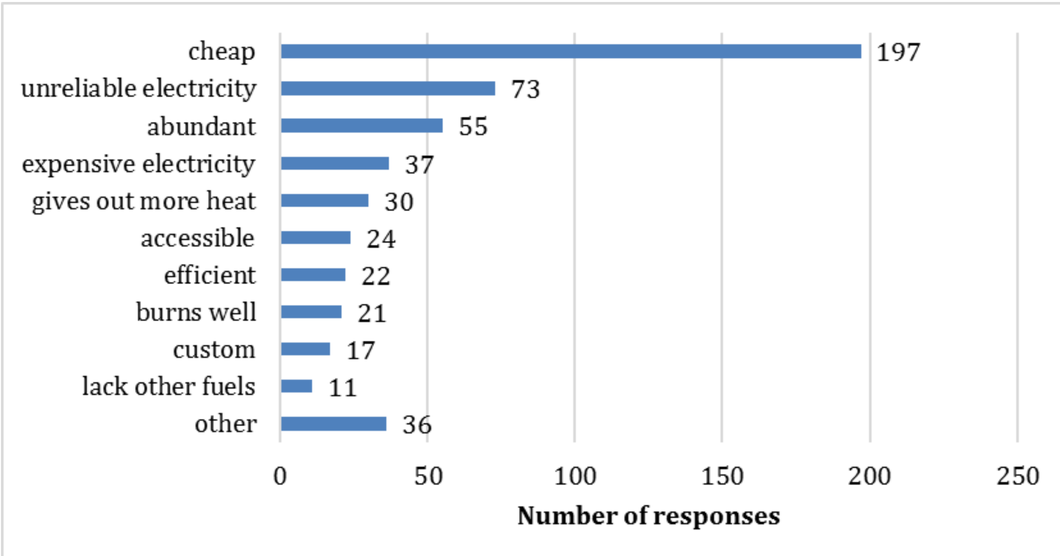
**Figure 58: Reasons for women mainly doing the cooking**




Source: Survey 2015.

Apart from cooking, households in Khatlon region use wood and dung predominantly for heating as well. Reasons abound, as shown in Figure 59, as to why this is the case. Foremost is the cost of biomass.

**Figure 59: Reasons to heat home wood and/or dung**




Source: Survey 2015.

Households perceive it to be cheaper to heat their homes using wood. Dung is sourced freely, albeit there is a cost in terms of time and effort to tending animals and preparing the dungcakes. Local biomass is also reportedly abundant and easily accessible. The next important reason is unreliability of electricity provision. Importantly, it is especially during cold months that electricity is rationed. This is due to the nature of electricity production that depends on flow of rivers since hydropower is the single source. Electricity is also perceived to be expensive, because heating requires a lot more of it than other uses, such as lighting or cooking. Furthermore, householders use wood and dung because these sources apparently give out more heat and burn well in local stoves. They also believe these sources are more efficient.

Efficiency of biomass is likely a misperception; however, for local people, it may mean expediency and low costs, as opposed to conversion of one form of energy (electricity) into another (heat). Use of biomass for heating is also a matter of custom in that people are used to this practice. Moreover, alternative fuels, such as coal or LPG are not readily available and likely to be costly than biomass to be used for heating. The diversity of energy use patterns indicates that a mix of affordability, reliability, accessibility, availability, property of energy source as well as existing ways of using energy sources exert influence in the decisions of households regarding how they choose to heat their homes. Therefore, this complexity requires consideration of multiple factors at the same time when provision of alternative sources of energy (e.g. electricity) is contemplated.

## 6. *Discussion*

The factors influencing household energy decisions can be grouped under economic, educational, demographic, technological, ecological, cultural and institutional considerations. The extent of influence of each factor varies and the factors interact with each other in important ways. Addressing energy poverty in rural communities, then, requires that these factors and interactions should be taken into account in designing the solutions to ensure they actually work. The role of local communities in this process is of critical importance.

### *6.1 Economics*

In rural areas of Khatlon region, the impact of household income in energy use is counterintuitive in that households use more wood and dung as their economic wellbeing improves. It can be argued that the volume of consumption is currently below a level that would suffice household needs. Therefore, this gap is being filled when households earn more money, a share of which is devoted to increasing their energy consumption. Using more biomass is also motivated by unreliability of electricity and lack of access to other energy sources. In this respect, this study supports the literature on reliance on biomass use in rural areas (Heltberg, 2005; Mensah and Abu, 2013), particularly the *energy stacking* model (Masera and Navia, 1997; Masera et al., 2000).

The cost of energy, including electricity bills, purchase of kerosene for lamps, batteries for flashlights, and candles, as well as wood for cooking and heating, is also positively associated with wood and dung consumption, which is again counterintuitive. In other words, as the annual energy costs rise households seem to use more biomass. In this sense, this study contradicts the findings in the literature on the negative relationship between fuel price and fuel use, and more generally, the *energy ladder* model (Fitzgerald, Barnes, and McGranahan, 1990; Heltberg, 2005). The positive association may be indicative of gap filling as well. Rising costs demonstrate higher expenditure to procure energy. In conjunction with improving economic wellbeing, it can be argued that households begin to satisfy the unmet demand for energy. Conversely, those who are not spending as much are not consuming as much. This under-consumption points to inadequate access to energy – a situation fitting the description of energy poverty. As energy costs and consumption of biomass head in the direction of increase, it can further be argued that households are making use of available energy sources – primarily because alternative sources are either unreliable (e.g. electricity) or unavailable (e.g. LPG and coal). Making alternative sources available and more reliable, then, could lead to a shift away from using biomass, as also suggested by others (Fitzgerald, Barnes, and McGranahan, 1990; Mensah and Abu, 2013). Yet, as the various reasons for using biomass discussed in this chapter indicate such a shift may not occur because each energy source is used to satisfy a different need. Therefore, accepting the use of multiple energy sources to meet diverse needs as a reality as opposed to theoretical expectations of moving up the *energy ladder* may pave the way to actually addressing rural energy needs.

Household budget places a constraint on how much energy can be procured. Basic needs are prioritized in household consumption of goods and services. Energy is one such basic need and households do allocate money to source energy, as is evident from their continued purchase of energy in the face of rising costs of energy. A more fundamental basic need is food, which can compete with energy for the scarce household budget. In the context of rural communities in Khatlon region, a dual relationship between food and energy is revealed. On the one hand, with increasing cost of energy food expenditure decreases. It means that households continue to procure more energy at the expense of food. On the other hand, consumption of wood and dung is reduced when more money is spent on food. The complex tension of food versus fuel implies that presently households are enduring a compound effect of food insecurity and energy poverty.

Being employed in some sort of cash earning jobs is associated with more wood consumption. It indicates that households can afford to purchase more wood, as it was found in case of working women using charcoal (Nnaji, Ukwueze, and Chukwu, 2012). It also implies that time and effort are devoted to earning income, a portion of which, then, is allocated to satisfying the energy needs. In a sense, occupation confirms the positive correlation between income and energy consumption. Therefore, it can be argued that expanding employment opportunities would allow households to better meet their energy needs. Further, they are currently spending money on wood because this source is available and reliable. They could reallocate this spending to purchase electricity or other fuels, such as LPG or coal, provided the latter are accessible and dependable.

In short, the economic factors do influence household energy decisions. However, the relationships are nonlinear, and other factors also impact household's use of certain energy sources. A key reason is that different needs (e.g. cooking, lighting, bread baking) are satisfied with different energy sources (e.g. wood, dung, electricity). Therefore, the challenge is to better understand the household energy needs and then make available appropriate energy sources to meet those needs.

### *6.2 Education*

In the context of Khatlon region, the level of education does not appear to affect the use of energy. In other words, no statistically significant difference was found in their consumption of wood and dung between households with members attaining more years of education compared to those with fewer years of education. This finding is not supported in the literature. A higher level of education does not necessarily mean higher income generation because there are few jobs in rural areas, and even then, the pay is low. Therefore, the differences emerge elsewhere, such as in people's occupation and household income in general, as discussed above. For education to influence energy use it is necessary to go beyond wood and dung because the value of education lies in the knowledge of adverse effects of biomass burning. However, due to inaccessibility and unreliability of electricity households predominantly rely on biomass, even though they may well be aware of the latter's negative health effects. This is another indication of lack of energy options that keeps household in poverty.

### *6.3 Demographics*

Demographic characteristics of households, including household size, and age and gender of household members can exert influence in household energy decisions. In Khatlon region, neither the size of the household nor the age of the household head or that of other members in the households exhibits any significant difference in terms of wood use. Again, these findings diverge from the literature. There is, however, a difference between households with members of elderly age in terms of dung use. Namely, they appear to consume more dung, which may be due to the elderly's physical ability to tend to livestock and prepare dungcakes as opposed to fetching firewood from distant locations or chopping wood to fit into stoves. As for the role of gender in energy use decisions, no significant difference is detected either. But the interaction between age and gender of head of household shows that households headed by an older woman use less wood. It could be due to availability of more dung that usually women make into cakes for burning. Apart from difficulty for older women to fetch wood from woodlands, they may not be able to afford buying wood either because most women in rural areas are unemployed. The fact that demographic characteristics do not strongly drive household energy use decisions provides additional evidence that current energy consumption is at the very basic level. Furthermore, given lack of access to other sources of energy it is unrealistic to expect differentiation in energy use patterns.

## 6.4 *Technology*

As was discussed above, energy options are limited. This also impacts availability of technologies to harness and convert energy to useful forms in order to satisfy household's needs. In Khatlon region, connectivity to the electricity grid is positively associated with biomass consumption. In other words, those connected to the grid use more wood and dung than those who lack access to electricity. Given that electricity supply is erratic it can be argued that connected households fill in the gap with more biomass when electricity is not available. Further, there is an associated income effect as connected household's annual income is greater; hence, they can afford more energy. The likelihood of a switch between biomass and electricity, then, depends on the reliability of energy source, as also found in other studies (Fitzgerald, Barnes, and McGranahan, 1990; Mensah and Abu, 2013). The current state of access to energy determines the kind of technologies that can be used in rural areas. Put simply, householders hold on to their wood stoves while they acquire electric devices that serve the same purpose. It should be noted that apart from unreliability of electricity, there are important socio-cultural reasons why households use certain technologies (see sub-section 6.6).

Another important technological consideration to energy use is materials and design of houses. Heat retention is a key concern in mountain communities that endure long and cold winters. Adobe houses may be good at natural climate control; however, concrete floors, thin roofs, single-glazed windows, and loose doors lead to substantial heat losses. Thermal insulation and installation of double-glazed windows and snug doors could reduce much of the losses, but only a handful of households have done such modifications to their houses. Granted, such additions can be very costly. Thus, when the cold arrives householders struggle to keep warm. Often they heat one room during the day and sleep in other rooms that are unheated. In brief, technological options can improve access to energy. The challenge is cost as well as appropriateness to the context and needs of local communities.

### *6.5 Ecology*

In rural areas of Khatlon region, people mostly engage in agro-pastoral livelihood strategy. They have small plots of land (1-2 ha), on which they grow wheat and vegetables. They also raise animals, including cows, sheep and goats for milk and meat. Such livelihood strategy requires a close relationship with the environment, which is also known as subsistence. It is within this system that energy use patterns of rural households take shape. Animals provide dung that is used as fuel. Woodlands are the main source of firewood. Leftover straw from crops as well as pruned branches from orchard trees provide woody biomass that is used as additional source of fuel. Put simply, the agro-pastoral activity is intimately linked to household energy use. The decisions to use more or less wood or dung are then impacted by what goes on in the system. For example, householders may want to keep more animals to have access to more dung. But more animals require more fodder, which means more land should be devoted to grasses or more fodder collected from woodlands. All of these require access to land, time and labor. Livestock also needs shelter, which means devoting a part one's property to a building instead of growing vegetables or trees. In other words, each element in the system can enable or constrain the decisions. Therefore, one must consider the entire system in order to understand energy use patterns and then, look for ways to improve the situation. In short, energy use is in sync with the local people's relations with their ecology, upon which they depend for their livelihood. Thus, efforts at improving access to energy options coming from outside the system need to integrate those options well into the system in order to be effective. One way to achieve this is to consider the many factors discussed in this chapter that impact energy decisions of rural households. Most importantly, a close attention to people's needs should be the first step before any sort of energy provision can be formulated. Ultimately, energy provision should be combined with consideration of rural employment and provision of social services (e.g. health and education) to make a tangible impact in terms of poverty alleviation.

### *6.6 Culture*

In Khatlon region, women are expected cook food and make dungcakes while men bring wood from forests. Unemployment is another major reason why women take on the responsibility for cooking, and other house chores. Women's reproductive roles is also very important to consider as it significantly impacts their employment options. Reliance on wood and dung is particularly strong for cooking special meals, such *oshi palav* and *oshi burida*. Apart from perceived better taste, expediency and traditional ways of cooking these meals on biomass, there are practical constraints to using electricity for cooking. These include cost, reliability and inappropriateness of electricity. Perhaps, as equally if not more importantly, cultural factors impact how meals are prepared, as other studies also revealed (Fitzgerald, Barnes, and

McGranahan, 1990; Masera & Navia, 1997; Masera et al., 2000; Heltberg, 2005; Pundo and Fraser, 2006).

Food is a known cultural product. Like any other cultural group, Tajiks also have a cuisine of their own. It is true that certain meals would be more or less preferred by individuals; however, there is a range of foods that are prepared and consumed by larger groups of people that share a certain identity. Food is also a marker of identity among other things such as place of origin, religion, social norms, etc. Certain types of food require a certain method of preparation that involves using an energy source in a certain way. Bread baking is a case in point. As Box 1 explains, the example of *chapoti* shows that food is not simply a type of bread that can be easily substituted for another because it serves an important social function as well. Therefore, its method of preparation is key to the quality of *chapoti*. It is due to such considerations that people prefer to bake their bread in *tanoors* using fire instead of electric ovens.

**Box 1: Cultural significance of *chapoti* bread**

Bread is a staple food in Tajikistan. There are different types of bread that are baked and consumed in different ways. For example, *chapoti* is thin round bread that is baked in the *tanoor* (vertical clay oven) that is heated by burning wood or dung. It is the first piece of dough that is slapped onto the red-hot wall of the *tanoor* and scraped off within two-three minutes as it bakes very fast. *Chapoti* is consumed with hot soups. When there is a large social gathering for some occasion in the household, *chapoti* and hot meat soup is the standard meal. The soup is served in *tabaq*, which is a large wooden dish of conical shape with flat bottom, and *chapoti* is torn into small pieces and dunked into soup. The meat is also cut into small pieces and left in the *tabaq*. Two or three people share a meal and eat *chapoti* and meat with their right hand. As they eat, usually they keep on adding *chapoti* to the soup until it is all soaked up, and finally one person finishes it up by scraping all the crumbs from the bottom and sides with a piece of *chapoti* until the *tabaq* is clean. Everyone is expected to clean their *tabaq* to show respect for the host. (Source: my observations in Khatlon villages, July 2013)

### 6.7 *Institutions*

Institutions can critically impact household energy decisions. In the Khatlon region, the government owns all the land and gives use rights to farmers. Such an arrangement could constrain the choice of farmers about what to grow in their fields. Because there is very little arable land available in the mountains, and the climate for some crops may not be suitable, farmers are not obligated to cultivate cash crops, such as cotton. So, they have latitude in their choice of crops.

Forests and woodlands are also owned by the state and farmers pay a certain fee to collect dry wood. During the interviews some participants indicated that the local forest agencies do not have adequate resources to look after the forests. They cannot monitor wood collection, let alone engage in forest rehabilitation. As a result, the need for firewood often leads to indiscriminate cutting of trees that has led to deforestation. In efforts to improve food security farmers also increased the number of their livestock. This increase has led to further damages because animals graze in the woodlands and eat the seedlings and saplings, thereby preventing the forest to come back. The farmers shared a concern that with this trend, all the forest will ultimately be decimated putting their livelihoods in danger. However, they look to the government to remedy the situation, perhaps because the forest is state-owned. Ineffectiveness of the state institutions is of great concern to the future of forests and woodlands.

A community-based forest management scheme could be an alternative. But the design of such a scheme requires strong local institutions that seem to be lacking at present. Part of the reason for such state of affairs rests with the continued legacy of the former Soviet Union that effectively decimated local institutions of civil society in favor of central governance. As the central governance is failing at its task, perhaps the time has come to reinvigorate local institutions and devolve the authority to local people to manage local resources. There are some efforts towards this end by nongovernmental organizations, such as GIZ in GBAO region. Preliminary findings from pilot projects suggest that there is some promise in this approach as forest cover improved, at the same time contributing to people's livelihoods (Mislimshoeva, et al., 2013). Therefore, it is well worth learning from such pilots as well as from international experience in community forestry to help reverse the deforestation trends in Khatlon region. This is a necessary effort as rural people depend on forest products for their survival.

As for energy provision, particularly electricity, local people also look to the government to ensure reliable and affordable supply. Again, the legacy of electrification is still strong. However, it need not constrain alternative options that can come from small-scale technologies, such as solar, wind, and biogas devices. The role of private sector is currently very weak in the energy market. Incentive structures may need to be put in place to attract entrepreneurs and develop new business opportunities in energy provision and service. Rural households are already paying for energy; therefore, a local energy market has a potential to be developed.

In short, the institutions of state, market and civil society are presently incapable of ensuring quality access to energy and sustainable use of local resources. Such a situation leaves individual households on their own to find ways to meet their energy needs. There is a lot of potential in community development and private sector mobilization that is left untapped. Involvement of local people in the management of forests as well as incentivizing the entrepreneurs to start business in energy provision (through small-scale technologies) could be a starting point to addressing the problem of energy poverty in rural areas. The state alone cannot and should not be expected to fix the problem.

### *6.8 Food and energy sovereignty to solve energy poverty in Tajikistan*

In view of the above factors influencing household energy decisions, analysis of options for improved access to energy requires priority attention to *energy services* – at the very least to lighting, cooking, space heating, cooling and information and communication. The underlying reasons or rationale for using certain energy sources need to be revealed so that people's preferences and values can be taken into account when weighing different options. In order to enable poor households to move out of energy poverty, the energy access options should critically include the component of *energy for earning a living* as well as *for community services* (Practical Action, 2014). These components enable the households to improve their living conditions by engaging in productive activities, staying healthy and getting educated. In other words, the enabling conditions should be created through provision of relevant forms of energy so that energy poverty can be eradicated.

Efforts to reduce and subsequently eradicate energy poverty need to go hand in hand with improving people's capacity to address their livelihood challenges. This is captured under the concept of *energy sovereignty*, which requires that conditions need to be created so that people can exercise their abilities and realize their full potential beyond satisfying their basic needs. The idea of improving access to energy services suggests that people have various needs and the latter can be satisfied by deploying variety of energy sources. In other words, the emphasis is on the services that energy forms make available. The question of how energy services should be satisfied is a normative one that cannot be answered without involvement of intended beneficiaries of services. This realization opens a door of opportunity to address the issue of poverty with improved access to energy.

As an illustration of how this opportunity can be realized, the relationship between food and energy provides a prime example. Because food and energy are interconnected the processes of food and energy sovereignty are mutually reinforcing. Under conditions of energy poverty, the relationship is negative as, for instance, lack of energy exacerbates food availability and consumption. The interactions are discussed in greater detail below.

In rural areas of Tajikistan, most of the people engage in agriculture for their livelihood. It includes cultivation of land and rearing of livestock. Most of the households are small-holders with around $1-2$ hectares of land, on which grains (wheat and barley) are cultivated as the main subsistence crop. It is not unusual to allocate about a quarter of the land to grow potatoes, which is another major staple. Households also have a small parcel of land as kitchen gardens where they grow vegetables, including carrots, onions, cabbage, tomatoes and cucumbers. The gardens tend to have some fruit-bearing trees such as apricots, mulberries, apples, pears, walnuts, cherries, and grapes. Non-fruit-bearing trees of salix and populus species are also planted as they can be used for construction purposes. Some households allocate a part of their land to growing fodder (most commonly alfalfa); however, the size of the allocated parcel varies significantly depending on the need for fodder as well as availability of other means of obtaining fodder, such as collecting grass that grows widely in common use lands or buying it from neighbors who have excess. Fodder is mostly obtained at the harvest of grain crops by gathering the stems and leaves that remain after threshing. As for livestock rearing, people usually keep between one to four cows, a bull, and five to ten sheep and goats. Some raise chickens for eggs, some have a donkey or a horse.

With household size of seven to eight people on average, there is plenty of work for everyone, however, not sufficient output to provide for everyone's wellbeing. The parcels of land are so small that they are restricted to cultivation of only one crop, namely wheat, which is the desired crop that is the basis for the main staple food, which is bread. The reasons for limited access to land are many, but most commonly it is due to physical unavailability. Because most of the terrain is mountainous (93% of the country) actual arable land area is limited. Availability of water is another constraint.

The available land under cultivation is often degraded as a result of monocropping and lack of access to fertilizers; hence, the yields are low. In some cases land is abandoned because output is not worth the effort. As a local source of fertilizer, animal dung is available in good supply. However, it is mostly burned to satisfy household's cooking and heating needs. This competition for the resource arises from lack of access to other energy sources. Because the yields are low and insufficient to subsist on, households have to purchase food to make up for the shortfall. This requires access to cash, which households try to secure by engaging in beyond farm activities. Some members do not work full time on the farm, but take a job as teachers, doctors, or government employees depending on their training and availability of jobs. Others migrate to larger farms and cities as well as to other countries abroad for seasonal employment. Earning cash is important in rural areas not only to satisfy food consumption needs, but also to pay for a range of other necessities. A major need for cash is to pay for electricity bills and replacement or repairing of electric devices, including stoves and lightbulbs. Wood is not freely available, as it may appear at first. Because all forests belong to the state, households pay a certain fee[14] to the forest service agency to collect wood. Some households that do not have any livestock buy moist dung from their neighbors and press it and dry it under the sun for subsequent burning.

Food and energy expenses compete for limited amount of cash that is generated mostly out of farm. Rural households juggle between these two major needs and other expenses such as clothes and shoes, school uniforms and books, farming equipment and house repairs, celebration of holidays and weddings, and supporting neighbors in their solemn occasion. Trade-offs are not easy to make as each household

[14] According to Kirchhoff & Fabian (2010), in GBAO region 1 $m^3$ of firewood with thicker branches was 70 Somoni; 1 $m^3$ of firewood with small coppice twigs was 40 Somoni in 2010 (exchange rate of US$1 = 4.4 Somoni). In Khatlon region, the reported cost was about 80 Somoni for self-collection, but some households bought from private vendors at a rate of about 1000 Somoni per truckload (reportedly 2-3 $m^3$ of mostly thick logs).

may guide its decision by using a set of criteria that may be different from that of another household. These decision criteria are important to take into account because they determine the priorities that people place on different things. With regards to energy services, household decisions are particularly important to consider firsthand in order to match the form of energy as closely as possible to the desired energy need. Failure to do so would result in provision of a form of energy that is not used or under-used for intended purpose. A prime example of this is evident in the use of electricity for cooking in rural areas.

In the summertime when electricity is physically available through connection to the national grid, households continue to use fuelwood or dung to cook their meals. As there is a limited amount of cash available, households tend to ‘economize’ on using electricity by burning biomass. In other words, there is only so much that households are able to allocate for their electricity consumption. It follows that increasing availability of electricity in wintertime - when its supply is currently erratic - may bring relatively less comfort due to its limited consumption. To facilitate increased consumption, either the price of electricity should be lowered or a safety net be designed to cushion part of the burden. Another solution is to increase cash availability for households through increasing their income earning opportunities. Their opportunities are constrained in the way they make use of the resources at their disposal. If dung were not burned but used as fertilizer in the fields, the yields would increase, which in turn would reduce the need for purchased food, and thus free up some cash for alternative uses. This money could be used to pay for additional electricity consumption to displace more of dung use an energy source. A positive feedback loop could subsequently result in improved access to modern energy services (electricity) while improving food security (by using dung to replenish the soil).

The above scenario shows that there are potential solutions to energy and food security at the local scale. It can be realized through processes of food and energy sovereignty, namely by assisting local people in better utilization of their local resources as well as providing better access to resources outside the village boundary. To refer once again to the example of dung for intended energy service of cooking, it is possible to convert dung into biogas. This is a better approach because the remaining slurry after using up all the gas can still be applied as fertilizer - thus, retaining its usefulness for agriculture as well. Assisting local people in installation of biogas digesters would be more beneficial and locally relevant than investing in greater centralized electricity production capacity and provision through the grid.

What is important in the analysis of energy options for poverty reduction is as much about technical and economic feasibility as it is about the extent to which it contributes to local economic development through satisfaction of energy needs. In the example of electricity and dung the focus was on cooking as energy service, which is a household consumptive use of energy. The changes in the volume and transformation of the energy sources can bring about positive results as discussed above. However, their contribution to local economic development and poverty reduction is relatively limited. The category of energy for productive uses holds a greater potential towards that end, for example, as motive power for agriculture. Furthermore, using electricity in agriculture can be extremely beneficial. Water pumping can bring new fields into use, thus increasing overall food availability. Use of electric threshers and electric mills can save days of manual work. Apart from out of home activities, electricity can be useful to run home-based businesses, such as dairy processing. Access to greenhouses and cold storage can make more produce available at critical times of the year. In short, access to modern energy services can create enabling conditions for efforts targeted at poverty eradication and improving of living standards in rural areas of Tajikistan.

## *7. Conclusion*

Many factors influence the decisions of energy use at the household scale. Based on the survey of households residing in mountain areas of Khatlon region, economic, technological, ecological, cultural and institutional factors are found to be most influential, whereas educational and demographic factors least influential in determining energy use patterns. This study shows that household consumption of energy, particularly wood and dung, are insufficient to meet their needs. This is evident in the way households increase their use of biomass when their incomes increase and even when energy costs rise. The same is true of households connected to the electricity grid, owning larger houses (more rooms), and engaging in income earning jobs. Therefore, households seem to be filling a gap in their energy consumption when they are more capable to do so. There may be some threshold that has not been reached yet to allow people to reduce their reliance on biomass. Future research is needed to further investigate the existence of such a threshold as well as the gap-filling strategy. Reliability, abundance and affordability of biomass lead to its greater use as opposed to electricity use. There is competition between food and fuel for household budget as well as for cultivation of land (e.g. dung as fuel or fertilizer). Food taste and methods of preparation along with social expectations of women's responsibility for cooking (which is partly motivated by their unemployment and reproductive roles) further encourage reliance on biomass. There are mutually reinforcing relations between food and energy in farming communities. Ultimately, the agro-pastoral system determines how energy is used at the household scale in rural areas. More importantly, the institutions of state, market and civil society are currently underperforming in their respective roles to improve access to energy for rural households.

The influential factors are absolutely crucial to be taken into account both in the analysis of household energy use and the efforts to improve energy access. Beyond the relevance of each factor in its own terms, it should be recognized that they interact with each other in important ways. For example, improvement in economic wellbeing may enable a household to buy an electric device for cooking. However, the cultural preferences for food (e.g. bread) may require that the electric device be suitable for the purpose, or else it will not be used. Therefore, regardless of how much their income improves people will continue to burn biomass. But in the long-run, assuming mismanagement of forest resources is not addressed, biomass availability will reduce, which will threaten the cultural continuity of bread baking. In this example all influential factors interact with each other and over time create nonlinear relations. The task of ensuring quality access to energy, then, becomes very difficult.

In short, a plethora of socio-cultural and ecological factors influence household energy decision-making in rural areas of Tajikistan. While some of the factors may be within control of local people (e.g. changing cooking habits), many are clearly out of their reach (e.g. changing electricity price). Not surprisingly, these factors interact in myriad ways and their influence is hard to plan for and therefore, predict. Nevertheless, programs and projects aimed at eradicating energy poverty and improving energy security need to take these factors in account in order to be successful. Reliance only on technical and economic efficiency is clearly insufficient. Ecological, institutional and cultural characteristics of target population should be well-studied and then incorporated into energy solutions. Local people should not only be involved in all stages of energy provision projects but, in fact, they should drive the initiatives to improve their wellbeing through satisfying their energy needs. This is what energy sovereignty ultimately entails.

## CONCLUSION AND POLICY IMPLICATIONS

The importance of access to energy is rising in the global agenda owing to increasing recognition of its role in poverty reduction and climate change adaptation. The new Sustainable Development Goals, adopted by the United Nations on September 25, 2015, included "ensur[ing] access to affordable, reliable, sustainable and modern energy for all" as a goal to be achieved by 2030 (UN News Center, 2015). This goal is important because 1.3 billion people (18% of global population) lack access to electricity, and 2.6 billion (38% of global population) rely on burning wood, dung and other biomass in polluting stoves that cause respiratory diseases. Moreover, 95% of these energy-poor people live in sub-Saharan Africa or developing Asia, and 84% live in rural areas (IEA, 2015). This dire lack of access to basic services exacerbates poverty and further increases vulnerability to external shocks. Access is constrained by various factors, including physical and economic scarcity of resources, inadequate provision by public or private sector entities, and outside pressures such as climate change. It is important to recognize that fossil fuels (coal, oil, gas) may not be the best solutions to energy poverty because they emit greenhouse gases that accelerate climate change. Renewable sources such as solar and wind power along with energy efficiency are more climate-friendly and pro-poor. As also recognized by Practical Action (2013), there is critical need for further research to better understand the co-benefits of energy access and adaptation at the local level to inform our responses.

As a developing country, Tajikistan also experiences severe problems with energy access. Although over 90% of households in the country are connected to the electricity grid, access to electricity is neither reliable nor affordable. During winter, when energy needs are particularly acute, households experience daily blackouts. This lack of access is due to key vulnerabilities of the energy system that include insufficient energy production capacity, unreliable and expensive energy imports, dwindling power infrastructure causing technical and economic losses, inadequate transparency in the power sector, lack of regional cooperation in energy and water resource sharing, and inadequate financial resources to address all of the above.

Energy poverty reflects the current condition of access to energy services in rural areas of Tajikistan. Although rural households do demonstrate resilience in the face of intermittent energy provision, their reliance on using biomass has repercussions for their quality of life. Rural communities continue to rely on solid biomass (wood, straw, animal dung) to meet their thermal energy needs. Removing crop residues and animal dung from fields to burn for heating and cooking leads to soil degradation and lower agricultural productivity. Air pollution from burning biomass indoors adversely affects human health. Women and children spend many hours to collect biomass from distant locations as nearer woodlands have been depleted. Deforestation causes more soil erosion and leads to disappearance of wild plants and animals that communities depend on for food, medicine, clothing, household tools and cultural festivals. The forest is home to wild plants and animals whose survival may be increasingly threatened. Therefore, meaningful efforts are needed towards reforestation and providing alternative sources of energy to reduce the pressure.

## 1. *Policy implications and recommendations to alleviate energy poverty in Tajikistan*

In order to address the pressing challenge of energy poverty, the following strategies are recommended.

### *1.1 Securing access to energy improves resilience and livelihoods*

For rural communities in Tajikistan, access to energy is crucial to improving livelihoods. Beyond satisfying basic needs such as cooking and heating, reliable access to electricity increases productivity as people mechanize agricultural activities such as milling and processing, run factories and shops with better lighting, and extend the shelf lives of products and vaccines through refrigeration. Evidence suggests that such improvements in turn contribute to resilience because communities can tap into their enhanced capacities and diversify their livelihoods. Educated and healthy men and women with access to energy are more productive, and therefore better-off than those who are not. Furthermore, energy supply systems provide jobs and livelihoods for many people.

Burning animal dung instead of applying it in the fields impairs soil fertility. It means that farmers risk losing their most important source of livelihood, when nutrients are not returned to the field. Alternative strategies, such as use of biogas digesters, can provide a means to maximize the value of dung for both heating (gas) and fertilizer (slurry). Given that the temperate zone and rocky substrate are major obstacles to deployment of such technology, some above-ground units have been experimented with varying degrees of success. Such projects lack necessary investment to further refine the technologies to provide for households' thermal needs.

### *1.2 Building the potential of small-scale energy technologies*

To improve access to energy, a mutually beneficial sharing of water and energy resources among Central Asian countries is a possibility that is much lauded, yet it breeds more controversy than cooperation. Another potential solution, currently underexplored, rests with small-scale technologies such as solar home systems, micro-hydro units, biogas digesters, improved cooking stoves, residential wind turbines and thermal insulation of homes. Easily deployed, maintained and configurable to needs, plus cost-effective and environmentally sustainable in the long-term, these technologies can be optimal to rural areas. Such technologies can lead the transition from energy poverty to security, thereby enhancing the prospects for rural development.

Electricity is very flexible in that it can satisfy several needs. However, the challenge is that it is not directly available from nature because it is an energy carrier. Some other energy source needs to be converted into electricity. Availability of conversion technologies at appropriate scale, such as solar panels and wind turbines, could potentially provide for the lighting, and information and communication needs. There is potential for developing small businesses to offer mobile phone charging services. Again, solar panels can be an option to provide such service more reliably.

### *1.3 Developing business opportunities for small-scale energy in rural areas*

Ensuring rural energy access is an untapped business opportunity in Tajikistan. Lack of business activity in rural areas is attributed to unreliable electricity supply. Put simply, no rational actor would start a business if electricity supply were not reliable enough to maintain business activities. Attempts to attract investors into energy generation have been directed at large energy complexes. For rural areas, however, the potential lies in small-scale technologies. Pilot projects by non-governmental organizations disseminating solar home systems, installing biogas digesters, training craftsmen to make efficient doors, windows and cooking stoves, and providing materials for thermal insulation have raised awareness among households of alternative ways to harness and conserve energy. Market response, however, is slow at best. In these early stages, the government could step up to provide financial incentives to providers and/or customers to spur development and sales of alternative technologies. Flexible payment options, including loans and leases, could be structured to facilitate adoption. Thus, provision of energy technologies would extend beyond buyers and sellers to include service providers from technicians to bankers. Greater access to household energy in rural areas would soften the pressure of demand for grid electricity that could in turn be channelled to other sectors of the economy.

### *1.4 Incentivizing private sector participation in rural energy provision*

Private sector engagement in energy provision should be elevated in the list of priorities in policies targeting energy poverty. Small-scale technologies such as solar home systems, micro-hydro units, biogas digesters, improved cooking stoves, residential wind turbines and thermal insulation of homes are appropriate to rural areas and can be provided through private businesses. Some incentive structure is needed to set up the supply (value) chain for alternative technologies. Therefore, the government should step in to provide a clear policy directive supporting the proliferation of such technologies. Some form of financial incentive should be made available. It may include a tax break or lifting of import tariffs for firms bringing technologies to the local market, a direct subsidy or low-interest loan to households installing a technology, or some combination of these instruments. Funding should be made available to local developers already experimenting with adapting and improving technologies to local conditions. New lines of research should be encouraged and financed to pioneer locally designed technologies.

### *1.5 Rethinking community energy priorities for development*

Energy is valued for the services it enables to bring about. For households these services include lighting, cooking and water heating, space heating, cooling, telecommunications, mobility, and income generation. In rural areas, these energy services are often derived from multiple energy sources such as grid electricity, candles, kerosene, wood, agricultural residues, animal dung, or draught animal power. Such complexity and context-dependence shies away from one-size-fits-all solutions to expanding access to energy services. For example, electricity is a very flexible energy form that can suffice many of the services. However, rural households continue to use wood and dung for cooking even when electricity is available. This paradoxical situation hints at issues of affordability and appropriateness (suitability) of technology. In other words, provision does not automatically translate into use. To facilitate increased consumption, either the price of electricity should be lowered or a safety net be designed to cushion part of the burden. Another option is to increase cash availability for households through increasing their income earning opportunities. For example, if dung were not burned but applied in the fields as fertilizer, yields would increase, which in turn would reduce the need for purchased food, and thus free up cash for alternative uses. The money could be used to pay for additional electricity consumption to displace dung use as an energy source. Further, dung can be converted to biogas that is used for cooking and the remaining slurry can still be used as fertilizer. Assisting rural farmers in installation of biogas digesters would be more beneficial and locally relevant as it enhances energy access while also improving food security (by using dung to replenish the soil).

### *1.6 Energy sources must be culturally appropriate*

Beyond cost and availability, other factors also influence household energy choice. Social expectations and cultural beliefs are a pertinent example. Children and women engage in biomass collection and cooking because these activities are perceived to be their jobs. Another factor that influences household decisions to settle on a certain energy use pattern is food preference. Food is a known cultural product. Like any other cultural group, Tajiks also have cuisine of their own. There is a culture of bread baking in traditional *tanoors* (vertically installed clay ovens of cylindrical shape) in which wood and/or dung is burned. The different types of bread baked in these *tanoors* are impossible to bake in an electric oven. Yet another reason for relying on solid fuels is that people allegedly feel that warmth of burning wood is qualitatively better than that coming from electric heaters. Heat from woodstove is also perceived to be good for health, particularly relieving leg and back pain. On the contrary, electric heaters reportedly cause headaches. Efforts to eliminate energy poverty, therefore, would need to take cultural factors into account in addition to efficiency, cost-effectiveness, health and environmental considerations.

### *1.7 Capitalizing on energy provision for rural development*

A close attention is needed to provide *energy for earning a living*. As Practical Action (2014) outlines, energy can be harnessed effectively to improve livelihoods through the following services: earning off the land, running micro and small-scale enterprises (MSEs), expanding employment opportunities, and earning from supplying energy. Empirical studies are lacking on productive energy use in Tajikistan. Rural households appear to have limited use of energy for productive purposes. Usually small shops use electricity for lighting and refrigeration. In agriculture, tractors are deployed to transport manure and seeds to the fields and plow the land. During harvest season, grain, produce and hay are transported from the fields to the house. Combine harvesters and electric threshers are rarely used due to exorbitant costs. With greater access to energy, through consideration of services and communities being closely involved, there is potential to alleviate energy poverty in rural areas. For this to begin to take shape, energy policy must look beyond the one-size-fits-all approach of electrification, and into alternative technologies.

Of equal importance is *energy for community services.* Practical Action (2014) groups such services under four categories: (a) health care - hospitals, clinics and health posts; (b) education - schools, universities, and training centers; (c) public institutions - government offices, police stations, religious buildings, etc.; and (d) infrastructure services - water and street lighting. All of these are very relevant to improvement of quality of life in rural areas of Tajikistan. However, information is scarce on energy use for community services. In rural areas, health posts, schools, and government and community buildings are dependent on intermittent grid electricity, and wood and/or coal provided by the government for winter heating. Physical energy (manual labor) is used to haul water from water points. Street lighting is nonexistent. Similar to earning a living, attention to services and partnership with local communities are essential to adequate provision of community services.

In sum, these avenues are admittedly not new to policymakers in Tajikistan. However, their relevance and significance may not have been duly appreciated. This dissertation is a first step towards raising the profile of the energy poverty as an urgent challenge through analysis of the energy use patterns at the level of households. The detailed analysis of energy use provides empirical support to underscore the urgency of the problem. In light of this analysis, small-scale technologies through private sector engagement demonstrate appropriateness as a potentially powerful mechanism to alleviate, and eventually eradicate, energy poverty in Tajikistan.

Overall, better understanding of the needs is required before any energy policy is designed. Use of alternative technologies is recommended, as they are more appropriate for rural areas. A package of reinforcing measures to address the challenge of energy access may also include improvements in efficiency, reduction in demand, and expansion of supply of electricity through grid. Ultimately, the role of households and their communities should be given priority in addressing their energy challenges.

# APPENDICES

## *1. Supporting tables for Chapter 1 on energy security*

### Table 52: Overview of energy efficiency measures

| No | Title of the energy saving measure | End-use targeted | List of energy saving actions substantiating the measure | Time frame | Estimated energy savings in 2020 (ktoe) | Estimated costs (USD) |
|---|---|---|---|---|---|---|
| **Measures for energy efficiency in supply (production/transformation, transmission and distribution)** | | | | | | |
| **E.1.** | Revitalization of district heating systems | • Consumption of natural gas | • Detailed energy audit of district heating systems in Dushanbe and other 5 cities with existing systems in place<br>• Proposing solutions for revitalization of heat generation plants, heat distribution networks, substations and metering<br>• Proposing solutions for fuel switching<br>• Implementation | • Study – by the end of 2011<br>• Implementation: 2012 – 2020 | N.A. | 125,000 |
| **E.2.** | Reducing losses in electric transmission and distribution grids | • Electricity | • Detailed analysis of conditions in transmission and distribution network<br>• Proposing solutions for reduction of losses<br>• Implementation | • Study – by the end of 2011<br>• Implementation: 2012 – 2020 | 25 | 125,000 |
| **General measures for building sector (regulation, information)** | | | | | | |
| **B.1.** | Building codes and Enforcement | • New buildings<br>• Existing buildings undergoing refurbishments | Preparation and enforcement of regulation on:<br>• Thermal insulation of buildings<br>• Efficiency requirements for heating systems in buildings<br>• Efficiency requirements for ventilation and air-conditioning systems in buildings | • Preparation of regulation and enforcement – by January 2013 | 27 | 25,000 |

| No | Title of the energy saving measure | End-use targeted | List of energy saving actions substantiating the measure | Time frame | Estimated energy savings in 2020 (ktoe) | Estimated costs (USD) |
|---|---|---|---|---|---|---|
| **B.2.** | Minimal Equipment Energy Performance Standards | • Heating boilers<br>• Household appliances<br>• Lighting products<br>• Office equipment | Preparation and enforcement of regulation on EE standards for:<br>• Heating/cooling appliances (including boilers and split air-conditioning systems)<br>• Refrigerators and freezers<br>• Lighting products in the domestic and tertiary sectors<br>• Office equipment | • Preparation of regulation and enforcement – by January 2013 | N.A. | 25,000 |
| **B.3.** | Energy Labeling Scheme | • Household appliances | • Preparation and enforcement of regulation on obligatory energy efficiency labeling of household appliances | • Preparation of regulation and enforcement – by July 2012 | 34 | 25,000 |
| **B.4.** | Energy Audits Scheme | • Existing buildings | • Preparation and enforcement of regulation on energy audits<br>• Establishing educational program for auditors | • Preparation of regulation – by September 2011<br>• Establishment of educational program – by December 2011 | N.A. | 50,000 |
| **B.5.** | Public Promotion of Energy Efficiency | • All end uses | • Preparation and implementation of promotional campaigns for EE<br>• Establishment of EE Info centers in 4 major cities | • Launch of campaign – by September 2011<br>• Establishment of EE info centers – by September 2011 | 13.5 | 200,000 |
| **Measures to demonstrate exemplary role of the public sector** | | | | | | |
| **P.1.** | "House in Order" project | • State owned existing buildings | • Introduction of energy management<br>• Awareness raising workshops for employees<br>• Energy audits<br>• Implementation of cost-effective technical measures (demonstration projects) | • Preparation of project and launch – January 2012<br>• Total duration of project: 5 years | 1 | 25,000 |
| **P.2.** | "Energy Efficient Public Lighting" project | • Public lighting systems in major cities | • Energy audits of public lighting systems<br>• Retrofits of selected public lights systems by replacement of light bulbs, lighting fixtures and introduction of automatic regulation | • Preparation of project and launch – January 2012<br>• Total duration f project: 2 years | 0.5 | 20,000 |

| No | Title of the energy saving measure | End-use targeted | List of energy saving actions substantiating the measure | Time frame | Estimated energy savings in 2020 (ktoe) | Estimated costs (USD) |
|---|---|---|---|---|---|---|
| | | | **Financial instruments** | | | |
| **F.1.** | National Trust Fund for RES and EE | • All end-uses | • Subsidies for EE investment activities and projects as defined in the EEMP | • Establishment and full operation of the Fund – by July 2011 | N.A. | / |
| **F.2.** | Fiscal incentives for EE | • Equipment | • Study on Tajik fiscal system and proposal of fiscal incentives for EE equipment<br>• Transposition of recommendations to legislation and enforcement | • Preparation of the Study – by June 2012<br>• Enforcement of recommendations – by December 2012 | N.A. | 25,000 |
| | | | **Cooperative instruments** | | | |
| **C.1.** | Green Public Procurement | • Buildings and equipment used by public authorities | • Study on Tajik public procurement system and proposal for inclusion of energy efficiency as a criteria<br>• Transposition of recommendations to legislation and enforcement<br>• Preparation of implementing guidelines for green public procurement | • Preparation of the Study – by June 2012<br>• Enforcement of recommendations – by December 2012<br>• Actual implementation of green public procurement principles – January 2014 | N.A. | 50,000 |
| | | | **Energy efficiency measures for rural areas** | | | |
| **R.1.** | National Programme for RES and EE based IRD – National Scaling-Up | • Existing rural buildings | • Implementation of EE measures accompanying provision of RES electricity for 100,000 households | • 2011 – 2020 | N.A. | 555,000 (2011); 10,330,000 (2012-2015);<br>39,940,000 (2016-2020) |

| No | Title of the energy saving measure | End-use targeted | List of energy saving actions substantiating the measure | Time frame | Estimated energy savings in 2020 (ktoe) | Estimated costs (USD) |
|---|---|---|---|---|---|---|
| **R.2.** | Training for implementation of rural EE measures | • Existing rural buildings | • Demonstration projects – learning through implementation (part of R.1.) | • 2011 – 2020 (part of R.1) | N.A. | / |
| **Total energy savings expected by 2020 (ktoe)** | | | | | **101** | |
| **Total estimated costs by 2020 (without IRD)** | | | | | | **695,000** |

Source: Bukarica et al., 2011

## Table 53: Comparative analysis of different financing options for National Trust fund for RES and EE

| Alternative | Approx. possible annual incomes to the Fund (USD) | Pros | Cons | Note/Recommendation |
|---|---|---|---|---|
| **Environmental charges for pollutant emissions** | • Not available – the measure was not considered at all since it would heavily burden the Tajik industry | • Fairness – cost borne by those who caused pollution<br>• Effectiveness – large amount of money could be collected<br>• Stimulant for cleaner and more efficient technologies<br>• In line with Kyoto Protocol | • Strong institutional framework for administration needed<br>• Strong and efficient control mechanisms needed<br>• Additional burden to weak industry<br>• | **Not applicable in Tajikistan** for the time being due to economic situation and poor industrial conditions |
| **Special charge for motor vehicles** | • 875,000 from newly introduced charge<br>• If new charge is not introduced, but the existing ecological fee is allocated to the Fund - $1.75 M USD | • Fairness – cost borne by polluters (vehicles)<br>• Collecting system already established because of ecological fee | • Additional burden to car owners, since there is a significant ecological fee imposed | **The means collected will not suffice for incentivizing desired RES electricity production; however it is recommended to allocate the money collected from the existing ecological fee to the Fund** |
| **Special charge for imported vehicles** | • $17 M USD with the unit charge amounting only 1% of a vehicle selling price | • Fairness – cost borne by polluters<br>• Does not contribute to poverty progression<br>• Very small increase in the selling price of a car<br>• **Vast amounts of money might be collected** | • Requires good functioning of customs control and financial inspection | **Recommended for implementation in Tajikistan at the moment – coordination with Ministry of Finance necessary** |
| **Petroleum products levy** | • $4.6 M USD with levy amounting 0.01 Somoni / liter up to<br>• $13.8 M USD with levy amounting 00.03 Somoni / liter | • Easy to implement<br>• Does not require complicated institutional support<br>• Polluter pays<br>• Burdens only those who can afford it (owners of vehicles)<br>• Effectiveness – possible to collect large amounts by very small fee | • Increases costs of petroleum products<br>• Possible (probable) increase in prices of transportation services and in prices of all other goods and products → could cause progression of poverty (since petroleum products are almost 100% imported and prices vary significantly, causing changes in prices of other products and services)<br>• Prohibited new taxes due to economic crisis | **Possible for future implementation in Tajikistan** – easy to implement; significant amount of money could be collected and invested in RES and EE projects |
| **Electricity fee** | • $102,000 USD if the fee is imposed only to public sector<br>• $4.8 M USD if the fee is imposed to all electricity | • Fairness – RES electricity stimulated by electricity consumers<br>• Effectiveness – possible to collect large amounts by very small fee | • Strong institutional framework for administration needed<br>• Requires reorganization of energy sector – stronger control of monopoly in payments | **Not applicable in Tajikistan for the time being** due to existent energy poverty of more than half of the population |

| Alternative | Approx. possible annual incomes to the Fund (USD) | Pros | Cons | Note/Recommendation |
|---|---|---|---|---|
| | consumers | | • Increases electricity price to final consumers<br>• **Can't be imposed to population with limited access to electricity** | |
| **State budget allocations** | • Designed on tightness of the budget – allocations of existing petroleum taxes and ecological fees for vehicles could be made | • Easiest to implement if there is political will | • Not sustainable in the long term | **Needed in any amount as starter for RES and EE activities** |

Source: Morvaj et al, 2010a

## 2. *Insights from expert interviews*

### 2.1 *Energy need ranking*

Ranking sectors by energy need: 1-very slight; 2-slight; 3-moderate; 4-severe; 5-very severe

| Agency | Industry | Agriculture/ forestry | Transportation | Construction | Residential/ households | Commercial and public services |
|---|---|---|---|---|---|---|
| Strategic research (a) | 5 | 5 | 5 | 5 | 4 | 5 |
| Strategic research (b) | 5 | 5 | 5 | 5 | 4 | 4 |
| GIZ | 4 | 2 | 2 | 3 | 5 | 5 |
| TTU | 5 | 4 | 3 | 4 | 4 | 2 |
| GERES | 5 | 4 | 3 | 4 | 5 | 5 |
| Nature Protection | 4 | 5 | 4 | 3 | 5 | 5 |
| Barki Tojik | 5 | 3 | 5 | 5 | 5 | 5 |
| AVG | 4.71 | 4.00 | 3.86 | 4.14 | 4.57 | 4.43 |

### 2.2 *Energy security – definition, understanding*

- Energy security objectives comprise fulfilling energy needs in the country and exporting the surplus to regional markets
- Meeting domestic demand for energy
    - Demand as determined by population and industry needs, and supply as response to demand by producers (sort of market-based)
    - Meet from domestic resources, namely, hydropower – hence, reference are to electricity because other resources are scarce
        - Reason: prevent pressure on country's sovereignty when energy bullying occurs from producer countries
        - Domestic hydropower resources are sufficient to cover needs
- Water-energy security and expanding export of electricity to regional markets
    - Selling power is the goal, but purchase from other countries is not encouraged
- Qualifiers (descriptors, adjectives)
    - Energy (supply) should be – clean , affordable, reliable, sustainable, uninterrupted, sufficient, diversified, domestic, stable

- The experts grappled with how to prioritize or optimize energy security dimensions (or objectives). Everyone emphasized provision of electricity to meet domestic demand, and that such provision should be sourced domestically, primarily generated at hydropower plants. Experts were also in agreement to increase hydropower generation so that the surplus can be exported. Apart from electricity, however, experts offered diverse opinions that were at times conflicting. At one point, one would argue for satisfying energy demand for all sectors of the economy by further exploration of gas and oil and increased mining of coal in addition to hydropower generation. At another point, the same expert would make a strong case for mutually favorable energy trade with neighboring countries that effectively means procuring some energy carriers some of time from outside the country. Another would lament how low tariffs are a barrier to attract investment in energy sector. In the same breath, this expert would point out how high tariffs are burdening businesses and crippling their growth.

### *2.3 Energy problems*

- There is a chronic winter shortage of electricity due to seasonal characteristic of hydropower generation.
  - Winter low flows in rivers result in lower electricity generation at hydropower plants. As a result, a deficit of about 4 billion kWh is created, which necessitated rationing of electricity for domestic consumers (mainly in rural areas).
- Summer surplus of electricity has no profitable export route.
  - Summer high flows can be harnessed to increase generation over and above the demand within the country. However, the potential surplus of about 7-8 billion kWh cannot be realized because opportunities for export are limited. Because Tajikistan is switched off of the Central Asian Power System (CAPS) exports are no longer possible to other Central Asian countries (which used to be the case prior to year 2009). The only country part of former CAPS is Kyrgyzstan that is able to import summer electricity coming through the north of Tajikistan using a separate transmission line. Kyrgyzstan imports a limited volume as they also produce electricity at hydropower plants. This trade is feasible only because the tariff is 1.5 cents/kWh. Tajikistan is willing to sell at such a low price because otherwise they would have to shunt the water past the turbine without earning a penny. The trade with Afghanistan is slightly advantageous at 3 cents/kWh; however, they can absorb only a limited supply due to low capacity of transmission lines. Disruption of electricity trade via CAPS in Central Asia is taking a toll on all countries. Experts conveyed a sense of agreement among the technical

counterparts in Tajikistan and Uzbekistan that the trade was indeed mutually beneficial. However, they regretted that this understanding is not shared by political leadership in the respective countries.

- Political issues: Uneasy interstate relations between Tajikistan and Uzbekistan take a toll on energy provision in Tajikistan.
    - Obstruction of plans to build large hydropower plants, namely the Roghun HPP
        - Reasons: concern about water supply for irrigation
        - Losing competitive edge to Tajikistan in the regional energy market, particularly electricity export to South Asia, is a big worry to Uzbekistan. This is because electricity is admittedly cheaper to produce at hydropower plants (in Tajikistan) than coal-fired or gas-fired power plants (in Uzbekistan). Tajikistan puts a price tag of 3 cents/kWh on its export of electricity to Afghanistan, whereas Uzbekistan charges 7 cents/kWh. Because Tajikistan's electricity export volumes are very small, Uzbekistan is able to maintain a higher price taking advantage of substantial unmet demand and securing a larger market share in Afghanistan. Therefore, Uzbekistan stands to lose if Tajikistan manages to increase hydropower production and expand transmission network capacity, effectively increasing exports, to Afghanistan.
        - Some experts believe that Uzbekistan tried to disrupt the impact assessment of Roghun HPP (e.g. by not attending the consultation meetings with all riparian countries), but succeeded only in delaying it. When the assessment results proved to be favorable to the project, Uzbekistan rejected the results questioning the objectivity of the study, and pointing out that Uzbek experts were not consulted in the process. Further concerns were shared to the detrimental effect that construction of large dam would have on drying up of Aral Sea and the ecology of Amu Darya River and its ecosystem. Some experts noted that Uzbekistan has 23 sizeable water reservoirs in its territory; hence, alleging that ecology is not their real concern. Rather, Uzbekistan is more concerned about reduction in water supply as Roghun dam can avail Tajkistan of greater control over Vakhsh River flow – a tributary of Amu Darya River. The experts suggested that such fears are misplaced because Tajikistan does not at present use its quota of water as allocated by the Almaty agreement. Water behind Roghun is supposedly to be accumulated gradually by harnessing this unused water

quota that will not have an adverse impact downstream. Furthermore, restriction of water supply downstream would negatively impact the agricultural sector of Tajikistan as well. Since hydropower generation requires letting of water pass through turbines it is absurd to believe that water can somehow be hoarded behind the dam.

- Apart from controversy around Roghun HPP on Vakhsh River, some experts shared insights about Uzbekistan putting pressure on Chinese companies not to construct a proposed cascade of hydropower plants on Zerafshan River. Such allegations would be difficult to substantiate. Nonetheless, a sense of mistrust is conveyed that alerts to how much the relations soured between the two neighbors.
- One expert also noted that sentiments run high among people that Uzbekistan is to be blamed for all our misfortunes[15]. Whether or not such viewpoint holds much water, it is a shrewd political strategy to deflect the responsibility for domestic economic troubles by blaming outsiders. Another expert expressed frustration with this blame game saying "ambition is a road to nowhere", referring to efforts to construct Roghun HPP using domestic funds. "They should learn to negotiate", suggested the expert as an alternative course of action for Tajik policymakers.

- Part of energy shortage is due to inefficiencies in the energy system.
  - In addition to transmission and distribution losses that occur as a result of ageing infrastructure, large energy losses are evident in the construction sector. Making of construction materials (e.g. concrete, steel reinforcement) is energy intensive, particularly owing to outdated technologies used in the process. Buildings are constructed without regard to energy efficiency. Some experts estimate heating losses in ferroconcrete structures to be several times larger than industry standard in former communist states of Eastern Europe. It should be noted that virtually all heating in apartment buildings comes from electricity – a very inefficient conversion process in itself. Lack of efficiency standards and absence of energy passports for buildings threaten to perpetuate the problem. Another significant efficiency gap lies in the so-called "culture" of energy use by people. Experts point to the root of the problem in the legacy of the Soviet energy provision that lacked systematic metering if any at all. People used energy as much as

[15] A Wikileaks cable reports of a Tajik official making such a claim at a press conference following withdrawal of Uzbekistan from CAPS (https://wikileaks.org/plusd/pdf/?df=40675).

they wanted because it was abundant and cheap (heavily subsidized). Energy conservation practices as simple as switching off lights, using more efficient bulbs and other devices are not gaining ground yet. Despite massive country-wide campaign for fluorescent (efficient) bulbs householders and businesses continue to use incandescent ones. This is due, on the one hand, to the latter costing less per unit at the time of purchase. On the other hand, some fluorescent bulbs are low quality and go to waste very quickly; hence, defeating the purpose of being cost-efficient in the long-run. Apparently, there are a lot of low quality energy devices in the local markets. One expert tested some products and found inconsistency in their reported efficiencies and actual performance. For example, an electric heating device showed a certain number on its manual, but in fact produced much less heat while consuming a lot more electricity. In general, the overall efficiency of devices is believed to be at least twice as low as stated in their description. Apart from technical losses, there are commercial losses that result from non-payment for electricity use or bypassing the meters. While arrears are partly owing to inability to pay (poverty), there are also reported cases of collusion between employees of the electric utility and users (households or businesses), in which the latter pay for a fraction of the actual use (as a bribe). In such cases actual electricity use goes unaccounted for.

- Shortage of electricity entails a number of impacts.
  - Economic activity suffers as industry production grinds to a halt and businesses and services sector operates on limited capacity. Potentially viable industries have no prospects of being realized when there is no reliable energy supply. For example, lack of electricity along with poor roads, finances, personnel and technology are main barriers to mining for minerals, which are reportedly diverse and abundant in the country. Poor road conditions are not only hindering prospects for mining industry, they are the main culprits that beat a good vehicle into scraps in a matter of few trips.
  - The reduction in economic activity has a negative effect on the country gross domestic product (GDP) as well as its budget as the tax base shrinks. Apart from unaffordability of electricity tariffs for commercial sector, experts attribute lack of business activity in rural areas and its sluggish development in urban areas to lack of access to reliable energy all year-round. Chronic lack of electricity means that no rational investor would invest because half a year the production would stall. It does not make business sense to run a factory half a year and shut it down the other half.

  - With decrease in the volume of domestically produced goods and services the outstanding demand is met with increased import of the same. Moreover, when energy carriers are purchased from abroad, usually in dollars, foreign currency reserves are hit, and the combined effect is one of depreciation of the country's currency (Tajik somoni). In addition, fluctuations in exchange rate of Russian rouble and Kazakh tenge send a ripple through real prices to the economy in Tajikistan.

- Electricity tariffs are perceived either low or high depending on who is impacted.
  - For domestic consumers the current rate of 12.6 dirams/kWh (1.6 cents/kWh[16]) is believed to be low, although not necessarily affordable for all households. The public sector consumers (including state-funded entities, utilities and sport complexes) are charged 12.2 dirams/kWh. The rates for the aluminum smelter (TALCO) are lower at 7.2 dirams/kWh in summer and 11.8 dirams/kWh in winter months. It should be noted that TALCO takes up about 40% of all electricity consumed in the country. Even lower are the rates for water supply and irrigation pumps at 2.2 and 8.2 dirams/kWh in summer and winter seasons respectively. Electric transport pays 8.2 dirams/kWh, but its consumption is very small. Overall, experts are of the opinion that such low tariff rates lead to wasteful consumption, inability of Barki Tojik power company to recover costs, and hindering the prospect of attracting investment in new generation capacity. Hence, low tariffs are blamed for inefficiencies, shortages, and lack of finances to improve the energy sector.
  - On the other hand, tariff rate for businesses (industry, services) at 30.6 dirams/kWh is believed to be disproportionately high. Such a rate hints at cross-subsidization that allows for lower tariffs for other consumer categories. Some businesses cannot afford high prices and cease activity. Some find ingenious ways to hide their actual consumption (fiddling with or bypassing meters, striking a deal with collectors). Therefore, high tariffs are seen to cripple business activity and spawn corruption.
  - The major problems that experts identified with electricity tariffs is the lack of transparency in how they are calculated. Allegedly, Barki Tojik

[16] 1 USD = 7.8398 TJS according to National Bank of Tajikistan on 10 February 2016 (http://www.nbt.tj/en/kurs/kurs.php?date=10.02.2016). It should be noted that Tajik Somoni (TJS) depreciated substantially against United States Dollar (USD) since July 1, 2014 when the tariff of 12.6 dirams was set (up by 15% from 11 dirams - http://www.ams.tj/ru/component/content/article/23-habary-maqolaho/179-2014-07-05-05-16-32.html). Then the exchange rate was 1 USD = 4.9423 TJS, translating 12.6 dirams/kWh into 2.5 cents/kWh (http://www.nbt.tj/en/kurs/kurs.php?date=01.07.2014). Therefore, conversion in dollar terms is for illustration purpose only.

arrives at a tariff structure based on some function of costs associated with generation, transmission and distribution of electricity. However, it is the Antimonopoly Agency that ultimately sets the tariffs because Barki Tojik is a natural monopoly in control of all three branches of the electricity system. Experts believe that the tariffs are socially oriented, i.e. premised on affordability (that requires subsidization), rather than making business sense (generating profits). Therefore, lack of finances to upgrade and expand the capacity of the system are attributed to overall low tariff rates.

- Improving the energy system and addressing chronic shortages requires financial means that are lacking at present.
    - Beyond the routine operation and maintenance costs addition of new generating capacity requires substantial funding. For one, the Roghun HPP is estimated to cost $3-5 billion or equivalent to half of the country's GDP. Government does not have sufficient funds to cover such high costs. Private sector interest (both domestic and international) in electricity sector is lacking. With the exception of Pamir Energy Company, Sangtuda 1 and Sangtuda-2 hydropower plants, there are no big players in the electricity market in Tajikistan because Barki Tojik is in charge of generation, transmission and distribution for majority of consumers in the country. Moreover, the fact that Barki Tojik is substantially indebted to Sangtuda 1 (TJS505 million) and Sangtuda 2 (TJS315 million)[17], private investors are reluctant to enter the market. It should be noted that Barki Tojik's dues in greater part come from non-payments from agricultural sectors (irrigation pumps) and residential consumers (although technical losses are notable as well). Beyond difficulties in collecting payments, another concern is apparently low level of tariffs that does not permit recouping of costs, let alone making a profit. Furthermore, some experts shared the concern that investors fear they would not be able to expatriate their profits or lose their investment outright, as some cases of grabbing businesses (a grocery chain, a bowling place, a gas stations chain) had

[17] Reported on February 5, 2015 by Avesta news agency: http://www.avesta.tj/sociaty/38217-dolgi-barki-tochik-dostigli-15-mlrd-somoni.html. In addition, Barki Tojik owes taxes to state budget in the amount of TJS142 million, as the agency reports. [note: also check out: http://www.avesta.tj/business/30377-barki-tochik-zadolzhal-51-mlrd-somoni-gosenergoholdingu-zadolzhali-856-mln-somoni.html; and http://www.avesta.tj/business/34320-barki-tochik-zadolzhal-bolee-1-mlrd-somoni-a-emu-dolzhny-svyshe-11-mlrd-somoni.html (shows debit and credit debts owed by/to whom); this one from 2014 on residential consumer's indebtedness: http://www.avesta.tj/business/26687-naselenie-i-hozyaystvuyuschie-subekty-zadolzhali-barki-tochik-bolee-1-mlrd-somoni.html) this one on writing off the debts: http://www.centrasia.ru/newsA.php?st=1403844600

allegedly occurred in the past. Lack of accountability is another concern; however, some experts said that it is not so much paying of bribes that keeps investors at bay. Rather the rules of the game are either unclear (i.e. who to pay, for what, when and how much) or unpredictable (i.e. rules could change in a whim). Such uncertainty makes any investment extremely risky.

  - Delay in implementation of the restructuring plan for Barki Tojik is another obstacle to private sector investment. The plan envisages three stages: (a) "commercialization" that allows unbundling of generation, transmission and distribution while changing from vertical to horizontal integration; (2) "competition" that separates the distribution component into legal entities and allows independent generation businesses access to the transmission network; and finally, (3) "divestment" that open each component up for privatization.

- Electricity production solely at hydropower plants and overreliance of the economy on hydroelectricity makes Tajikistan vulnerable to vagaries of precipitation and long-term climate change. With global warming, precipitation is changing its patterns and falling more as rain than snow. It means less accumulation on mountaintops and faster melting of glaciers. Expert shared a serious concern about retreating of mountain glaciers that are the main source of water in Central Asian region. The Fedchenko glacier on Pamir mountains has reportedly shrunk by 30%, and is retreating further as temperature increases. Another effect on glacier melting, that experts indicated, is that of the salt exposed by the drying of Aral Sea that is blown by the winds reaching as far east as the Pamir mountains. Some experts believe that given this long-term impact on glaciers hydropower may be a risky energy source. Alternative sources of energy, including conventional (coal, gas and oil) and unconventional (wind, solar, and biomass) should be pursued to hedge the risks. Others, however, were of the opinion that building reservoirs would be necessary to store water coming from rain and glacier melt to secure sufficient water supply for agriculture and electricity production in the long-run. Regardless of uncertainty about climate effects and conflicting views on energy production options, high dependence on a single energy source was a common concern, and one that requires close attention.

- Making and implementing sound energy policy is inextricably tied to the quality of human resource engaged in the energy sector. Experts were deeply disturbed by the fact that educational institutions in the country were not producing qualified professionals. Part of the reason is that colleges are admitting too many students than existing faculty and resources can handle. Hence, quantity trumps quality. Moreover, the entrants are taken based on their ability to pay than merit. Experts alleged that some colleges are desperate for cash to sustain themselves. Therefore, they expand their intake by adding paid-only streams. After graduation, students find it hard to get a job. For one, they do not meet the requirements of the businesses. For a handful of graduates who are qualified the pay is insufficient to make a living. The public sector pays are even lower. Moreover, it is rife with corruption and nepotism. As a result, many graduates with diplomas leave the country for migrant work abroad, particularly to Russia. The lack of qualified human resources is, therefore, a major one that impacts all sectors of the economy. It is both an outcome of lack of access to energy and a cause of not improving the situation.

- Aside from hydropower, other conventional sources of energy such as coal, oil and natural gas are available in small volumes. Estimates of potential reserves are reportedly large enough that can surpass domestic demand and even be exported. However, difficulty of extraction coupled with absence of infrastructure and lack of access to finances, technologies, and expertise keep these resources underground. Energy imports are necessary to cover domestic demand; however, the situation is precarious.
    - On top of fluctuations in world prices, the dynamics in economic relationships between Tajikistan and its trade partners in the region complicate access to energy sources from abroad. At the time of interviews in April and May 2015, experts noted that despite falling global oil prices gasoline prices at local gas stations stayed put. Several factors might have been at play as experts explained. Local prices were expressed in local currency (Tajik Somoni) that had depreciated vis-à-vis the US dollars. Put differently, oil was becoming cheaper to buy in dollars, but dollars were becoming more expensive to buy in somoni. The combined effect on prices at the pump would be near zero. Depreciation of somoni was, in part, a spillover effect of Russian rouble losing its value[18]. The economic troubles in Russia hit the Tajik migrant workers whose remittances equal to nearly half of GDP in Tajikistan – making it the world's most remittance-dependent country[19]. Some migrants lost their jobs; others saw their earnings lose value as rouble collapsed against dollar. The decrease in flow and real value of remittances translated into reduction in domestic consumption, thus slowing the economic growth in Tajikistan[20]. Thus, instead of

[18] http://www.ft.com/cms/s/3/ad1be9b6-78af-11e5-a95a-27d368e1ddf7.html#axzz3zzfLNRvE
[19] Tajikistan tops the list of countries on the proportion of remittances in the GDP http://siteresources.worldbank.org/INTPROSPECTS/Resources/334934-1288990760745/MigrationandDevelopmentBrief24.pdf.
[20] https://www.worldbank.org/content/dam/Worldbank/Publications/ECA/centralasia/Tajikistan-Economic-Update-Spring-2015-en.pdf

reaping the benefits from lower world energy prices as importing country, Tajikistan suffered an economic downturn.

  - The halting of gas supplies from Uzbekistan since 2012 exacerbated the energy situation in the country. The experts recognize that overdue payments owed to Uzbekistan every year could not be tolerated. However, they also attributed part of the reason for cutting the gas supplies to soured relations between the two countries over Roghun HPP. Deprived of gas imports, consumers shifted to hydropower and coal. One gas-fired power plant shut down, another installed technology to convert coal to gas. Production at TALCO reportedly shrunk, although the experts cautioned that actual data is hard to come by from the aluminum smelter.
  - Severing Tajikistan from CAPS in 2009 broke off all electricity trade – import and export – via Uzbekistan. The experts surmised that disagreements about netting of trade between the two countries, accusations against Tajikistan about withdrawing more than its share, illegal tapping, and alleged crashing of infrastructure sending shocks to the entire electricity system led up to Uzbekistan switching off of CAPS.
  - The lack of access to trade in energy carriers results in overreliance on hydropower – a very risky situation.

- Energy use in agricultural sector of Tajikistan is perceived as a non-issue by some experts. The vegetative season corresponds with high river flows that allow increased hydropower generation. Plus demand for heating drops with warm weather and electricity-based cooling is insignificant. This sector is charged the lowest tariffs for electricity used to operate irrigation pumps. Given that export options for electricity are limited, virtually a price above zero is still reasonable. One issue, however, is that even the low price is not paid to the electric utility Barqi Tojik. This non-payment triggers a chain reaction, in which the utility cannot pay its generators, and the latter cannot pay their taxes (not to mention recouping costs or profiting the shareholders). Nonetheless, some experts doubted that Barqi Tojik did indeed channel the electricity it received from private generating companies to the agricultural sector. In their opinion, it does not add up when water at Nurek HPP is actually dumped past the turbines because there are no takers for the surplus electricity. In other words, Barqi Tojik need not buy electricity from private providers when it has excess generation capacity of its own during the irrigation season.
  - Besides electricity, there are other real costs to the agricultural sector that come from energy use. Fuel use in transport and machinery is an obvious cost item. Others include maintenance of irrigation channels (removing the silt) that requires fuels (diesel, gasoline, fuel oil),

breaking of water pumps, and regular wear and tear of machinery and equipment that require spare parts. Fuels and spare parts are sourced from outside the country. In this way, agricultural sector gets entangled into the web of complicated trade relations, and has to bear the repercussions when relations go sour.

### *2.4 Energy solutions*

- Increase capacity (generation)
  - The experts emphasized the need to expand electricity generation capacity, particularly deploying the massive hydropower potential in the country. Overall potential of hydropower is estimated at 527 billion kWh per year. Current utilization stands at around16-17 billon kWh or 5% of the potential.  Construction of large hydropower plants, namely Roghun HPP and Dashti Jum HPP, are considered as a key solution to achieving energy security for the population as well as the economy at large. While Dashti Jum HPP is at the early stage of conceptual development, many efforts have already gone to building of Roghun HPP. Projected to be the tallest dam in the world, Roghun HPP will have a generating capacity of 6000 MW and is expected to meet domestic demand for electricity as well as export the surplus to neighboring countries. One expert expressed confidence that it can supply almost half of the needs of Central Asian countries for electricity. Experts are of the view that once the first two turbines are put into operation the rest of the project can finance itself based on electricity sales. The project is considered safe from technical and environmental perspectives following a rigorous impact assessment facilitated by the World Bank. Hydropower is viewed as ecologically clean source of energy. In addition to providing substantial amount of electricity, the Roghun HPP is also expected to extend the life of the downstream Nurek HPP – the current powerhouse of the nation – by further reducing silting of the latter’s reservoir. When electricity provision is sustained in all four seasons, it takes pressure off other resources, such as wood and dung for cooking and heating. Furthermore, the Roghun dam can regulate river flow (e.g. for flood control), and provide fresh water through accumulation in reservoir; such water storage is important given melting of glaciers to ensure long-term water supply. Apart from freshwater supply, electricity could be used expanding agriculture via installation of electric water pumps.
  - The biggest constraints to realizing the project are lack of finances and opposition from Uzbekistan. One expert in the public sector pointed out that there is interest from investors but the question of percent of shares

that each investor can buy is highly contested. The government wants to hold majority of stakes, but investors are reluctant with this proposition. The experts, however, believe that the opposition from the downstream country (Uzbekistan) is also feeding into the reservations of potential investors in that the latter are skeptical of assurances by the Tajik government that the political stalemate will be resolved once financing is available. Hence, finding investors remains a challenge.

    - In addition to construction of new hydropower plants, upgrading of Nurek, Kayrakum and Varzov HPPs is also seen as expanding the generation capacity. Moreover, full operation of existing Sangtuda 1 (670MW) and Sangtuda 2 (220MW) HPPs could further boost electricity production. Apart from hydropower, additional capacity can be added by putting to operation Dushanbe TPP 2 (100 – 400MW). This thermal plant can use modern technologies to convert coal to gas to electricity while minimizing harmful emissions. It is believed that coal is available in sufficient quantity to guarantee operation of thermal plants for many decades.
    - Drilling for oil and natural gas is another possibility to expand supply. There are allegedly substantial resources, however, the depth of resources makes them technologically challenging and economically costly. Some experts noted that Gasprom (Russian company) is involved in explorations, but no major drilling has occurred. There is a need to offer concessions with mutually favorable conditions to attract investors. In brief, the experts were optimistic in their view that Tajikistan could cover all its energy needs using its own resources.

- Expand trade
    - Tajikistan has excess capacity in summertime; however, export routes are not available to take advantage of this surplus. A small portion of the surplus is exported to Afghanistan, and also Kyrgyzstan. The experts believe that the CASA-1000 project – that aims to transmit electricity from Kyrgyzstan and Tajikistan south to Afghanistan and Pakistan – would be a great push forward towards developing Tajikistan's economy. This project did attract investors and is entering the implementation stage. It will piggy-back on the existing transmission lines to northern Afghanistan, but also construct additional lines to expand export capacity. In the long-term, Tajikistan could look into expanding its export to India, Iran and China that are in need of power. However, experts recognized that the success of CASA-1000 will be a key determinant of whether further expansion is going to be feasible.

- Apart from the north-south export route, the experts suggested reconnected the Central Asian Power System (CAPS) that used to function until 2009, when Uzbekistan withdrew from it. Apparently there is agreement on the technical domain among energy professionals in all neighboring countries about mutual benefits, but the political climate is not conducive to this option. As one expert point out "We need energy diplomacy. There is a need to learn to negotiate and make deals." If reconnected, however, the result would be mutual exchange of energy according to season, and optimizing use of different energy sources (hydro, gas, coal for electricity production) at the regional level.

- Improve management and accountability
  - Electricity supply in Tajikistan is managed by the state-owned company Barqi Tojik. Experts believe that the company is effectively broke and lack necessary capacity to manage the system effectively. The government of Tajikistan has begun a reform process. To improve governance, a restructuring plan (executive decree #431 from 2001) is carried out in three phrases. First, commercialization includes creation of three vertically integrated departments within Barqi Tojik responsible for generation, transmission and distribution respectively. During this phase, the plan outlines conducting inventory of all funds, addressing the questions of division, and appraising of the financial situation. Next, competition envisages creation of independent companies from the three departments. Whatever remains of Barqi Tojik will be turned into systems operators to oversee transmission and distribution. Then, privatization will allow for prospective investors to acquire the independents companies. All three phases are expected to be complete by 2018.
  - Experts believe that transitioning to privatization will require adequate competence of human resources. One expert in the academia lamented that many graduates from technical fields do not have the knowledge and skills to enter the workforce. There are a handful of qualified graduates, but they are not able to get a job in the energy sector, and even when they do, they do not stay because of meager salaries. Therefore, there is need to support the higher education institutions with funding for training and research (including laboratories and experimental facilities) to prepare more qualified graduates, and there is need to create better incentives to attract and retain qualified professionals. It is true that the international non-governmental organizations can provide expertise. But it is also true that their presence is temporary at best. Experts also emphasized that civil

society should have a key role as it can provide a check on equity and fairness in the energy sector. This function becomes even more important with privatization of the electricity segment of the sector.

- Improve economic viability
  - Tariff reform is perceived by the experts as crucial to economic viability of the electricity production and consumption. At present, average electricity tariff of 12 dirams per kWh is not sufficient to recover costs let alone make a profit. Tariffs are socially oriented, which prevents recovering of costs related to operation and maintenance, upgrading of existing infrastructure, construction of new facilities, and even paying salaries of sector employees. The anti-monopoly agency sets the tariff based on cost estimates (equipment, fuel oil, taxes, salary) provided by Barqi Tojik. However, the exact formula is not made public. There is some intention of gradual increasing of tariffs, but details are unknown.

- Improve efficiency
  - Experts stressed that substantial gains can be reaped through energy efficiency measures. One allegedly successful national scale program was proliferation of efficient lightbulbs. While empirical assessment are lacking, experts point out anecdotal evidence that savings have resulted as a result of adoption of such lightbulbs by majority of households throughout the country. There a law on energy efficiency (revision from 2013), but it falls far short of making necessary provisions. For one, it does not specify energy requirements for buildings as the latter are seen to be extremely inefficient. Inefficient buildings mean large losses of heat during winter, and inadequate cooling in summer. Experts believe that simple solutions such as use of more efficient materials, e.g. aerated concrete, double-glazed windows and doors, etc., can tremendously improve efficiency of urban apartment buildings. To facilitate better thermal insulation, buildings codes should be developed and enforced specifying minimum requirements for energy efficiency. In particular, each building should have an energy passport. Thee specifics can be made into law by including the provisions in the energy efficiency law. Granted, efficiency gains can also ramp up the cost of housing. To remedy this, green loans for housing should be made available for 10 years or more payback period.
  - Apart from buildings, energy devices should be efficient as well. The local markets are flush with low quality energy goods. Such products should be prevented from entering the market because they hurt the

households twice: a) low quality devices consume more energy, and b) they do not last long.

- Larger losses occur at the higher level, including in transmission and distribution. These are due mainly to outdated infrastructure that require upgrading or replacement. Revamping energy infrastructure, however, requires substantial sums of money. Besides technical losses, there are also sizeable non-technical or commercial losses that stem from non-payment, syphoning off, and poor metering. While installation of accurate meters could resolve some of the non-technical losses, collection efforts inevitably clash with inability of consumers to pay. The provider can cut off non-payers, but if such entities are governmental agencies and more importantly, the agricultural sector, this option becomes complicated. Nonetheless, improving efficiency can be equivalent to adding more capacity without construction of new generation facilities.

- Diversify sources
    - The experts did recognize the role of alternative sources of energy to achieve energy security in Tajikistan. However, they did not attribute much significance to their role beyond mentioning that alternative sources soften the pressure of demand for electricity on major (industrial and urban) consumers. Small-scale hydropower was seen as the most prospective energy solution in rural areas. Some experts noted that some non-governmental organizations distribute solar panels to remote areas not connected to electricity grid. Some experts had also seen solar panels sold in local bazaars, and they believed that solar technology could be gradually taking ground if their cost becomes affordable. To expedite the proliferation of alternative technologies, there is a need to incorporate feed-in-tariffs schemes and innovative business solutions. The government can start using solar technology with street lighting and traffic lights. When asked about the potential of wind, experts said they did not have information about this source, but they generally did not view it as feasible.
    - Apart from alternative technologies, experts point out that reforestation should also be considered as an energy solution in rural areas. This is because rural households depend on this resource, and are likely to continue to do so until reliable and affordable electricity becomes available. Moreover, reforestation helps to prevent soil erosion, enrich oxygen in the atmosphere, create habitat for animals, and medicinal plants. To ensure sustainable use of existing forests, there is a need to reinforce ecological policing to prevent cutting of trees.

- Attract Investment
    - The experts admitted that the solutions proposed to achieve energy security would require substantial financing to materialize. The government should do more to attract investment from the private sector, including from domestic businessmen. To facilitate this process, the government should guarantee protection of investors' interests. One expert stated that "Private sector has the financial resources to invest in energy if only such investment was guaranteed by the government." According to another expert, "A combination of price (i.e. tariff), law and protection would help attract private money".

*3. Approval of research by the Institutional Review Board for Human Participants*

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## Institutional Review Board for Human Participants

## NOTICE OF EXPEDITED APPROVAL

| | |
|---|---|
| **To:** | Murodbek Laldjebaev |
| **From:** | Carol Devine, IRB Chairperson |
| **Protocol ID#:** | 1412005226 |
| **Protocol Title:** | Energy poverty, security and sovereignty in rural communities of Tajikistan |
| **Approval Date:** | February 05, 2015 |
| **Expiration Date:** | February 04, 2016 |

Cornell University's Institutional Review Board for Human Participants (IRB) has reviewed and approved the inclusion of human participants in the research activities described in the protocol referenced above. This approval shall remain in effect until **February 04, 2016**.

The following personnel are approved to perform research activities on this protocol:

- Murodbek Laldjebaev
- Karim-aly Kassam

This approval by the IRB means that human participants can be included in this research. However, there may be additional university and local policies that apply before research activities can begin under this protocol. It is the investigator's responsibility to ensure these requirements are also met.

Please note the following important conditions of approval for this study:

1. All consent forms, records of study participation, and other consent materials **must** be held by the investigator for **five years** after the close of the study.
2. Investigators must submit to the IRB any **proposed amendment** to the study protocol, consent forms, interviews, recruiting strategies, and other materials. Investigators may not use these materials with human participants until receipt of written IRB approval for the amendment. For information about study amendment procedures and access to the Amendments application form, please refer to the IRB website: http://www.irb.cornell.edu/forms.
3. Investigators must promptly report to the IRB any **unexpected events** involving human participants. The definition of prompt reporting depends upon the seriousness of the unexpected event. For guidance

on recognizing, defining, and reporting unexpected events to the IRB, please refer to the IRB website: http://www.irb.cornell.edu/policy.

If the use of human participants is to continue beyond the assigned approval period, the protocol must be re-reviewed and receive continuing approval. As the Principal Investigator it is your responsibility to obtain review and continued approval before the expiration date. Applications for renewal of approval must be submitted sufficiently in advance of the expiration date to permit the IRB to conduct its review before the current approval expires. Please allow three weeks for the review.

**Any research-related activities -- including recruitment and/or consent of participants, research-related interventions, data collection, and analysis of identifiable data -- conducted during a period of lapsed approval is unapproved research and can never be reported or published as research data.** If research-related activities occur during a lapse in the protocol approval, the activities become a research compliance issue and must be reported to the IRB via an unexpected event form (www.irb.cornell.edu/forms).

For questions related to this application or for IRB review procedures, please contact the IRB office at irbhp@cornell.edu or 255-6182. Visit the IRB website at www.irb.cornell.edu for policies, procedures, FAQs, forms, and other helpful information about Cornell's Human Participant Research Program. Please download the latest forms from the IRB website www.irb.cornell.edu/forms/ for each submission.

Cc: Karim-aly Kassam

## *4. Approval of research by the Institutional Review Board for Human Participants (extended to 2017)*

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### Institutional Review Board for Human Participants

### NOTICE OF EXPEDITED CONTINUATION APPROVAL

| | |
|---|---|
| **To:** | Murodbek Laldjebaev |
| **From:** | Carol Devine, IRB Chairperson *Carol M. Devine* |
| **Protocol ID#:** | 1412005226 |
| **Protocol Title:** | Energy poverty, security and sovereignty in rural communities of Tajikistan |
| **Approval Date:** | February 04, 2016 |
| **Expiration Date:** | February 03, 2017 |

Cornell University's Institutional Review Board for Human Participants (IRB) has reviewed and approved continuation of research activities described in the protocol referenced above. This approval shall remain in effect until **February 03, 2017**.

Please note the following:

- Renewal for purposes of data analysis with identifiers remaining.

The following personnel are approved to perform research activities on this protocol:

- Murodbek Laldjebaev
- Karim-aly Kassam

This approval by the IRB means that human participants can be included in this research. However, there may be additional university and local policies that apply before research activities can begin under this protocol. It is the investigator's responsibility to ensure these requirements are also met.

Please note the following important conditions of approval for this study:

1. All consent forms, records of study participation, and other consent materials **must** be held by the investigator for **five years** after the close of the study.
2. Investigators must submit to the IRB any **proposed amendment** to the study protocol, consent forms, interviews, recruiting strategies, and other materials. Investigators may not use these materials with human participants until receipt of written IRB approval for the amendment. For information about study amendment procedures and access to the Amendments application form, please refer to the IRB website: http://www.irb.cornell.edu/forms.

3. Investigators must promptly report to the IRB any **unexpected events** involving human participants. The definition of prompt reporting depends upon the seriousness of the unexpected event. For guidance on recognizing, defining, and reporting unexpected events to the IRB, please refer to the IRB website: http://www.irb.cornell.edu/policy.

If the use of human participants is to continue beyond the assigned approval period, the protocol must be re-reviewed and receive continuing approval. As the Principal Investigator it is your responsibility to obtain review and continued approval before the expiration date. Applications for renewal of approval must be submitted sufficiently in advance of the expiration date to permit the IRB to conduct its review before the current approval expires. Please allow three weeks for the review.

**Any research-related activities -- including recruitment and/or consent of participants, research-related interventions, data collection, and analysis of identifiable data -- conducted during a period of lapsed approval is unapproved research and can never be reported or published as research data.** If research-related activities occur during a lapse in the protocol approval, the activities become a research compliance issue and must be reported to the IRB via an unexpected event form (www.irb.cornell.edu/forms).

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Cc: Karim-aly Kassam

## *5. Expert interview questions*

*Energy poverty, security and sovereignty in rural communities in Tajikistan* *Laldjebaev M.*

**EXPERT INTERVIEW QUESTIONS**

**Thank you for your participation in this research project. Please answer the questions below as they apply to you (your organization). We guarantee confidentiality of your responses.**

**A. Energy problems:**

A.1. What are some major energy challenges facing the Republic of Tajikistan?

A.2. Rank the sectors' level of need according to the following scale. The same rank can be applied to multiple sectors if their level of need is considered about the same.

1=very slight, 2=slight, 3=moderate, 4=severe and 5=very severe

| industry | agriculture/ forestry | transportation | construction | residential/ households | commercial and public services |
|---|---|---|---|---|---|
| | | | | | |

A.3. What kinds of energy (carriers) are mostly needed?

**B. Energy security:**

B.1. How do you understand 'energy security' (definition, characteristics, main attributes, etc.)?

**C. Potential energy solutions:**

C.1. What have been or is being done to address the major energy challenges in the country?

C.2. How effective are the measures being undertaken?

C.3. What else would you suggest to improve energy security in Tajikistan?

C.4. What is the role of government, private sector, international organizations and civil society in improving energy security in Tajikistan?

**D. Energy data:**

D.1. Has your organization conducted any research on energy related aspects? If so, could you please provide reports, data or any related information?

D.2. Do you believe the year 1990 represents the desired state of energy consumption (i.e. a level of consumption that satisfies the energy needs of all sectors of the economy)?

D.3. Do have data on volume of consumption per energy source for each year available from 1980 to 2015? Breakdown by energy source, e.g. large, medium or small hydropower plants, coal, gas, etc.

D.4. Do you have data on volume of production per energy source for each year available from 1980 to 2015? Breakdown by sectors: a) industry b) agriculture/forestry c) transportation d) construction e) residential/households f) commercial and public services

D.5. Do you have data on location of potential energy sources?

D.6. Do you have data in the form of maps, including GIS data?

D.7. Do you have data on allocation of funding to exploit energy sources (budget or GDP)? Also per sector?

D.8. Do you have any other data that you think may be useful for this research project?

Thank you for your candid responses!

## 6. Household interview questions (English version)



**HOUSEHOLD INTERVIEW QUESTIONS**

**A. Electricity use:**

A.1. Do you experience any power cuts? Which hours of the day?

A.2. What do you use electricity for?

**B. Electricity receipts:**

B.1. Do you have any electricity receipts since January 2014?

**C. Lighting:**

C.1. What do you to light your home in the evening (when it's dark)?

C.2. How many hours of lighting do you need per day?

**D. Cooking:**

D.1. What fuel do you use to cook your meals?

D.2. How much [of fuel type] do you use per one loading of your stove? Note: write the local units; after the interview, ask the interviewee to set aside one loading of specified fuel and then measure its dimensions is meters (to get cubic meters) as well as its weight (to get kg).

D.3. Do often you bake your bread?

D.4. How many do your bake in one baking sessions?

D.5. How much [of fuel type] to you use each time you bake bread?

**E. Heating:**

E.1. How many rooms do you heat in winter (when it's cold)?

E.2. What are the dimensions of the room(s)? Note: if interviewee cannot tell, then measure using the tape.

E.3. How much hot water do you make for daily use, e.g. making tea, washing dishes?

E.4. How much hot water do you make for bathing?

E.5. How much hot water do you make for washing clothes?

E.6. How often do you wash clothes? (times per week)

**F. Fuel stock:**

F.1. How much fuel did you prepare for the winter? Note: wood, dung, straw in local measurements?

F.2. If bought any of it, how much did it cost?

F.3. Will the stocks of fuel last for the intended period (winter)?

**G. Migration:**

G.1. Has any member of your household ever migrated for work (e.g. in Russia)?

**H. Awareness of alternative technologies:**

H.1. Have you heard about solar panels, wind turbines that produce electricity, or biogas? Note: describe the systems with examples such as a rectangular thing mounted on top of a roof; a windmill like device; an big steel oil tank in which manure is mixed with water to produce gas.

**I. Switching to electricity:**

I.1. Would you abandon using wood/dung/straw if you had 24/7 electricity supply all year round?
I.2. Why yes/no?

**J. Mobility**

J.1. Do you travel outside your village?
J.2. How many times do you travel per month?
J.3. How much do you spend for travel?

---

**Reminder:**
**Write the local measurements of solid fuels after measuring/weighing for each separate fuel!**

## 7. *Survey questionnaire (English version)*

*Energy poverty, security and sovereignty in rural communities of Tajikistan* *Laldjebaev M.*

**HOUSEHOLD SURVEY QUESTIONNAIRE**

**number** ☐

| | | | |
|---|---|---|---|
| Region | **Khatlon** | Sub-district | |
| District ID<br>**1=Shurobod**<br>**2=Khovaling**<br>**3=Baljuvon** | | Village | |
| Name of respondent | | Phone No. (optional) | |
| Name of interviewer | | Phone No. | |

**Informed consent**

| | | | |
|---|---|---|---|
| Name of interviewer | | | |
| Signature of interviewer | | | |
| **Date of interview** | \|_\|_\|<br>Day | \|_\|_\|<br>Month | \|**2**\|**0**\|**1**\|**5**\|<br>Year |

**For data enterers ONLY.**

| | | | | | |
|---|---|---|---|---|---|
| Data enterer No1 | ____________________ | Signature | | Date:<br>dd/mm/year | \|_\|_\|.\|_\|_\|.\|2\|0\|1\|5\| |
| Data enterer No2 | ____________________ | Signature | | Date:<br>dd/mm/year | \|_\|_\|.\|_\|_\|.\|2\|0\|1\|5\| |

*Updated 19 March 2015* 1

**A. HOUSEHOLD COMPOSITION: Basic data and occupation of current household members at the time of the survey**

| | | Code A | 0=Male 1=Female | # years | 1=tajik; 2=uzbek; 3=kyrgyz; 4=other | Code B | Code C | Code D | |
|---|---|---|---|---|---|---|---|---|---|
| **№** | **Name** | **Relation to head of household** | **Sex** | **Age** | **Ethnicity** | **Marital status** | **Education** | **Main occupation** | **Secondary occupation** |
| 1 | | | | | | | | | |
| 2 | | | | | | | | | |
| 3 | | | | | | | | | |
| 4 | | | | | | | | | |
| 5 | | | | | | | | | |
| 6 | | | | | | | | | |
| 7 | | | | | | | | | |
| 8 | | | | | | | | | |
| 9 | | | | | | | | | |
| 10 | | | | | | | | | |
| 11 | | | | | | | | | |
| 12 | | | | | | | | | |
| 13 | | | | | | | | | |
| 14 | | | | | | | | | |
| 15 | | | | | | | | | |

*Note: Write the **household members who normally live and eat their meals together in dwelling**:

- Household heal, wife, children in order of age
- Other relatives then Non-relatives living in house
- Other people normally living HH who are on holiday or studing, but NOT those who have migrated for work more than 6 months out of the last 12.

| Code A | Code B | Code C | Code D | |
|---|---|---|---|---|
| 1=HH head | 1. Married | 1=no education | 1=pre-school | 10=artisan |
| 2=spouse | 2. Divorced | 2=non-completed primary | 2=at school | 11= public servant |
| 3=parent | 3. Separated | 3=primary | 3=unemployed | 12=NGO employee |
| 4=child | 4. Widowed | 4=non-completed secondary | 4=housewife | 13=military service |
| 5=grand child | 5. Single | 5=secondary | 5=farmer | 14=old age retired (over 60 years of age) |
| 6=sibling | | 6=technical/vocational graduate | 6=farm labourer (on state farm) | 15=benefits (e.g. child, disable, unemployment) |
| 7=daughter-in-law | | 7=university graduate | 7=casual labourer | 16=disabled (unable to work) |
| 8=other (name) | | 8=university post-graduate | 8=shepherd | 17=working abroad |
| | | 9=other | 9=trader (buy and sell) | 18=non-salaried other business |
| | | | | 19=other |

**B. DWELLING CHARASTERISTICS**

| 1 – owned;<br>2 – rented;<br>3 – other (specify) | years | 1 – single large house;<br>2 – two or more rooms;<br>3 - other (specify) | number | 1 – yes;<br>0 – no | 1 – yes;<br>0 – no | 1 – network (pipe);<br>2 – well;<br>3 – spring;<br>4 – stream/river;<br>5 - other (specify) | 1 – private inside;<br>2 – private outside;<br>3 – community;<br>4 - other (specify) | 1 – pit;<br>2 – pit with running water;<br>3 – flush toilet;<br>4 - other (specify) |
|---|---|---|---|---|---|---|---|---|
| **1. House ownership** | **2. Age of house** | **3. Type of house** | **4. Number of rooms** | **5. Separate kitchen?** | **6. Does kitchen have smoke ventilation?** | **7. Water supply** | **8. Type of latrine** | **9. Quality of latrine** |
| | | | | | | | | |

| 1 – living room;<br>2 – bedroom;<br>3 – guest room;<br>4 – other (specify) | Square meters | meter | 0 – no 2nd roof;<br>1 – wood and metal;<br>2 - other (specify) | 1 – clay;<br>2 – stone;<br>3 – brick/concrete;<br>4 - other (specify) | | | 1 – single;<br>2 – double | 1 – yes;<br>0 – no | narrative |
|---|---|---|---|---|---|---|---|---|---|
| **10. Designation of each room** | **11. Surface area** | **12. Height of ceiling** | **13. If second roof, roofing material is** | **14. Material on outer wall** | **15. Floor material** | **16. Roof material** | **17. Are windows single or double glazed?** | **18. Does any of the rooms have thermal insulation?** | **19. If yes, state room designation and part of the room (wall, floor, ceiling), material used for insulation** |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

**СИФАТҲОИ ИСТИФОДАИ ЭНЕРГИЯ**

**C. COOKING**

| 1 – home;<br>2 – eat out | Relation to HH<br>(Code A) | narrative | narrative |
|---|---|---|---|
| **1. Do you mostly cook at home or eat out?** | **2. Who in your household prepares most of the meals?** | **3. Why is this person responsible for cooking?** | **4. If no culturally relevant response is received, then the interviewer should probe by asking:**<br>**Is it expected in your community for men (women) to be responsible for cooking? What would happen if an opposite gender did this job? What would others in community think or say? What would happen to the person's (household's) status in the community?** |
| | | | |

| Name of meal | number | 1 – traditional clay stove; 2 – metal stove; 3 – electric stove; 4 – gas stove; 5 - other (specify) | | narrative, e.g., gas stove is used to quickly prepare a meal for guests | Number of days | somoni | 1 – wood; 2 – dung cakes; 3 – crop residue/straw; 4 – coal; 5 - other (specify) |
|---|---|---|---|---|---|---|---|
| **5. What kind of meals to you usually prepare?** | **6. How many cooked (hot) meals do you prepare per week?** | **7. What kind of stove do you use for cooking?** | **8. If mix of stoves, what is the main stove you use to cook most of your meals?** | **9. For other stove, specify the occasion of use.** | **10. For gas stove, how long does your tank last?** | **11. For gas stove, how much do you pay for one filling?** | **12. If main stove is traditional or metal stove, what fuel do you use for cooking?** |
| | | | | | | | |

| Local units: Wood/straw – bundle, embrace; Dung - number of cakes, in tray, in bag; Coal – in tray, in bag; Record all applicable. | For local units of fuel take measurements with hand-scale after interview, Ask household to put together bundle of wood, tray/bag of dung cakes or coal, etc. enough to prepare one meal. If a mix is used, ask to separate in proportion. Weigh all fuels used and record in kg. | 1 – yes; 2 – no | Amount per season |
|---|---|---|---|
| **13. How much of the specified fuel is used to cook one meal?** | **14. Fuel weight in kg** | **15. Do you use the same amount of fuel in all four seasons?** | **16. If not, how much more or less than the specified amount do you use in other seasons?** |
| | | | |

| 1 – yes (name the meal); 2 – no | narrative | narrative |
|---|---|---|
| **17. Is there any specific meal that is cooked using specific fuel?** | **18. Why is the specified meal cooked using the specified fuel?** | **19. If culturally relevant explanation is not offered, the interviewer should probe by asking: Would it be possible to cook that meal in a different way, for example, using electricity? Why not? Would they cook another meal instead and give up on the one in question if the required fuel were not available? Why not?** |
| | | |

| 1 – yes; 0 – no; 2 - partially | narrative | 1 – yes; 0 – noe | 1 – regular flat bread; 2 – thin bread; 3 – small round bread; 4 – other (specify) | Times per week | number | 1 – traditional clay stove; 2 – metal stove; 3 – electric stove; 4 – gas stove; 5 - other (specify) | 1 – wood; 2 – dung cakes; 3 – crop residue/straw; 4 – coal; 5 - other (specify) |
|---|---|---|---|---|---|---|---|
| **20. If electricity were provided 24/7 throughout the year, would you give up cooking on wood, dung, coal?** | **21. Why yes, why no, why partially?** | **22. Do you bake bread at home?** | **23. What types of bread do you bake?** | **24. How many times per week do you bake bread?** | **25. How many breads do you bake in one baking session?** | **26. What kind of oven/stove do you use for baking bread?** | **27. If traditional oven or metal stove, what fuel do you use for bread baking?** |
| | | | | | | | |

| Local units: Wood/straw – bundle, embrace; Dung - number of cakes, in tray, in bag; Coal – in tray, in bag; Record all applicable | For local units of fuel take measurements with hand-scale after interview, Ask household to put together bundle of wood, tray/bag of dung cakes or coal, etc. enough for one break baking session. If a mix is used, ask to separate in proportion. Weigh all fuels used and record in kg. |
|---|---|
| **28. How much of the specified fuel is used in one bread baking session??** | **29. Fuel weight in kg** |
| | |

| 1 – yes; 0 – no; 2 - partially | narraive | somoni |
|---|---|---|
| **30. If electricity were provided 24/7 throughout the year, would you give up cooking on wood, dung, coal?** | **31. Why yes, why no, why partially?** | **32. If yes or partially, how much would you be willing to pay per month for electricity for cooking?** |
| | | |

| 1 – collect; 2 – purchase; 3 – other (specify) | Relation to HH (Code A) | narrative | MATH |
|---|---|---|---|
| **33. How do you obtain your fuels? For each fuel record as appropriate** | **34. Who in your household collects wood/makes dung cakes?** | **35. Why is this person responsible for collecting wood/making dung cakes?** | **36. If no culturally relevant response is received, then the interviewer should probe by asking: Is it expected in your community for men (women) to be responsible for collecting wood/making dung cakes? What would happen if an opposite gender did this job? What would others in community think or say? What would happen to the person's (household's) status in the community?** |
| | | | |

| 1 – yes; 0 – no | e.g. heating | 1 – forest; 2 – fields; 3 – own garden; 4 – other (specify) | Local name of species | Local name of species |
|---|---|---|---|---|
| **37. Is all collected fuel used fo cooking only?** | **38. What are other used of collected fuel?** | **39. If fuel is collected, where do you collect from?** | **40. If forest or garden, which specied of trees/shrubs do you collect?** | **41. Which species is most commonly collected firewood from?** |
| | | | | |

| km | 1 – on back; 2 – on donkey; 3 – truck; 4 – other (specify) | hours | 1 – increased; 2 – decreased | 1 – a lot; 2 – a little | 1 – a lot; 2 – a little | narrative | year |
|---|---|---|---|---|---|---|---|
| **42. If collecing wood from forest, how far do you go to get fuel?** | **43. What mode of transport do you use to bring fuel?** | **44. How long does it take to go and come back?** | **45. Since Tajikistan's independence, has forest area increased or decreased?** | **46. If increased, how much it increased?** | **47. If decreased, how much decreased?** | **48. If increased/decreased, what contributed to it?** | **49. How long do you think the forest will be able to provide your community with firewood?** |
| | | | | | | | |

| Somoni per unit, e.g. per kg, per truck, (how much is one truckload? – in kg, cubic meters), per bundle, per number of dung cakes | 1 – forest agency; 2 – private vendor; 3 – neighbor; 4 – other (specify) | Narrative. Note: usually a permit for certain cubic meters of wood is purchased, and households collect on their own. | Narrative, e.g. denied the amount requested; sought side payments |
|---|---|---|---|
| **50. If purchased, how much do you spend on each fuel in one year?** | **51. Who do you purchase from?** | **52. If forest service, describe the procedure of payment and wood collection.** | **53. Have you had any problems purchasing from forest agency?** |
| | | | |

| 1 – yes; 0 – no | Narrative, e.g. heating | 1 – yes; 0 – no | Narrative, e.g. can physically bring only so much, not enough money to purchase |
|---|---|---|---|
| **54. Is all purchased fuel used for cooking only?** | **55. What are other uses of purchased fuel?** | **56. Is the amount collected and purchased sufficient for all your cooking needs?** | **57. If not, why?** |
| | | | |

| narrative | narrative | Local unit | percent | somoni |
|---|---|---|---|---|
| **58. What meals are you not able to cook because you don't have sufficient fuel?** | **59. What else would you cook if you had good supply of fuel available to you when you need it?** | **60. How much more fuel would you need to satisfy your cooking needs per day?** | **61. How much of the sufficient amount would be willing to buy?** | **62. How much would you be willing to pay for this proportion?** |
| | | | | |

**D. HEATING (space)**

| 1 – yes; 0 – no | number | 1 – traditional clay stove; 2 – metal stove; 3 – electric stove; 4 – gas stove; 5 - other (specify) | 1 – wood; 2 – dung cakes; 3 – crop residue/straw; 4 – coal; 5 - other (specify) |
|---|---|---|---|
| **1. Do you heat your home in winter (what it's cold)?** | **2. How many rooms do you heat?** | **3. What kind of stove do you use for space heating?** | **4. If traditional or metal stove, what fuel do you use for heating?** |
| | | | |

| Local units: Wood/straw – bundle, embrace; Dung - number of cakes, in tray, in bag; Coal – in tray, in bag; Record all applicable. | For local units of fuel take measurements with hand-scale after interview, Ask household to put together bundle of wood, tray/bag of dung cakes or coal, etc. enough to prepare one meal. If a mix is used, ask to separate in proportion. Weigh all fuels used and record in kg. |
|---|---|
| **5. How much of the specified fuel do you use to heat your per day? (if more than one room, ask for the one mostly occupied or heated)** | **6. Fuel weight in kg** |
| | |

| 1 – yes; 0 – no | Local units | 1 – yes; 0 – no | 1 – yes; 0 – no | Local units |
|---|---|---|---|---|
| **7. Does the specified amount also include cooking on the same stove while it provides heating?** | **8. If yes, how much do you think actually goes to heating?** | **9. Do you heat your home overnight?** | **10. If yes, does the amount you indicated per day also include overnight heating?** | **11. If no, how much fuel do you use for overnight heating?** |
| | | | | |

| 1 – yes; 0 – no | Narrative, e.g. can physically bring only so much, not enough money to purchase | Local units | Somoni per type of fuel |
|---|---|---|---|
| **12. Is the speficed amount for daily and overnight heating sufficient to provide comfortable temperature in your home?** | **13. If no, why?** | **14. How much more fuel would you need to satisfy your heating needs?** | **15. How much would you be willing to pay per month for your heating needs?** |
| | | | |

| 1 – yes (name the fuel); 0 – no | narrative | narrative |
|---|---|---|
| **16. Do you prefer to heat with specific type of fuel?** | **17. Why is the specified fuel preferred?** | **18. If culturally relevant explanation is not offered, the interviewer should probe by asking: Would it be possible to heat your home in a different way, for example, using electricity? Why not? Would you use another fuel instead and give up on the one in question if the required fuel were not available? Why not?** |
| | | |

| Local units | 1 – yes, 0 – no | Narrative, e.g. heated one room only, cooked in the same room, purchased fuel – amount/price? | Local units | 1 – yes; 0 – no; 2 – don't know | Narrative, e.g. heated one room only, cooked in the same room, purchased fuel |
|---|---|---|---|---|---|
| **19. How much fuel did you stock up for previous winter heating?** | **20. Was the stock sufficient to last you entire winter?** | **21. If not, how did you cope with the shortage?** | **22. How much did you stock up for this winter heating?** | **23. Do you think it will last you the entire winter?** | **24. If not, how are you going to cope with the shortage?** |
| | | | | | |

| Local units | Percent | Somoni | 1 – yes; 0 – no | Narrative, e.g. load shedding, low voltage, poor quality heater | Narrative, e.g. improvised/hand made; if purchased record the price, manufacturer, capacity; record for all heaters if more than one |
|---|---|---|---|---|---|
| **25. How much fuel stock would be sufficient to last you through the winter without any shortage?** | **26. How much of the suffieicnt amount would you be willing to buy?** | **27. How much would you be willing to pay for this proportion?** | **28. If heating with electric stove, is it sufficient to provide comfortable temperature throughout the day?** | **29. If no, why?** | **30. What type of electric heater do you use?** |
| | | | | | |

| 1 – yes; 0 – no; 2 - partially | narraive | somoni |
|---|---|---|
| **31. If electricity were provided 24/7 throughout the year, would you give up heating on wood, dung, coal?** | **32. Why yes, why no, why partially?** | **33. If yes or partially, how much would you be willing to pay per month for electricity for heating?** |
| | | |

**E. WATER HEATING**

| Times per day | liters | 1 – on traditional clay stove; 2 – on metal stove; 3 – on electric stove; 4 – on gas stove; 5 – in electric kettle; 6 – other (specify) | Local units | Narrative | narrative |
|---|---|---|---|---|---|
| **1. How many times per day do you make tea?** | **2. How much water do you boil at a time?** | **3. What type of stove do you mostly prefer to boil water?** | **4. If traditional or metal stove, how much fuel do you use for water heating only?** | **5. Why is this type of stove preferred?** | **6. If culturally relevant explanation is not offered, the interviewer should probe by asking: Would it be possible to boil water for tea in a different way, for example, using electricity? Why not? Would you use another stove instead and give up on the one in question if the required stove or fuel were not available? Why not?** |
| | | | | | |

| 1 – yes; 0 – no | 1 – bathing; 2 – washing clothes; 3 – washing dishes; 4 – for animal; 5 – other (specify) | Liters | 1 – yes; 0 – no | 1 – on traditional clay stove; 2 – on metal stove; 3 – on electric stove; 4 – on gas stove; 5 – in electric kettle; 6 – other (specify) | 1 – yes; 0 – no | Local units |
|---|---|---|---|---|---|---|
| **7. Do you use hot (warm) water for any other purpose?** | **8. What are other uses of hot water?** | **9. How much hot water do you need per day for other purposes?** | **10. Do you use the same stove as you do for boiling water for tea?** | **11. If no, specify the type of stove** | **12. If traditional or metal stove, do you have sufficient fuel for you water heating needs?** | **13. If not, how much more fuel would you need to satisfy your daily water heating needs?** |
| | | | | | | |

**F. COOLING**

| 1 – yes; 0 – no | 1 – electric fan; 2 – air conditioner; 3 – other (specify) | 1 – very uncomfortable; 2 – uncomfortable; 3 – neutral; 4 – comfortable; 5 – very comfortable | 1 – yes; 0 – no | 1 – yes; 0 – no | Narrative, e.g. load shedding |
|---|---|---|---|---|---|
| **1. Do you cool your home (during summer heat)?** | **2. If yes, what type of device do you use to cool your home?** | **3. If no, how comfortable or uncomfortable do you feel when cooling is not available?** | **4. Do you have a refrigerator?** | **5. If yes, are you able to use it when you need it?** | **6. If not able, why?** |
| | | | | | |

| Narrative, expensive, no electricity | Narrative, use neighbor's refrigerator, keep under water | Narrative | Narrative | Somoni |
|---|---|---|---|---|
| **7. If no refrigerator, why do you not have one?** | **8. If no refrigerator, how do you preserve your quickly perishable food products, like meat and milk?** | **9. If no refrigerator, how does it affect your life?** | **10. What would you do if you had a refrigerator?** | **11. If have refrigerator, how much would you be willing to pay per month to have continuous electricity supply for your refrigerator?** |
| | | | | |

**G. LIGHTING**

| 1 – electricity; 2 – electrici lantern; 3 – kerosene lamp; 4 – candles; 5 – other (specify). Record all applicable. | | 1 – main grid; 2 – local hydropower; 3 – solar panel; 4 – wind turbine; 5 – other (specify) | 1 – efficient; 2 – inefficient; Record watts for each bulb. |
|---|---|---|---|
| **1. What type of lighting device do you use to light your home when it's dark?** | **2. What is the most commonly used device?** | **3. If common device is electricity, where does your electricity come from?** | **4. What kind of light bulbs do you have?** |
| | | | |

| 1 – local shop/market; 2 – district shop/market; 3 – other (specify) | km | liter | price |
|---|---|---|---|
| **5. If common device is kerosene lamp, where do you get kerosene from?** | **6. How far do you have to travel to get kerosene?** | **7. How much kerosene do you buy?** | **8. How much do you pay per liter?** |
| | | | |

| 1 – local shop/market; 2 – district shop/market; 3 – other (specify) | km | number | price |
|---|---|---|---|
| **9. If common device is electric lanter, where do you get batteries from?** | **10. How far do you have to travel to get batteries?** | **11. How many batteries do you buy?** | **12. How much do you pay per battery?** |
| | | | |

| 1 – local shop/market; 2 – district shop/market; 3 – other (specify) | km | number | price |
|---|---|---|---|
| **13. If common device is candles, where do you get candles from?** | **14. How far do you have to travel to get candles?** | **15. How many candles do you buy?** | **16. How much do you pay per candle?** |
| | | | |

| hours | 1 – yes; 0 – no | Narrative, e.g. if electricity is common device – load shedding; if solar – not enough battery charge; if kerosene lamp – expensive, etc. | Narrative, e.g. sleep, use another device | Narrative | Narrative | somoni |
|---|---|---|---|---|---|---|
| **17. How many hours a day do you need lighting for?** | **18. For the specified common device, does your lighting source provide sufficient lighting for specified duration?** | **19. If not, why?** | **20. If not, what do you usually do?** | **21. What kind of activities are you not able to do because you don't have sufficient lighting?** | **22. What would you do if you had good quality lighting available to you when you need it?** | **23. How much would you be willing to pay per month for electric lighting?** |
| | | | | | | |

**H. INFORMATION AND COMMUNICATION**

| 1 – yes; 0 – no | 1 – cellphone; 2 – landline | number | 1 – talking to relatives; 2 – talking to friends; 3 – talking for business; 4 – texting; 5 – internet; 6 – other (specify) | 1 – very important; 2 – important; 3 – neutral; 4 – unimportant; 5 – very unimportant | somoni | Narrative, e.g. use car chager, send with neighbors to nearest town | Narrative | somoni |
|---|---|---|---|---|---|---|---|---|
| **1. Do you have a telephone?** | **2. What type of telephone is it?** | **3. If cellphone, how many cellphones are there in your household?** | **4. What do you use your cellphone for?** | **5. How important or unimportant is cellphone in your life?** | **6. How much do you spend on your cellphone use per month?** | **7. What do you do when there is no electricity for a long period to charge your cellphone?** | **8. If no telephone or cellphone, what could you do if you had one?** | **9. How much would you be willing to pay per month for charging your cellphone?** |
| | | | | | | | | |

**I. ENERGY SUPPLY**

| 1 – yes; 0 – no | 1 – yes; 0 – no | hours | 1 – daily; 2 – every other day; 3 – once a week; 4 – once in two weeks; 5 – once a month | 1 – yes; 0 – no | List months from beginning to end of power cuts | Hours, e.g. from 7am – 10 am |
|---|---|---|---|---|---|---|
| **1. Are you connected to electricity grid?** | **2. Have you experienced any power cuts within the past 24 hours?** | **3. If yes, for how many hours in total?** | **4. How often do you experience power cuts?** | **5. Do power cuts occur at the specified frequency throughout the year?** | **6. If no, which months do they mostly occur?** | **7. During which hours of the day do you get electricity during this period of power limits?** |
| | | | | | | |

| narrative | 1 – very satisfied; 2 – satisfied; 3 – neutral; 4 – unsatisfied; 5 – very unsatisfied | narrative | Narrative | hours | Hours | somoni |
|---|---|---|---|---|---|---|
| **8. What activities do you prioritize to get done during the times you get electricity?** | **9. How satisfied or unsatisfied are you with your electricity provision?** | **10. If satisfied (1 & 2), explain why?** | **11. If unsatisfied, explain why?** | **12. How many hours of electricity would you like to have per day?** | **13. During which hours of the day would you like to get electricity?** | **14. How much would you be willing to pay per month to get the desired hours of electricity?** |
| | | | | | | |

| 1 – yes; 0 – no | Narrative, e.g. solar panels | 1 – yes; 0 – no | narrative | 1 – very satisfied; 2 – satisfied; 3 – neutral; 4 – unsatisfied; 5 – very unsatisfied | MATH | MATH |
|---|---|---|---|---|---|---|
| **15. Do you know of any other way to get electricity apart from the grid?** | **16. If yes, name the ways?** | **17. Have you ever used any of the mentioned technologies?** | **18. If yes, why? If not, why?** | **19. If yes, overall how satisfied or unsatisfied were (are) you about it?** | **20. If satisfied (1 & 2), name up to five things you like(d) a lot about it.** | **21. If unsatisfied (4 & 5), name up to five things that you dislike(d) a lot about it.** |
| | | | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 – yes; 0 – no | Ask the household to bring the receipts and record kilowatt hours used and amount billed per month | | kWh | January 2014 | | April 2014 | | July 2014 | | October 2014 | | January 2015 | |
| **22. Do you have electricity bills?** | | | somoni | | | | | | | | | | |
| | | | kWh | February 2014 | | May 2014 | | August 2014 | | November 2014 | | February 2015 | |
| | | | somoni | | | | | | | | | | |
| | | | kWh | March 2014 | | June 2014 | | September 2014 | | December 2014 | | March 2015 | |
| | | | somoni | | | | | | | | | | |

**LIVELIHOOD CHARACTERISTICS**

**J. LAND**

**1. List types of LAND the household owns, rents, and uses**

| | Hectare | Hectare |
|---|---|---|
| **2. Land type** | **AREA** | |
| | Irrigated (2014) | Rain-fed (2014) |
| **a. Land owned (share received after break-up of state farm)** | | |
| Arable | | |
| Orchard | | |
| Natural hayland (not sown) | | |
| **6. Land rented (or using land which belongs to someone else** | | |
| Arable | | |
| Orchard | | |
| Natural hayland (not sown) | | |
| **3. Kitchen garden** | | |
| **4. President's land** | | |
| **5. Hayland on pasture** (common, free of charge) | | |
| **6. Other** (unofficial arable land in mountains) | | |

**7. Output and income from irrigated and rain-fed lands in the last 12 months:**

| | Kg | Hectare | yes=1 no=2 | yes=1 no=2 | Kg | Hectare | yes=1 no=2 | yes=1 no=2 | Kg NA=99 | Code A | Somoni | Somoni |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Output from irrigated land** | | | | **Output from rain-fed land** | | | | | | | |
| **Type of produce** | **General output** | **Area** | Mineral fertilizer used? | Organic fertilizer used? | **General output** | **Area** | Mineral fertilizer used? | Organic fertilizer used? | **Amount sold** | **Where sold?** | **Transport costs** | **Cash** |
| Potato | | | | | | | | | | | | |
| Wheat | | | | | | | | | | | | |
| Barley | | | | | | | | | | | | |
| Corn | | 99 | 99 | 99 | | 99 | 99 | 99 | | | | |
| Beans | | 99 | 99 | 99 | | 99 | 99 | 99 | | | | |
| Safflower | | 99 | 99 | 99 | | 99 | 99 | 99 | | | | |
| Sunflower | | 99 | 99 | 99 | | 99 | 99 | 99 | | | | |
| Watermelon | | 99 | 99 | 99 | | 99 | 99 | 99 | | | | |
| Alfalfa | | 99 | 99 | 99 | | 99 | 99 | 99 | | | | |
| Sainfoin | | 99 | 99 | 99 | | 99 | 99 | 99 | | | | |
| Grass | | 99 | 99 | 99 | | 99 | 99 | 99 | | | | |
| Other____ | | 99 | 99 | 99 | | 99 | 99 | 99 | | | | |

| **Code A** | | | |
|---|---|---|---|
| 1=friends/neighbours/relatives | 3=market in Survey Region | 5=market outside Tajikistan | 7=other |
| 2=passing traders | 4=market outside Survey Region | 6=cross-border market | |

**8. Output and income from fruit (trees) on rented/private land or in kitchen garden in last 12 months:**

| | # | # | Kg | Kg | Yes=1 No=2 | Yes=1 No=2 | Kg or NA=99 | Code A | TJS | TJS |
|---|---|---|---|---|---|---|---|---|---|---|
| **FRUIT TYPE** | Number of trees/ vines **owned** | Trees **planted** in the last 12 months? | **Irrigated Amount Produced** | **Rain Fed Amount Produced** | Any Fertilizer Used? | Pesticide Used? | **Amount Sold?** | Where Sold? | Transport Costs? | **Cash** |
| Apple | | | | | | | | | | |
| Pear | | | | | | | | | | |
| Apricot | | | | | | | | | | |
| Peach | | | | | | | | | | |
| Mulberry | | | | | | | | | | |
| Grape | | | | | | | | | | |
| Plum | | | | | | | | | | |
| Cherry | | | | | | | | | | |
| Walnut | | | | | | | | | | |
| Persimmon | | | | | | | | | | |
| Pomegrenade | | | | | | | | | | |
| Fig | | | | | | | | | | |
| Quince | | | | | | | | | | |
| Other fresh fruit | | | | | | | | | | |
| Conserved fruit | 99 | 99 | 99 | 99 | 99 | 99 | | | | |
| Dried fruit | 99 | 99 | 99 | 99 | 99 | 99 | | | | |
| Other fruit product | 99 | 99 | 99 | 99 | 99 | 99 | | | | |

| narrative | 1 – yes; 0 – no | Narrative, .e.g. buy flour from market | hectare | 1 – yes; 0 – no | narrative |
|---|---|---|---|---|---|
| **9. What did you use the money for?** | **10. Would the harvest be sufficient to feed your family until new new harvest?** | **11. If not, how would you cope with the shortage?** | **12. How much more land would be suffieicnt to satisfy your needs?** | **13. Is there more land available in your village area that you could use?** | **14. If yes, what are some obstacles that prevent you from accessing additional land?** |
| | | | | | |

**K. LIVESTOCK**

**1. Numbers of Livestock and Production/collection and Income made from livestockand wild products in the last 12 months**

| | number | Product type | Kg/L | Kg/L NA=99 | Code A | Somoni |
|---|---|---|---|---|---|---|
| **Type of stock** | Total head | **Product type** | **Amount produced/collected?** | **Amount sold?** | **Where sold?** | **Income made** |
| Yak | | Milk | | | | |
| Kyroc | | Yogurt | | | | |
| Sheep | | Butter | | | | |
| Goat | | Cream | | | | |
| Chicken | | Kefir | | | | |
| Horse | | Qurut (dried yogurt) | | | | |
| Donkey | | Fresh cheese | | | | |
| Turkey | | Meat | | | | |
| Goose | | Eggs | | | | |
| Duck | | Skin | | | | |
| Bees (hives) | | Wool | | | | |
| Other___ | | Honey | | | | |
| | | Blackcurrent | | | | |
| | | Buckthorn | | | | |
| | | Blackberries | | | | |
| | | Wild Cumin | | | | |
| | | Herbal plants | | | | |
| | | Timber | | | | |
| | | Firewood | | | | |
| | | Other wild | | | | |
| | | Other | | | | |

**CODE A**

1= neighbors/relatives/friends;
2=outside traders;
3=in district market;
4= in regional market;
5= in cross-border market;
6= to tourists;
7=in outside market;
8=other ___________

| Narrative | Narrative | 1 – yes; 0 – no | Narrative, e.g. buy from neighbor | Number of kind of animal | Narrative |
|---|---|---|---|---|---|
| **2. What did you use the money for?** | **3. Briefly explain why do keep livestock? Which household needs does it satisfy?** | **4. Is the number of animals you have sufficient to meet your needs?** | **5. If not, how do you cope with the shortage?** | **6. How many more animals would be sufficient to satisfy your needs?** | **7. What are some obstacles that prevent you from breeding more animals?** |
| | | | | | |

**L. Other types of Non-agricultural income of household**

**1. Other types of non-agricultural income of the household made in the last 12 months:**

| **Code A** | | | 1= Male<br>2= Female | Age | **Code B** |
|---|---|---|---|---|---|
| **Type of income** | **Average amount of income per month** | **Months in the last 12 months income received** | **Earned by** | | **Who makes decision for the usage of this income?** |
| | | | | | |
| | | | | | |
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| | | | | | |

| **Code A** | | **Code B** |
|---|---|---|
| 1=Old age pension;<br>2=Benefits (child, invalid, unemployment);<br>3=Salary;<br>4=Remittances;<br>5=Hired farm labourer;<br>6=Casual labour;<br>7=Shepherd fees;<br>8=Trade;<br>9=Sale of artisan products;<br>10=Rental of machinery;<br>11=Rent of assets; | 12=Sale of assets;<br>13=Chaykhana/teahouse;<br>14=gueshouse;<br>15=repair of machinery/equipment;<br>16=vulcanization;<br>17= diviner;<br>18=conducting training courses;<br>19=shop;<br>20=Other________ | 1=Self;<br>2=HH Head;<br>3=spouse;<br>4=Parent;<br>5=Child;<br>6=grand-child;<br>7=Sibling;<br>8=other:_________________________. |

| Name of item | Percent | Somoni | Percent | 1 – yes; 0 – no; 2 – partially | Somoni | Narrative |
|---|---|---|---|---|---|---|
| **2. What items do you spend most of your income on?** | **3. What proportion do you spend on each specified item?** | **4. If not already specified, how much per month do you spend on food?** | **5. What percentage of your income goes to your food needs?** | **6. Is your income sufficient to satisfy your needs?** | **7. If no or partially, how much more would you need per month?** | **8. What are some obstacles that prevent you from making that additional amount?** |
| | | | | | | |

**M. Functioning assests belonging to the household (not to relatives living in another dwelling)**

| | yes=1, no=2 | Somoni |
|---|---|---|
| **Asset type** | **Own item** | **Cost** (Only if purchased in 2014) |
| **Own home** | | |
| **Own apartment** | | |
| **Own 2nd** | | |
| **Warehouse (storage)** | | |
| **Motorbike** | | |
| **Truck** | | |
| **TV** | | |
| **DVD player** | | |
| **Satellite dish** | | |
| **Computer** | | |
| **Electric washing machine** | | |
| **Sewing machine** | | |
| **Tractor** | | |
| **Internet** | | |
| **Other**____________________ | | |
| | | |
| | | |
| | | |
| | | |

**N. Access to road**

| | | |
|---|---|---|
| **1. Do you have access to any type of road?** | 1= yes, 2= no | |
| **2. If yes, how many times per month do you travel on this road?** | Times per month | |
| **3. How much in total do you spend per month on transportation?** | Somoni | |

**O. Access to market**

| | | | | | |
|---|---|---|---|---|---|
| **1. How far is closest market located? (indicate by meter)** | | | | | |
| **2. Do you go to the market?** | 1= yes, 2= no | | | | |
| **3. Name the type of market you go to.** | Market at the village level | Market at the sub-district level | Market at the district level | Market at the provincial level | Cross-border market |
| | | | | | |
| **4. How often do you go to the above markets?** | | | | | |
| | 1=daily; 2=weekly; 3=моҳе як бор; 4=quarterly; 5=semi-annually; 6=annually; 7= other___ | | | | |
| **5. How much do you spend per month in the market?** | Somoni | | | | |

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