Stakeholder Value Network Analysis for the Energy System of Saudi Arabia

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ABSTRACT

Saudi Arabia is experiencing a considerable escalation in its consumption of electricity, provoked by economic progress and population increase. Such an escalation threatens the economic output of the Kingdom: more oil and gas are needed to produce electricity and thus less oil and gas available for international trade. Therefore, the Kingdom faces the challenge of looking to atomic and renewable energy as options to fill the electricity gap for the upcoming decades. In this thesis, One of the main challenges is that the energy sector is controlled by multiple stakeholders. We address such a challenge through Stakeholder Value Network Analysis. We provide a thorough characterization of the stakeholder network in terms of direct and indirect value exchange from the point of view of a focal organization: government. We quantify the value exchange in the network and provide a research grounded ranking of the most important stakeholders and the most important transactions of value throughout the network and directly linked to the Saudi government. Finally, we use such characterization and quantification of the stakeholder network to identify the mechanisms and tradeoffs that the government has to include regarding atomic and renewable energies in the production of electricity.

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Dedication

I had the support of so many people to make this happen that it will be unfair to mention just a couple.

Prof. Edward Crawley, my supervisor, gave me the confidence and opportunity of working with him.

Dr. Bruce Cameron, and the rest of my forty-niners, gave me the foundations and perspective for developing this work

Judith Osornio and Francisco Alonso, my parents, gave me the support for spanning my boundaries

Miguel Alonso, my brother, gave me the belief of being doing something worthy

Atenea Lara, my love with no measure ☼ ♥ ☽ ∞, gave me the inspiration for discovering my purpose in life. Mi Amor, me salvaste de la vida

Andrew Whitaker, Alexander Rudat, Jose Salazar and Jorge Huguenin, and many others (you see the point of unfairness here), gave me the friendship for sharing experiences in life

Carlos Locht, my mirror, gave me the intuition for finding myself

Boston, my city, gave me the feeling of belonging

Leonid Chindelevitch, Masahiro Ono, Masashi Hirose, Ross Collins and Willis-Read Button, my roommates, gave me their patience for bearing with me

All the people that said "no," gave me the basis for finding the ones—my kind—that say "yes"

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Table of Contents

TABLE OF CONTENTS **5**

LIST OF FIGURES **6**

1. INTRODUCTION **8**

1.1. MOTIVATION 8
1.2. SAUDI ARABIA MAIN DIRECTIONS 13
1.2.1. ENHANCING ECONOMIC DEVELOPMENT 14
1.2.2. ENHANCING HUMAN DEVELOPMENT 16
1.2.3. ENHANCING PRIVATE INDUSTRY 16
1.3. GENERAL OBJECTIVES 17
1.4. THE CENTER FOR COMPLEX ENGINEERING SYSTEMS (CCES) 18
1.5. STAKEHOLDER VALUE NETWORK ANALYSIS (SVNA) 19
1.6. RELEVANT LITERATURE ON STAKEHOLDER ANALYSIS 24
1.6.1. PREVIOUS MIT WORK 29
1.7. SPECIFIC OBJECTIVES 30

2. QUALITATIVE ANALYSIS OF THE ENERGY SYSTEM OF SAUDI ARABIA **33**

2.1. THE PARTICULAR ROLE OF THE GOVERNMENT IN SAUDI ARABIA 33
2.2. THE STAKEHOLDER NETWORK OF THE ENERGY SYSTEM OF SAUDI ARABIA 39
2.3. STAKEHOLDER CHARACTERIZATION TEMPLATES 45
2.4. SVNA VALUE EXCHANGE 48
2.4.1. INPUT / OUTPUT VALUE EXCHANGE DIAGRAM FOR THE POLICY MAKING ARENA 57
2.4.2. INPUT / OUTPUT VALUE EXCHANGE DIAGRAM FOR THE ECONOMIC DEVELOPMENT ARENA .. 61
2.4.3. INPUT / OUTPUT VALUE EXCHANGE DIAGRAM FOR THE ENERGY SUPPLY ARENA 67
2.4.4. INPUT / OUTPUT VALUE EXCHANGE DIAGRAM FOR THE HUMAN CAPITAL ARENA 72
2.5. THE STAKEHOLDER NETWORK BY VALUE FLOW CATEGORY 77
2.6. SUMMARY 85

3. STAKEHOLDER SURVEYS AND QUANTITATIVE METRICS **87**

3.1. SVNA QUESTIONNAIRES 88
3.2. SVNA INTERVIEWS 94
3.3. COMPUTATION OF SCORES FOR VALUE LOOPS 96
3.4. QUANTITATIVE METRICS OF SVNA 99
3.4.1. NORMALIZED WEIGHTED STAKEHOLDER OCCURRENCE (NWSO) 100
3.4.2. WEIGHTED "GOVERNMENT" INPUT AND OUTPUT OCCURRENCE (WIO AND WOO) 101
3.4.3. WEIGHTED VALUE FLOW OCCURRENCE (WFVO) 102
3.4.4. MOST SIGNIFICANT VALUE LOOPS 102
3.5. SUMMARY 103

4. QUANTITATIVE ANALYSIS OF THE STAKEHOLDER NETWORK **104**

4.1. NWSO RESULTS 104
4.2. WEIGHTED GOVERNMENT INPUTS AND OUTPUTS 108
4.3. WVFO RESULTS 114
4.4. MOST IMPORTANT VALUE CYCLES 116
4.5. SUMMARY 122

5. SIMPLIFIED STAKEHOLDER NETWORK AND POLICY ANALYSIS 125
5.1. STATE OWNED VERSUS PRIVATE INDUSTRY REGULATED BY THE GOVERNMENT 126
5.2. ECONOMIC INCENTIVES FOR THE ALTERNATIVE ENERGY INDUSTRY 133
5.3. INVESTMENT IN EDUCATION AND KNOWLEDGE CREATION 138
5.4. DATA ACCESSIBILITY IN THE KINGDOM 141
5.5. RECOMMENDATIONS 142
APPENDIX A: STAKEHOLDER CHARACTERIZATION TEMPLATES 144
LIST OF SOURCES 155

List of Figures

FIGURE 1 - GDP FOR THE KINGDOM OF SAUDI ARABIA BY SECTOR (MEP, 2011) 9
FIGURE 2 - CRUDE OIL SPOT PRICES (EIA, 2012) 9
FIGURE 3 - GROWTH LEVELS OF SOLD ELECTRICITY (%) (SEC, 2010) 11
FIGURE 4 - ELECTRICITY CONSUMPTION IN THE KINGDOM, 2011 (ECRA, 2011) 11
FIGURE 5 - SOURCES FOR PRODUCTION FOR ELECTRICITY IN THE KINGDOM, 2011 (ECRA, 2011) 12
FIGURE 6 - POPULATION AND URBAN POPULATION, SELECTED COUNTRIES (GAPMINDER, 2012) 13
FIGURE 7 - COST CURVE FOR CHANGING OF ENERGY EFFICIENCY PERFORMANCE (NILSSON, 1995) 16
FIGURE 8 - EXPECTED ENERGY NEEDS FOR 2030 (KACARE, 2010) 18
FIGURE 9 - SIMPLE STAKEHOLDER NETWORK 21
FIGURE 10 - STAKEHOLDER MAP FOR THE NASA EARTH OBSERVATION PROGRAM (SUTHERLAND, 2009) 22
FIGURE 11 - STAKEHOLDER MAP FOR THE NASA EARTH OBSERVATION PROGRAM SHOWING ONLY PRIORITY VALUE EXCHANGES (SUTHERLAND, 2009) 23
FIGURE 12 - STAKEHOLDER MAP SHOWING DIRECT TRANSACTIONS BETWEEN STAKEHOLDERS AND THE CENTRAL ORGANIZATION 25
FIGURE 13 - ELEMENTS IN BONKE'S FRAMEWORK FOR STAKEHOLDER MAPS 26
FIGURE 14 - EXAMPLE OF STAKEHOLDER MAPPING WITH BONKE'S FRAMEWORK 28
FIGURE 15 - CALGENE INTEGRATED STRATEGY USING BARON'S FRAMEWORK 29
FIGURE 16 - KACARE DESIRED ENERGY MIX FOR 2030 (AL-SULAIMAN, 2011) (THE SOURCE DID NOT PROVIDE UNITS FOR THE CHART) 37
FIGURE 17 - LEVEL 0 PERSPECTIVE: THE FOUR "ARENAS" INCLUDED IN THE STAKEHOLDER NETWORK OF THE ENERGY SYSTEM OF SAUDI ARABIA (ARROWS INDICATE VALUE FLOW) 41
FIGURE 18 - LEVEL 1, ENERGY STAKEHOLDER NETWORK (ARROWS INDICATE VALUE FLOW) 42
FIGURE 19 - LEVEL 2, ENERGY STAKEHOLDER NETWORK 43
FIGURE 20 - CHARACTERIZATION TEMPLATE FOR THE "SCIENTISTS" STAKEHOLDER - NASA EARTH OBSERVATIONS PROGRAM (SUTHERLAND, 2009) 47
FIGURE 21 - CHARACTERIZATION TEMPLATE FOR THE STAKEHOLDER "GOVERNMENT" 49
FIGURE 22 - VALUE FLOW TYPES (AND COLOR CODE) FOR THE ENERGY SYSTEM OF SAUDI ARABIA 50
FIGURE 23 - FULL MAP OF VALUE EXCHANGE - SAUDI ARABIA ENERGY NETWORK 52
FIGURE 24 - INPUT / OUTPUT VALUE EXCHANGE – GOVERNMENT 59
FIGURE 25 - INPUT / OUTPUT VALUE EXCHANGE - INTERNATIONAL GOVERNANCE 60
FIGURE 26 - INPUT / OUTPUT VALUE EXCHANGE – MANUFACTURING AND SERVICES INDUSTRY 62
FIGURE 27 - INPUT / OUTPUT VALUE EXCHANGE – ECONOMIC CITIES 63
FIGURE 28 - INPUT / OUTPUT VALUE EXCHANGE – INVESTMENT ENTITIES 65
FIGURE 29 - INPUT / OUTPUT VALUE EXCHANGE – OIL AND GAS INDUSTRY 66
FIGURE 30 - INPUT / OUTPUT VALUE EXCHANGE – UTILITIES COMPANIES 69
FIGURE 31 - INPUT / OUTPUT VALUE EXCHANGE – ALTERNATIVE ENERGY INDUSTRY 70
FIGURE 32 - INPUT / OUTPUT VALUE EXCHANGE – PEOPLE 74

FIGURE 33 - INPUT / OUTPUT VALUE EXCHANGE – UNIVERSITIES AND RESEARCH CENTERS 75
FIGURE 34 - INPUT / OUTPUT VALUE EXCHANGE – MEDIA 76
FIGURE 35 – STAKEHOLDER NETWORK, POLICY AND OPINION VALUE FLOW 78
FIGURE 36 – STAKEHOLDER NETWORK, CAPITAL VALUE FLOW 79
FIGURE 37 – STAKEHOLDER NETWORK, ENERGY VALUE FLOW 81
FIGURE 38 - KNOWLEDGE AND INFORMATION VALUE FLOW 82
FIGURE 39 – STAKEHOLDER NETWORK, GOODS AND SERVICES VALUE FLOW 83
FIGURE 40 - JOBS AND PUBLIC BENEFIT VALUE FLOW 86
FIGURE 41 - SATISFACTION / REGRET QUESTIONNAIRE OF SVNA 90
FIGURE 42 – SOURCE IMPORTANCE QUESTION OF SVNA QUESTIONNAIRE 91
FIGURE 43 - SPECIFIC EXAMPLE OF THE USAGE OF SVNA QUESTIONNAIRE 92
FIGURE 44 - EXAMPLE OF A VALUE LOOP AND ITS QUANTIFICATION FOR SVNA: IN THE RED BOX (THE SPECIFIC NUMBERS ARE JUST FOR ILLUSTRATION) 97
FIGURE 45 - INPUT / OUTPUT DIAGRAM FOR GOVERNMENT 98
FIGURE 46 - NWSO FOR THE STAKEHOLDER NETWORK (THE RED BARS SHOW .25 PERCENTILES OF VALUE, REMIND THAT "GOVERNMENT" HAS A NWSO OF 1) 105
FIGURE 47 - WEIGHTED INPUT OCCURRENCE (TO GOVERNMENT) (THE RED BARS SHOW .25 PERCENTILES OF VALUE) 109
FIGURE 48 - WEIGHTED OUTPUT OCCURRENCE (FROM GOVERNMENT). (THE RED BARS INDICATE .25 PERCENTILES OF VALUE) 113
FIGURE 49 - WEIGHTED VALUE FLOW OCCURRENCE FOR THE STAKEHOLDER NETWORK (RED BARS REPRESENT .25 PERCENTILES) 117
FIGURE 50 - TOP VALUE CYCLES PART 1 120
FIGURE 51 - TOP CYCLES, PART 2 121
FIGURE 52 - TOP VALUE CYCLES PART 3 123
FIGURE 53 - TOP VALUE CYCLES PART 4 124
FIGURE 54 - SIMPLIFIED STAKEHOLDER NETWORK FROM THE POINT OF VIEW OF GOVERNMENT 129
FIGURE 55 - SIMPLIFIED STAKEHOLDER NETWORK WITH THE TOP VALUE CYCLES 130
FIGURE 56 - OIL OUTPUT (TBPD) BY SIX LARGE OPEC PRODUCERS (1973 - 2009) (NAKOV & NUÑO, 2011) 131
FIGURE 57 - COMPARISON, GROSS FIXED CAPITAL FORMATION IN SAUDI ARABIA (SFAKIANAKIS ET AL., 2011) 138
FIGURE 58 - CHARACTERIZATION TEMPLATE – GOVERNMENT ("MINISTRY OF COMMERCE AND INDUSTRY," 2006, "MINISTRY OF ECONOMY AND PLANNING," N.D., "MINISTRY OF TRANSPORT," N.D., "SAUDI GEOLOGICAL SURVEY," 2012, "SAUDI INDUSTRIAL PROPERTY AUTHORITY," 2012) 144
FIGURE 59 - CHARACTERIZATION TEMPLATE – INTERNATIONAL GOVERNANCE ("IPCC - INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE," N.D., "OPEC," 2012, "THE COOPERATION COUNCIL FOR THE ARAB STATES OF THE GULF - SECRETARIAT GENERAL," 2012) 145
FIGURE 60 - CHARACTERIZATION TEMPLATE – MANUFACTURING AND SERVICES INDUSTRY ("MAADEN | SAUDI AABIAN MINING COMPANY," 2012, "ROYAL COMMISSION FOR JUBAIL & YANBU," 2010, "STC," 2012, "WELCOME TO THE SABIC HOMEPAGE," 2012) 146
FIGURE 61 - CHARACTERIZATION TEMPLATE – ECONOMIC CITIES ("JAZAN ECONOMIC CITY, SAUDI ARABIA," 2010, "ROYAL COMMISSION FOR JUBAIL & YANBU," 2010; SAGIA, N.D.-A) 147
FIGURE 62 - CHARACTERIZATION TEMPLATE – INVESTMENT ENTITIES 148
FIGURE 63 - CHARACTERIZATION TEMPLATE – OIL AND GAS INDUSTRY (ARAMCO, 2012) 149
FIGURE 64 - CHARACTERIZATION TEMPLATE – UTILITIES COMPANIES ("NATIONAL WATER COMPANY," 2011, "SALINE WATER CONVERSION CORPORATION," 2012; SEC, 2010) 150
FIGURE 65 - CHARACTERIZATION TEMPLATE – ALTERNATIVE ENERGY INDUSTRY (KACARE, 2010) 151
FIGURE 66 - CHARACTERIZATION TEMPLATE – PEOPLE 152
FIGURE 67 - CHARACTERIZATION TEMPLATE – UNIVERSITIES AND RESEARCH CENTERS ("KACST," 2012, "KAPSARC," 2012, "KAUST," 2012, "KFUPM," N.D., "KSU," 2010) 153
FIGURE 68 - CHARACTERIZATION TEMPLATE – MEDIA 154

1. Introduction

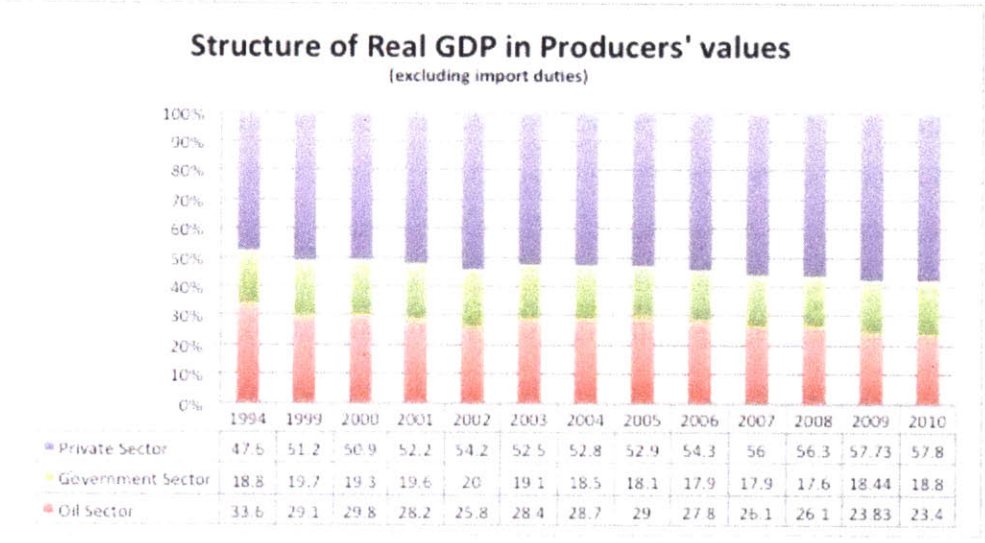
1.1. Motivation

The oil industry of Saudi Arabia is an important component of its economy. Figure 1 shows the percentage of the Kingdom's GDP relative to the Government and the private sectors. We can see that from 1994 to 2010 the oil sector's GDP decreased from being 33.6% of the Kingdom's economy to 23.4%, so it still accounts for almost a quarter (MEP, 2011). However, the oil industry can be divided into two components: foreign trade and internal consumption. It is the former that generates most of the revenue for the Kingdom. The reason is that while the international market price per barrel of oil is currently around $100 (see Figure 2) the price for internal consumption is much lower (EIA, 2012). The price charged by Saudi Aramco to the Saudi Electric Company is $4.24 per barrel (Alyousef & Stevens, 2011). Therefore, it is in the best economic interest of the Kingdom to dedicate as much of its oil production as possible to international trade.

However, oil is an indispensable commodity for internal use in the Kingdom, mainly for the production of electricity. As a parenthetical note, we want to call to the reader's attention that electricity is not constrained to powering buildings and houses and not even only for personal and other electrical appliances. In Saudi Arabia, electricity is heavily used for air conditioning and water heating, both for personal use and for cooking. Figure 3 shows how electricity consumption in Saudi Arabia has increased 85.9% from 2000 to 2010 (Figure 3 shows forecasts from 2011 to 2016) (SEC, 2010).

Such an increase in the consumption of electricity has two main causes: total population increase and urban population increase. Figure 6 contrasts the population and urban population increase between the Kingdom of Saudi Arabia and selected countries (Gapminder, 2012). We can see that Saudi Arabia has had the largest urban population increase and has reached the urban population

percentage of the United States, one of the top developed and industrialized countries on the globe. Further, in 2012 Saudi Arabia's population was currently 27.1 million and it is expected to double by 2050 (MEP, 2011; Mirkin, 2012). The urban population increased mainly because the Kingdom is largely a desert and thus people tend to gather in urban centers for shelter and quality of life.



	1994	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Private Sector	47.6	51.2	50.9	52.2	54.2	52.5	52.8	52.9	54.3	56	56.3	57.73	57.8
Government Sector	18.8	19.7	19.3	19.6	20	19.1	18.5	18.1	17.9	17.9	17.6	18.44	18.8
Oil Sector	33.6	29.1	29.8	28.2	25.8	28.4	28.7	29	27.8	26.1	26.1	23.83	23.4

Figure 1 - GDP for the Kingdom of Saudi Arabia by sector (MEP, 2011)

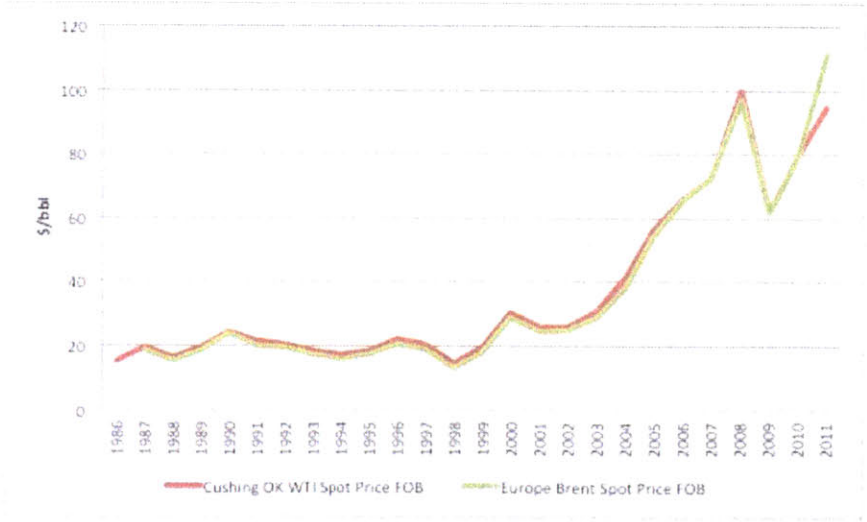


Figure 2 - Crude oil spot prices (EIA, 2012)

Electricity consumption in the Kingdom for 2009 is shown in Figure 4. We can see that residential and commercial consumption (an activity strongly related

to the size of the population) accounts for 64% total electricity consumption (ECRA, 2011). This fact confirms our previous argument that overall population and urban population increase are putting considerable stress on the current energy needs of the Kingdom. What is worse, most of the electric power in the Kingdom is generated using crude oil and natural gas, which is obtained as a consequence of oil extraction. To illustrate this fact, we look into the sources of energy for producing electricity in the Kingdom. Figure 5 shows the sources for electricity production in for 2011 (ECRA, 2011). Crude oil accounts for 34% and natural gas accounts for 38% (both included under Oil Sector when computing GDP in Figure 1) of total electricity production.

To recap, we have shown that Saudi Arabia's economy relies heavily on the oil industry, that considerable amounts of oil and natural gas are used for the production of electricity, and the consumption of electricity is increasing because of population increase in the Kingdom. Naturally, the Kingdom is concerned about this phenomenon and it has made forecasts to evaluate energy needs in the upcoming years. Figure 8 shows that, according to the King Abdulla City for Atomic and Renewable Energy, by 2030 the Kingdom will have a gap of 80,000 MW (KACARE, 2010). Such a gap would have to be filled by crude oil and natural gas (currently exported) if the government does not look into alternative sources of energy. This gap of course would have critical consequences for the development of the Kingdom, as oil revenues are the main funding source for the national objectives formulated every five years in the Kingdom's National Development Plan (MEP, 2010).

Given such a negative scenario, the Kingdom has made it a national priority to shift the energy supply for the production of electricity from oil and natural gas to a balanced mix that includes alternative sources of energy (atomic and renewables). One of the most visible actions in this effort is the creation of the King Abdulla City for Atomic and Renewable Energy (KACARE) (KACARE, 2010). KACARE has the mandate to look into renewable energy, such as wind, geothermal and solar (of which the Kingdom can potentially be a major producer because of its geographic conditions), and atomic energy. Accordingly,

KACARE's mission is conducive to a "sustainable national energy mix in which atomic and renewable energies are viable integrated" (KACARE, 2010).

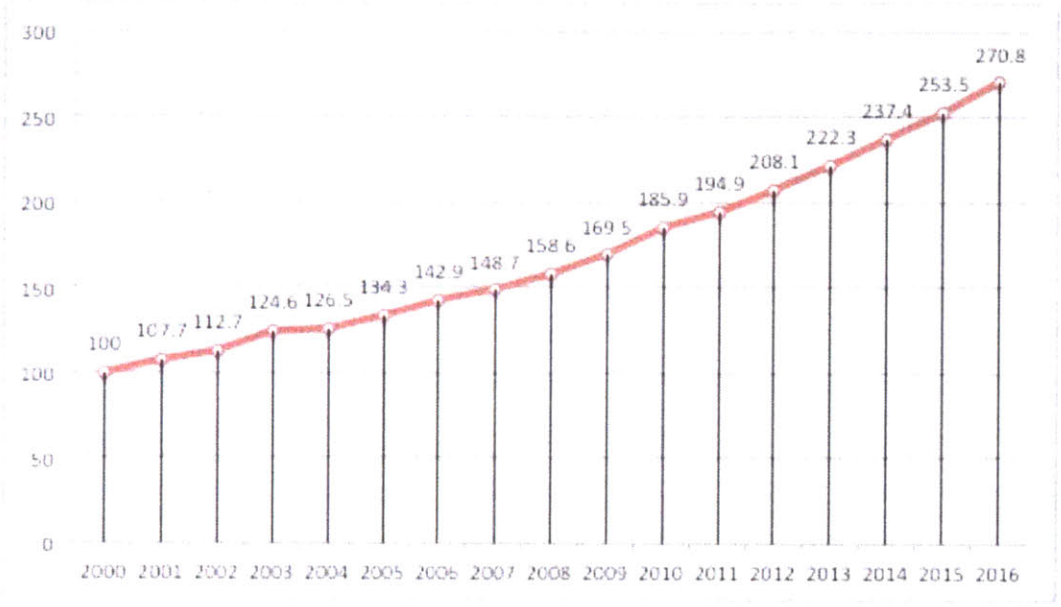


Figure 3 - Growth levels of sold electricity (%) (SEC, 2010)

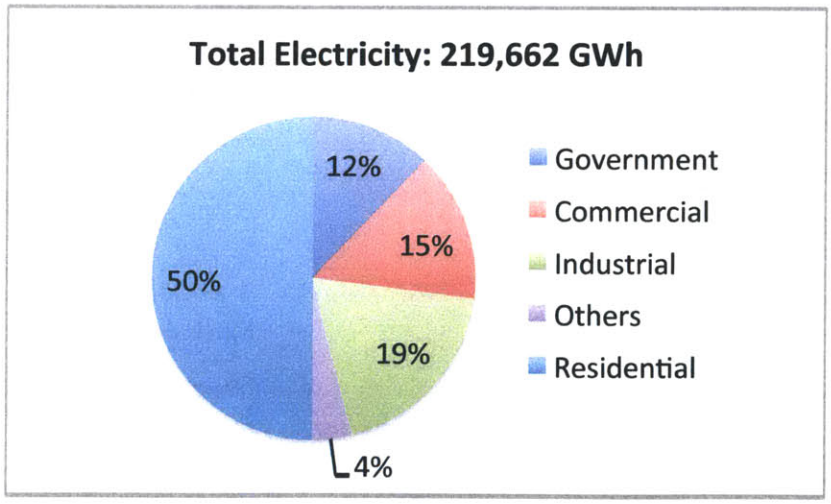


Figure 4 - Electricity consumption in the Kingdom, 2011 (ECRA, 2011)

Nevertheless, achieving the objective of shifting the energy supply for the production of electricity from oil and natural gas to a balanced mix that includes alternative sources of energy is not a trivial task. This is further complicated by the large number of government agencies and stakeholders involved.

Furthermore, from meetings with representatives from the government, it became clear to the author of this thesis that there are major challenges in communication between and within government agencies and industries; there are also challenges in understanding the obligations and responsibilities that each government agency has in terms of achieving the shift to energy balance, since the national atomic and renewable energy policy is yet to be finalized ("Royal Decree establishing King Abdulaziz City for Atomic and Renewable Energy," 2010).

Therefore, the Kingdom of Saudi Arabia must follow a comprehensive approach that takes into account all the stakeholders involved in the achievement of such energy objective and their interactions. Such a comprehensive approach is the contribution of this thesis to the Integrated Energy Decision Support System as funded by the Center for Complex Engineering Systems (see below). In this thesis we will analyze the energy stakeholder network of the Kingdom of Saudi Arabia from the point of view of a focal organization: government. At the end of this thesis we will provide will policy recommendations for the Kingdom of Saudi Arabia conducive to shifting electricity production from oil and gas to a balanced mix that includes atomic and renewable energy.

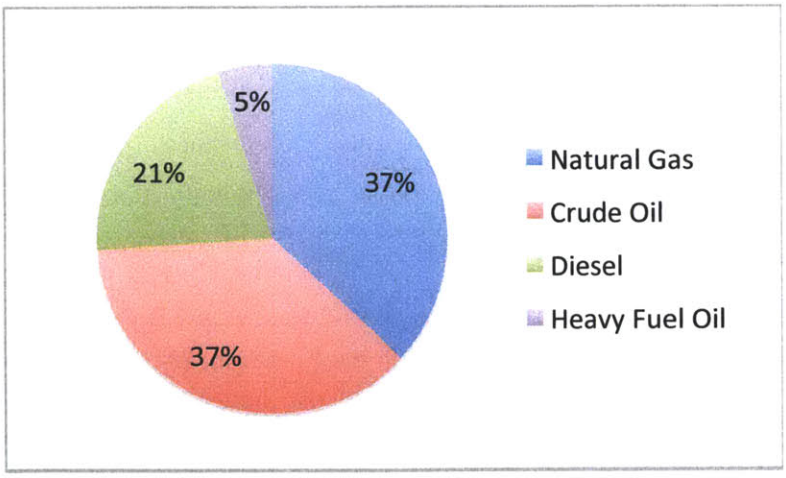


Figure 5 - Sources for production for electricity in the Kingdom, 2011 (ECRA, 2011)

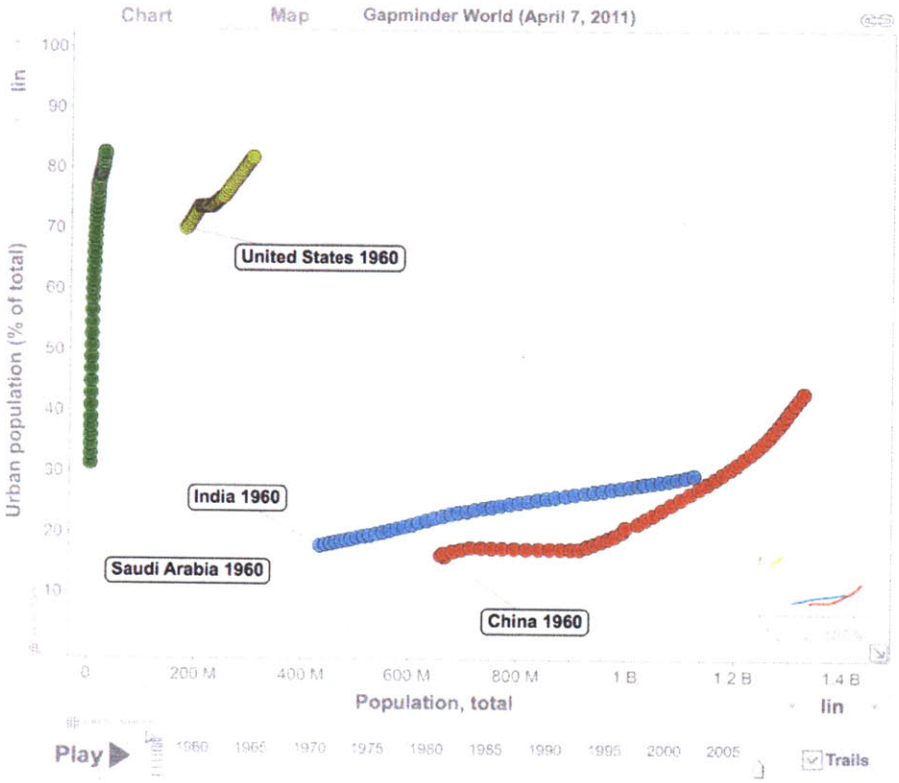


Figure 6 - Population and urban population, selected countries (Gapminder, 2012)

1.2. Saudi Arabia Main Directions

Although the motivation for this thesis is tangible—shifting the sources for the production of electricity from oil and gas to a balanced mix that includes atomic and renewable energy—the author believes the Kingdom of Saudi Arabia has not given full consideration to it until recently. A clear signal of such lack of awareness is the absence in the current development plan of the high consumption of electricity (MEP, 2010). Therefore, as Saudi Arabia prepares the next national development plan (2015) they will have the challenge of going forward in the directions laid out in the 9th development plan and addressing the shift of energy supply for the production of electricity.

In this section, we will look at the roadmap that the Kingdom is set to follow and what impact each of these objectives will have on the energy challenge ahead of the Kingdom. We will go through each of these decisions in

the order it appears in the 9th development plan, thus giving them the same importance that the Kingdom gives them. But first, it is worth mentioning that the Kingdom is concerned about its dependence on the oil industry for its wealth and development plans. Thus, the current development plan states "the Plan has paid special attention to the development of non-oil natural resources to enhance their contribution to local value chains, and to achieving a steady expansion in the use of modern technologies and improved production methods" (MEP, 2010).

On the one hand, we see that the Kingdom is concerned with improving efficiency, which would reduce costs and increase profit margins for industries—including oil and gas. On the other hand, we see that the Kingdom wants to develop non-oil industries. They are not saying that overnight they will be able to produce the amount of GDP that they currently produce with oil as shown in Figure 1, but in the long run they seek a wider (horizontal expansion) industry. Putting together these objectives with the challenge of this thesis, we realize that if they achieve the shift in the production of electricity, they will be able to ensure a backup for the development of the Kingdom in upcoming decades—that is, more reserves of oil and natural gas.

Next, we continue to describe and analyze some of the current paths to follow for the Kingdom of Saudi Arabia. The following list is not comprehensive but includes the paths to follow that are more related to the topic of this thesis. For a full list of paths, the reader should review the current development plan (MEP, 2010).

1.2.1. Enhancing Economic Development

The 9th development plan calls upon the Kingdom "To diversify the economic base horizontally and vertically, expand the absorptive and productive capacities of the national economy and enhance its competitiveness, and maximize the return on competitive advantages." Further, the Kingdom also puts emphasis on sustainable development: "to achieve sustainable economic and social

development by accelerating the rate of economic growth and social welfare" (MEP, 2010).

There are two arguments we want to make here. First, not only does the Kingdom want to grow their economy but they also want to achieve growth in a sustainable manner. The World Commission on Environment and Development defines sustainability as "development that meets the needs of the present, without compromising the ability of future generations to meet their own needs" (United Nations, 1987). In other words: to use existing resources—especially renewable resources—at a rate that is less than the rate at which resources renew. Thus, the economic-development objective of the Kingdom has twofold consequences for their energy challenge. That is, by fulfilling the electricity demand for the economic development of the Kingdom, they must be sure not to jeopardize their ability to fulfill the electricity demand in the future.

The second argument we want to make is that the Kingdom wants to achieve sustainability by—based on their statement—accelerating the rate of economic growth. As we introduced above, such a statement might be slightly contradictory. This is because the costs of improving energy efficiency will rise prices in the short term, while the energy system of a country changes from a "ceteris paribus" (everything else constant) procedure of implementation of new energy sources to properly assessing the requirements of the new system, see Figure 7 (Nilsson, 1995). Therefore, provided that the Kingdom is able to increase the rate of economic growth—which in current society means increase the rate of consumption of most resources—while keeping a sustainable combined rate of extraction and recovery of its renewable and non-renewable resources, and provided that the Kingdom will achieve the shift in the production of electricity (to a balanced mix that includes atomic and renewable energy) they will still require a period of learning and adaptation. In other words, the Kingdom will potentially have to find a balance between keeping up economic growth and moving toward sustainable sources of energy.

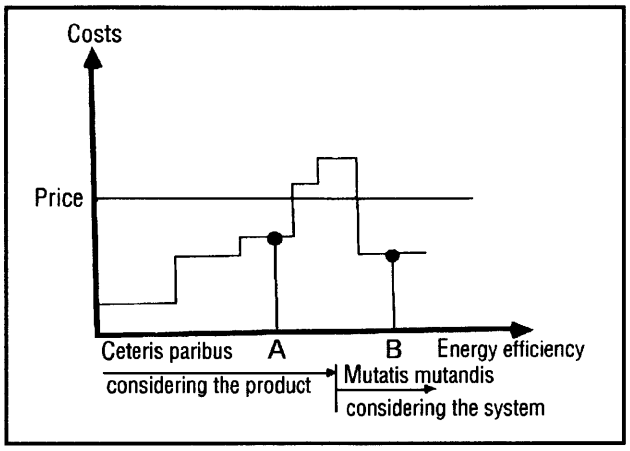


Figure 7 - Cost curve for changing of energy efficiency performance (Nilsson, 1995)

1.2.2. Enhancing Human Development

The Kingdom wants "to move towards a knowledge-based economy and consolidate the basis of an information society" (MEP, 2010). A key challenge for the Kingdom in growing sustainably is their current lack of human capital that can propel them in the right direction. The Kingdom is very much aware of this: "To enhance human development, expand the range of options open to individuals to enable them to acquire and use knowledge, skills and expertise, and provide appropriate healthcare services" (MEP, 2010). Clearly, the challenge of expanding human development relates to the main topic of this thesis—shifting the energy inputs for the production of electricity from oil and gas to alternatives—because the Kingdom will require people who have the knowledge to enable them to achieve this shift. The transition will require not only technological expertise but also political and societal know-how.

1.2.3. Enhancing Private Industry

In the next chapter we discuss further the government of Saudi Arabia and the control they have over their main industries. For now, we will say that the Kingdom recognizes that in order to become competitive in the regional and

international arena, they need to enhance the role of private industry—especially after joining the World Trade Organization in 2005 (WTO, 2005). In the 9th development plan, the Kingdom express: "To enhance the role of the private sector in socioeconomic and environmental development and expand domains of private investments (domestic and foreign) and public-private partnerships." Thus, we see that to tackle the challenge developed in this thesis—shifting the energy inputs for the production of electricity from oil and gas to alternative sources—the Kingdom has two options: to develop a state-owned enterprise that takes charge of producing atomic energy and renewables or to lay out an economic and policy environment necessary for the industry to flourish on its own.

1.3. General objectives

Based on the motivation of this thesis, we put forth our general objectives:

1. Identify what mechanisms the government has for influencing and propelling the stakeholder network in the new direction
2. Identify the pros and cons of each of those mechanisms

In other words, we will use the results of model presented below to analyze the Saudi Arabia energy challenge and suggest a potential path to follow for the Kingdom to succeed in their challenge.

In the following sections we provide more depth to our knowledge of the Stakeholder Value Network Analysis (SVNA) and also develop a literature review of similar methodologies. However, before doing this, we find it worthwhile to introduce the major effort of which this research is part: the Center for Complex and Engineering Systems, which has provided the funding for this research.

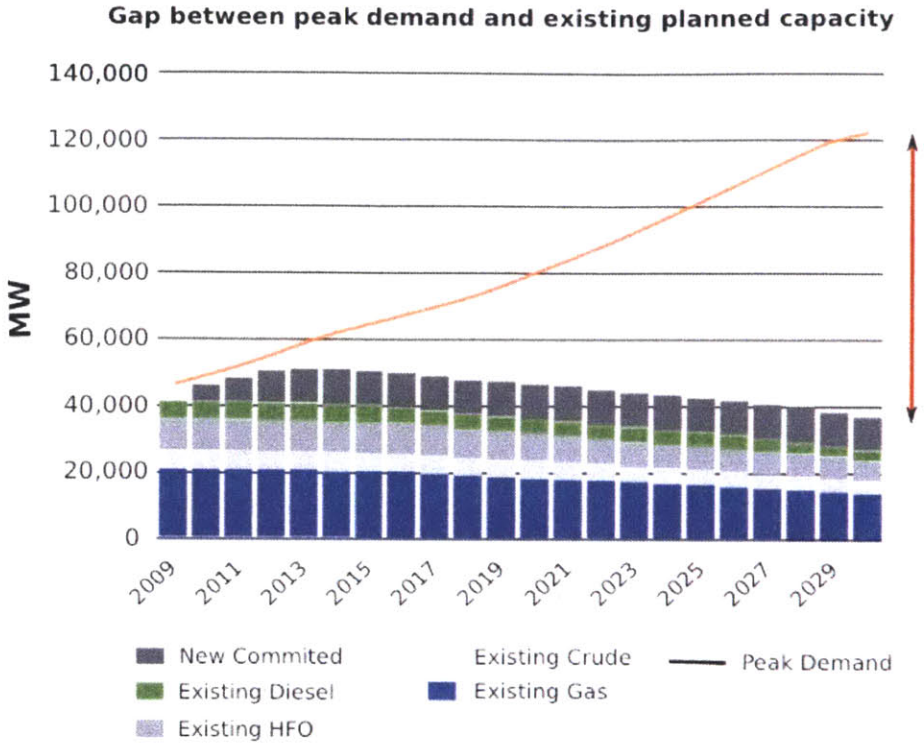


Figure 8 - Expected energy needs for 2030 (KACARE, 2010)

1.4. The Center for Complex Engineering Systems (CCES)

CCES is a major collaboration between the Massachusetts Institute of Technology (MIT) and the King Abdullaziz City for Science and Technology (KACST) ("CCES," n.d.). CCES, established in 2011, has the major objective of creating knowledge that contributes to solving Complex Engineering Systems. Professor Olivier de Weck, Co-Director of CCES, defines an engineering system as "a class of systems characterized by a high degree of technical complexity, social intricacy, and elaborate processes, aimed at fulfilling important functions in society" (de Weck, Roos, & Magee, 2011). Based on this definition and the aforementioned framework of this thesis, it is clear that the Energy System of the Kingdom it is itself a complex system and it clearly has many opportunities to have an impact and to create fundamentals, key principles of operation, for the

field of Engineering Systems (ESD, n.d.). For this reason CCES has decided to work on creating an Integrated Energy Decision Support System (IEDSS) for the Kingdom of Saudi Arabia, as one of its major projects.

IEDSS has the objective of creating a "software-based Integrated Energy Decision Support System (IEDSS) that will create a flexible software environment to model the energy balance at the municipal, regional and national level" (IEDSS, 2012). The aim of such a Decision Support System, as its name states, is to assist planners and policy makers in their analysis and planning tasks. IEDSS's major goal is to be a critical input for the creation of the subsequent five-year National Development Plans on the subject of shifting the internal energy balance of the Kingdom.

In order to achieve such an ambitious objective, this thesis contributes to IEDSS by providing an analysis that takes into consideration both the technical and policy complexity that arises from the importance of energy management to both the economic development of the Kingdom and for the wellbeing of Saudi Arabia's citizens. The output of this thesis for IEDSS will be a ranking of stakeholders that IEDSS has to serve as well as the interactions between such stakeholders. Such an output will be provided in Chapter 4. In Further, because the Kingdom's main economic asset is the production and export of energy, the success in shifting the internal energy balance will direct the Kingdom's future role in the World Arena. IEDSS is aware of this importance and states that "IEDSS will contain a stakeholder network analysis capability" (IEDSS, 2012).

Such is the topic of this thesis. The Systems Architecture Lab of Professor Edward Crawley at MIT has developed considerable work on this subject. We, The Systems Architecture Lab, call our methodology Stakeholder Value Network Analysis (SVNA).

1.5. Stakeholder Value Network Analysis (SVNA)

The highest-level objective of SVNA is to assist policy makers and planners in their planning process so that they can maximize value delivery to each

stakeholder and to the whole network itself. "Value" is created between individuals and organizations whenever there is a transaction or interaction between them. The reader should be careful not to confine his understanding to "capital" or "money" when presented with the term "transaction." As an example, consider an interaction between stakeholders where one presents data to the other. The recipient of data received value from the interaction: this is a value transaction.

We define "stakeholders for the energy system of Saudi Arabia" as those who (1) have a direct or indirect affect on the energy production and consumption of the Kingdom of Saudi Arabia, or (2) receive direct or indirect benefits from energy production and consumption in the Kingdom, or (3) possess a significant, legitimate interest in energy production and consumption in the Kingdom (Fu & Feng, 2011). Finally, the "stakeholder network" comprises all the stakeholders and their direct and indirect transactions of value. From now on, we will call the stakeholders involved in the production and consumption of energy in the Kingdom the Stakeholder Network.

Traditional methodologies for analyzing stakeholder interactions often rely only on direct transactions of value (we will expand on this on the Literature Review). In contrast, SVNA conducts an exhaustive analysis of all direct and indirect transactions of value among all of the stakeholders within the network. To illustrate this concept, consider Figure 9. For most people, it is clear that stakeholders A and B interact with each other. However, A interacts with D indirectly. If we suppose that A provides data to B and B uses such data for budget planning, that affects how much money D receives from B. Thus, the data that A shared with B influenced the money that D received. Such a transaction is an indirect transaction of value.

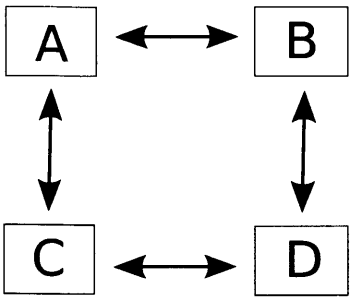


Figure 9 - Simple stakeholder network

SVNA conducts the aforementioned comprehensive analysis of all direct and indirect transactions of value by dividing its analysis into two main parts: a qualitative and a quantitative one. In the qualitative part, we conduct a thorough search of various literature sources to understand who are the stakeholders that are relevant to the system at hand, in this case the energy system of the Kingdom of Saudi Arabia. Subsequently, we continue using the literature to articulate the goals, objectives and needs of each stakeholder included in the network. This step gives us a clear understanding of the role of each stakeholder in the network.

The next step in the qualitative analysis consists of connecting all of the stakeholders to each other and thus visualizing the network we want to analyze. As we explained above, in a network there are transactions of value. Using the language of the specific objectives of SVNA (stated below) we say that such transactions of value take place when fulfilling the need of a stakeholder—which is instrumental to achieve its objectives and subsequently its goals—by using an output from another stakeholder. Thus, SVNA builds the network by connecting all the outputs to the inputs of every stakeholder. Such an approach allow us to identify inputs—need of a stakeholder—that are not served by an output from another stakeholder (Cameron, 2007; Sutherland, 2009). The output of this step in the qualitative analysis is a stakeholder map that depicts all the direct and indirect transactions of value within the network. Figure 10 illustrates this concept by showing the stakeholder map produced by SVNA for the NASA Earth Observation Program (Sutherland, 2009).

Figure 10 contains a myriad of information relevant to policy analysts and policy makers. However, more work needs to be done in order to prioritize the exchanges of value within the network. This work is done in the quantitative part of SVNA. The objective of the quantitative analysis is to prioritize all the direct and indirect transactions of value, as well as to prioritize stakeholders, based on how much value each transaction deliver through the whole network. The SVNA quantification method is based on Kano's method for assessing customer requirements (Walden, 1993). Based on Kano's principles, SVNA creates surveys to be answered by researchers, experts, and the stakeholders themselves.

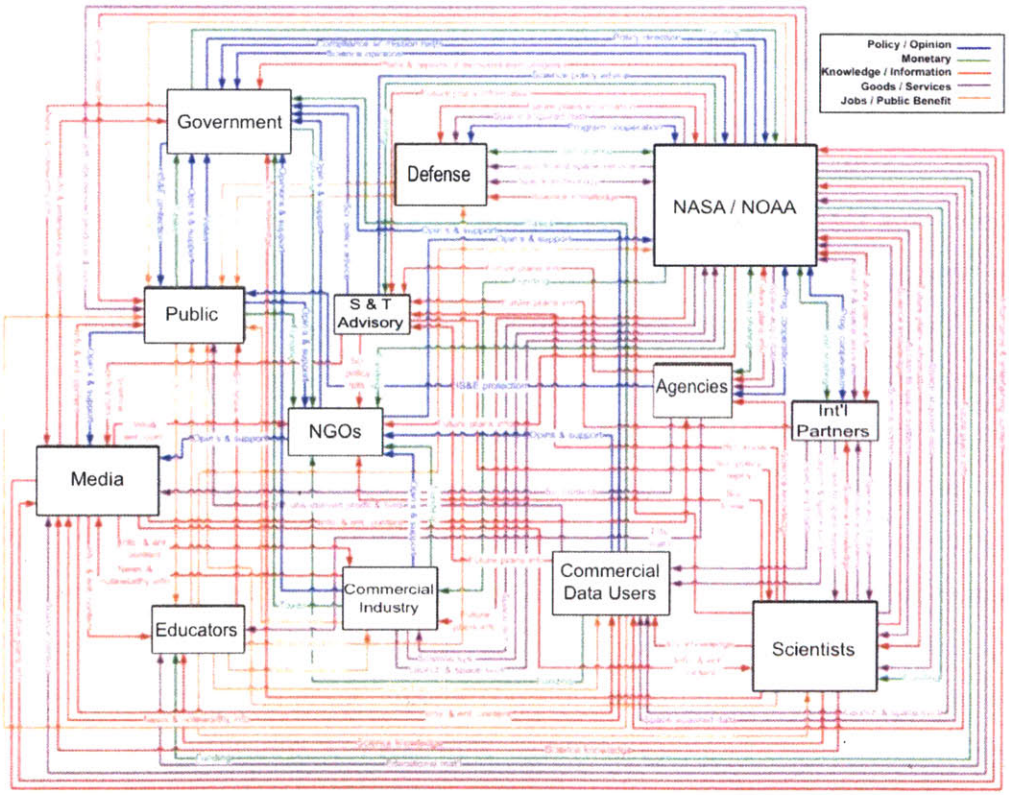


Figure 10 - Stakeholder map for the NASA Earth observation program (Sutherland, 2009)

The final output of SVNA provides a clear ranking of the most important stakeholders, the most important direct value exchanges, and the most important value loops (chains of value exchange that start and end on the same

stakeholder). An illustration of this output is shown in Figure 11. The map shown presents only the priority value exchanges throughout the network. In the Quantitative Analysis section of this thesis, we present the metrics we use to carry out such a prioritization of stakeholders and value exchanges.

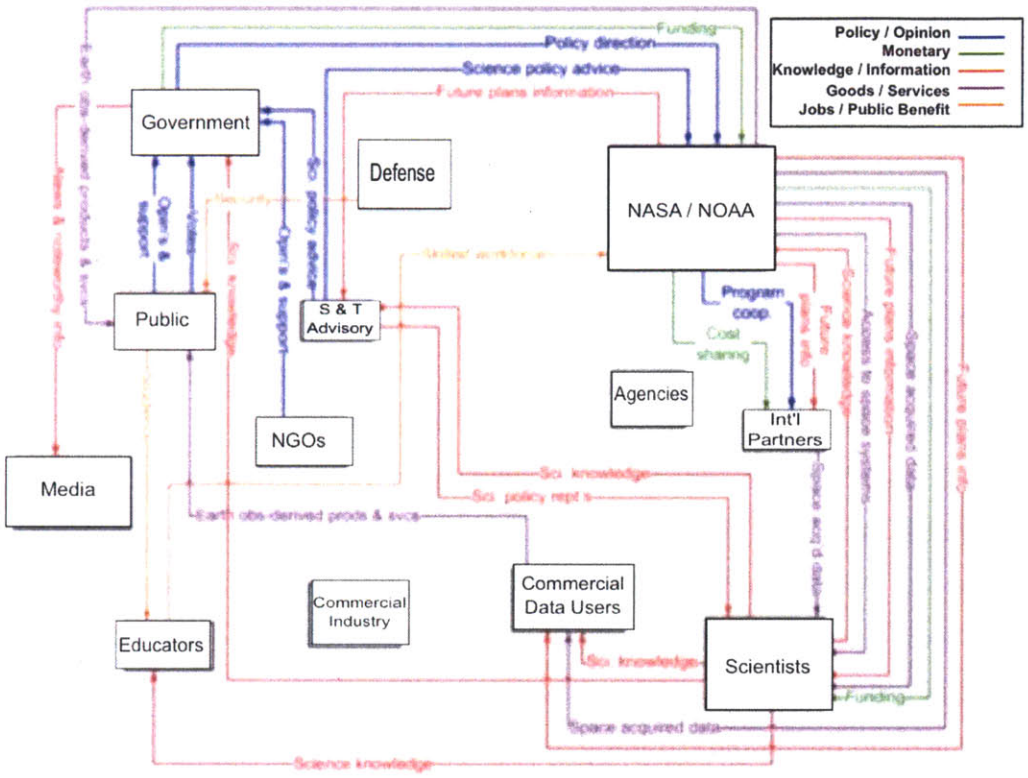


Figure 11 - Stakeholder map for the NASA Earth observation program showing only priority value exchanges (Sutherland, 2009)

After both parts of the analysis are completed, the qualitative and que quantitative one, we SVNA adds additional value. In other words, the outputs of the qualitative and quantitative analysis fulfill the specific objectives of this thesis. Afterwards, we take the SVNA results, build a simplified but comprehensive version of the stakeholder network and continue to perform policy and planning analysis to deliver specific recommendations for the Kingdom. Thus, we will state these objectives in the final section of this chapter. But before doing this, we will

provide an analysis of relevant literature on other stakeholder analysis techniques.

1.6. Relevant Literature on Stakeholder Analysis

In 1984, Edward Freeman established the basis for modern theory of stakeholder analysis in his book, *Strategic Management: a Stakeholder Approach*. As the title of the book implies, Freeman sees the identification and characterization of stakeholders as a strategic step in the management of an organization. He acknowledges that there are internal and external factors that determine the success of an organization and that there are stakeholders on both sides whose interests must be taken into account (Freeman, 1984).

Freeman provides a broad definition of a stakeholder: "any group or individual who can affect or is affected by the achievement of an organization's purpose." With this definition, Freeman calls to attention that stakeholders are not just "well established" companies but also "illegitimate" groups, as he calls them. That is, groups of people that have a significant influence inside or outside the organization and could jeopardize the success of a management strategy.

Even almost 20 years ago, Freeman came up with the idea of using maps to visualize the interaction between stakeholders (see Figure 12). In this map we can see examples of "illegitimate" organizations as Freeman calls them. "Activist Groups" and "Political Groups" are organizations that have no clear establishment but that influence the central stakeholder. It is clear how most of the rest of the stakeholders in Figure 12 fit Freeman's definition. We also can see that Freeman uses arrows to indicate directional interaction between stakeholders; however, "interaction" is an abstract concept. Freeman expanded such a concept and included plus ("+") or minus ("-") signs to represent interaction between stakeholders.

In the above section we highlighted the importance of "indirect interactions" in a stakeholder network. Freeman did introduce this concept by using simple examples like the one shown in Figure 9. However, Freeman expresses his concern that (as of the time he published his work) there were no clear methodologies to create management strategies that could be instrumental in the organization in pursuit of its success. SVNA has created a clear and well-grounded methodology to quantify and prioritize such indirect transactions of value (Cameron, Crawley, Loureiro, & Rebentisch, 2007).

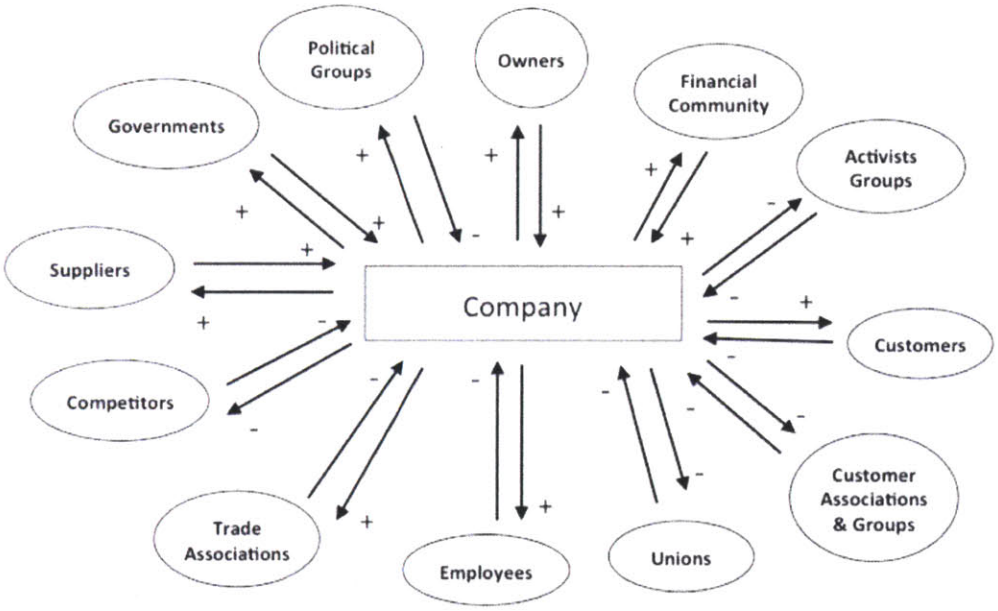


Figure 12 - Stakeholder map showing direct transactions between stakeholders and the central organization

In 2004, Winch edited *The Wiley Guide to Managing Projects*. In this compilation of methodologies, Winch presents a concrete process for identifying and assessing a stakeholder network in the pursuit of completing a project (Winch, 2004). The steps he proposes are:

- Identify the stakeholders with a claim on the project
- Classify all of the stakeholders' claims

- Evaluate the capability and influence each stakeholder has in pursuing such claims
- Assess how each individual claim would affect the definition and execution of the project at hand

Additionally, Winch proposes classifying the type of influence or power that a stakeholder can have in the network in one of five categories: physical, positional, resource, expert, and personal power. Further, as Freeman did, Winch proposes using Bonke's framework to produce stakeholder maps to better visualize the interactions between stakeholders (Winch, 2004).

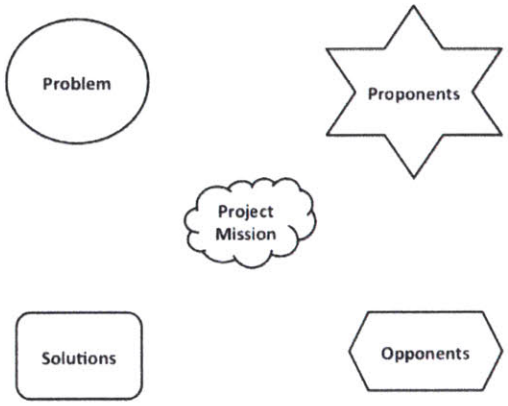


Figure 13 - Elements in Bonke's framework for stakeholder maps

Figure 13 shows the elements of Bonke's framework to create stakeholder maps. Bonke proposes visualizing the "project mission" with a cloud. Such a mission will face "problems," represented by circles, that are addressed by "solutions," represented by rectangles. The project mission will have both "proponent" stakeholders, represented by stars, as well as "opponent" stakeholders, represented by a polygon. Pinto presents case studies using Bonke's framework to analyze the stakeholder network. Figure 14 shows the stakeholder map for a project whose mission was to build houses in the British dependent territory of Montserrat after a major volcanic eruption (Pinto, Cleland, & Slevin, 2001).

Figure 14 shows that the project mission is to "provide houses quickly." There are different proponents to achieve the project mission: the government of

Montserrat (GOM), the Department for International Development (DfID), Brown & Root (construction managers) and of course the citizens themselves (users). Each of these proponents offers solutions based on its point of view of the "problem." For GOM there are three problems:

1. Unsuitable houses
2. Stabilize society
3. Provide employment

For DfID, the main problem is to stabilize the population of the British colony. For the users, the main problem is that they are living in unsuitable houses. For Brown & Root, the construction managers, the main problem is that they have to deliver the project, for which they have been hired, on time. Figure 14 shows that while all of the previous stakeholders' proposed solutions involve an emergency program that uses either prefabricated houses or traditional houses to achieve the project mission, "Environmentalists" (the opponents of the project) propose using a better design because the main problems, from their point of view, are marine pollution and soil erosion.

Finally, Baron proposes analyzing a project and its stakeholders by using an economics point of view: a market driven framework (Baron, 1995). For Baron, there are two major strategies that a company or organization can follow in order to achieve its mission: a "market driven" or a "non-market driven" strategy. He expands on the latter, arguing that when a company's project involves public institutions, then the company can use an integrated strategy (market and non-market driven) in order to achieve its objectives. Further, if the company's industry has many "market rivals," then the company can use such an integrated strategy to transform "market rivals" into "non-market" allies that push some type of regulation that will benefit the industry.

To illustrate this point, Baron presents the example of Calgene, Inc.: a small biotechnology company that was the first to bring a genetically engineered food to market: tomatoes with a marker gene. Figure 15 illustrates the integrated strategy Calgene followed to satisfy the stakeholder network. In the "market strategy" Calgene engaged "Grocers" to educate them about genetically

engineering food, the "Public" to respond to expected objections from activists, and the "Suppliers" to alleviate their concern about the uncertainty of acceptance from the "Public." In the "non-market strategy," Calgene engaged "DOA" (Department of Agriculture) to petition a field trial, and a subsequent petition for production of their products, "FDA" (Federal Drug Administration) for a petition to add the marker gene to their tomatoes, and developed relationships with Congress so that they could "exercise pressure" when FDA evaluated Calgene's petition.

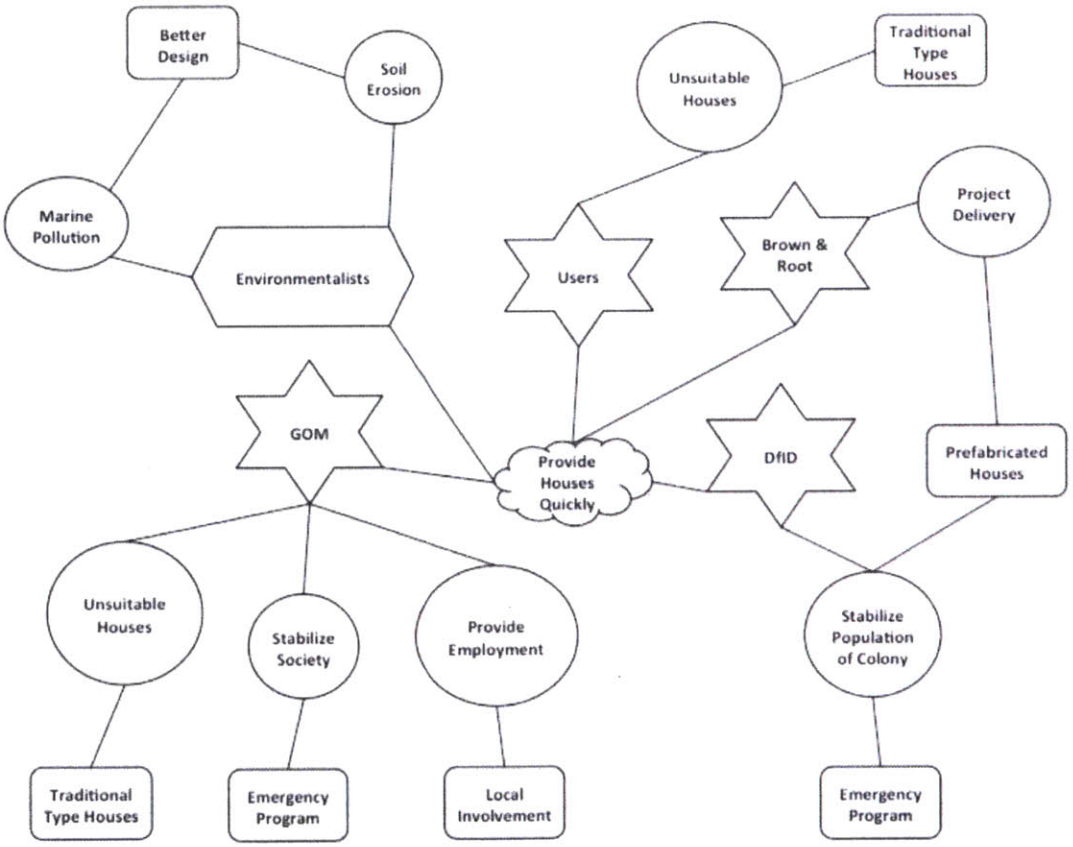


Figure 14 - Example of stakeholder mapping with Bonke's framework

SVNA builds on all of the aforementioned methodologies of Stakeholder Analysis. We provide a comprehensive step-by-step characterization of the network and a sound mapping technique. We consider direct and indirect

transactions of value: money, knowledge, policy, welfare, etc. We establish a well-grounded methodology to quantify the hundreds of value exchanges in the stakeholder network. We develop a software tool that computes the millions of value loops (chains of value exchange that begin and end with the same stakeholder). Finally, we present metrics that are conducive to a clear and discernible prioritization of efforts so that policy makers and planners can maximize the value delivered to the whole network.

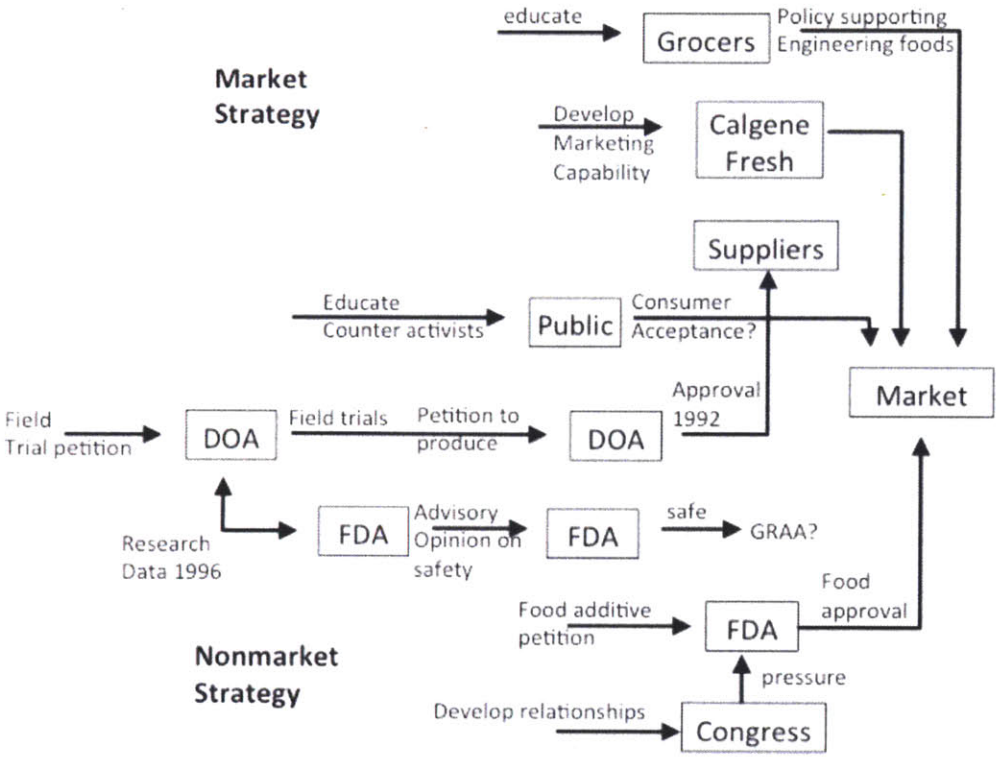


Figure 15 - Calgene integrated strategy using Baron's framework

1.6.1. Previous MIT work

The Systems Architecture Lab by MIT's Edward Crawley has carried out considerable research on stakeholder analysis. First, Catanzaro built a model based on the premise that an organization must allocate resources for the

achievements of its outputs (goals and objectives) based on the ability of such outputs to influence the delivery of the inputs that the organization needs (Catanzaro, 2006). Catanzaro did not consider different types of value as we do on this thesis but assumed that every stakeholder is able to provide all the needs that any other stakeholder in the network needs. Thus, he models only "one" value cycle but considers short term and long term value cycles.

Later, Cameron developed the concept of direct and indirect value exchange of different types (Cameron, 2007; Cameron et al., 2007; Cameron, Seher, & Crawley, 2011). He initiated the mapping techniques that SVNA uses and considered value loops of different lengths. Additionally, he created the numerical methodology that allows the quantitative analysis of SVNA. Afterwards, Sutherland refined Cameron's work: he created different perspectives or "levels" of visualization for the stakeholder maps, formalized the process for characterization of stakeholders by the use of "characterization stakeholder templates," and refined the surveys that SVNA used to conduct the quantitative part of the analysis (Sutherland, 2009, 2012) (Sutherland, 2009), (Sutherland, 2012). Additionally, Fu and Feng applied SVNA to China's energy conservation campaign (Fu & Feng, 2011).

1.7. Specific objectives

In the first sections of this thesis we described Saudi Arabia's context, the need to provide a comprehensive approach to lay out the roadmap to follow to shift the inputs for electricity production from oil and gas to renewables, and the current paths for the Kingdom to follow, as laid out in their current development plan (MEP, 2010). We also introduced the tools we will be using for modeling the problem: the Stakeholder Value Network Analysis.

We now state the main contribution of this thesis: to provide insights into the critical stakeholders and flows that have the likelihood of having the highest impact on achieving the future mix of energy including atomic and renewable

energy to meet future electricity demands. Thus, in this section we state our specific objectives, which can be divided into two parts:

Quantitative

- To develop a complete understanding of the stakeholders of the energy system of Saudi Arabia by articulating the goals, objectives, and needs of every stakeholder included in the network
- To understand the important interactions among all stakeholders by constructing a detailed stakeholder map showing the inputs and outputs of each stakeholder

Quantitative

- To identify the most important stakeholders, the highest value-producing interactions among stakeholders, and most important outputs of the energy system of Saudi Arabia

The fulfillment of these specific objectives will allow us to address our general objectives presented above: providing policy recommendations and a comprehensive approach for the Government to propel the Kingdom to produce electricity with a balanced mix that includes atomic energy and renewable resources.

We will present the work introduced in this chapter in detail for the Energy System of the Kingdom in the following chapters. In Chapter 2 we will start characterizing the stakeholder network: the relevant stakeholders, the central role that the government has in the Kingdom and the relevant direct and indirect value exchanges. We will present various visualization diagrams that will help us grasp the complexity of the stakeholder network. In Chapter 3 we will describe

how we interviewed stakeholder network representatives, with what purpose, and how we use these interviews to quantify and prioritize the complexity we describe in Chapter 2 so that we reduce such complexity. We do this by using four measures that quantity value flow throughout the stakeholder network. Gradually, in Chapters 2 and 3 we will unfold the general objectives presented above.

In Chapter 4 we present the results of these four metrics and dip deeper into the discussion of our general objectives. Finally, in Chapter 5 we will use the results presented in Chapter 4 to present simplified but comprehensive views of the stakeholder network. These views will allow us a clear prioritization of the mechanisms and choices we recommend the government of Saudi Arabia to take toward a sustainable supply of electricity in the Kingdom for the upcoming decades

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2. Qualitative Analysis of the Energy System of Saudi Arabia

In the previous chapter we introduced the specific objectives of the qualitative part of SVNA. In this chapter we will present in detail every step we took to achieve these specific objectives. This methodology has been refined throughout the years by Edward Crawley and the Systems Architecture Lab at MIT (Cameron, 2007; Fu & Feng, 2011; Sutherland, 2009). For a step by step description of SVNA, the reader should refer to chapter 6 of Sutherland's thesis: *Stakeholder Value Network Modeling Process* (Sutherland, 2009). In his thesis, Sutherland describes how to apply SVNA to analyze the stakeholder network of any complex engineering system, project or enterprise.

The first general objective of the qualitative part of SVNA entails a thorough characterization of each stakeholder in the network. The most readily available sources to achieve this task are the literature: policy documents, performance reports, websites and the like. Two particular sources were instrumental in attaining a comprehensive overview of the political and economic context surrounding the Energy System of Saudi Arabia: *The Ninth Development Plan of the Kingdom of Saudi Arabia* and *The Saudi Arabian Economy: Policies, Achievements and Challenges* (MEP, 2010; Ramady, 2010).

2.1. The Particular Role of the Government in Saudi Arabia

We start the stakeholder network characterization by looking at the particular role of the government in Saudi Arabia. Both of the aforementioned documents, *The Ninth Development Plan of the Kingdom of Saudi Arabia* and *The Saudi Arabian Economy: Policies, Achievements and Challenges,* highlight the central role that the government plays in Saudi Arabia (MEP, 2010; Ramady, 2010). It is mainly

because of this finding that we established the general objectives of this thesis around government and the "orchestra director" role in Saudi Arabia. As we introduced in the previous chapter, in SVNA language, we call such a central stakeholder the "focal organization" (Sutherland, 2009).

The particular role of the government of Saudi Arabia is a key acknowledgement in our course of study and a main difference between this study and studies done for NASA or China's energy conservation campaign (Cameron et al., 2007; Fu & Feng, 2011). That is, not only is the Kingdom's most important industry energy, more specifically the oil and gas industry, but oil and gas are owned by the state; furthermore, the state is a monarchy (Royal Embassy of Saudi Arabia, 2012). The Kingdom of Saudi Arabia in its current form has existed only since 1932, founded by King Abdul-Aziz bin Saud (Ramady, 2010). Thus, we faced the question: to approach our analysis by considering government agencies as separate actors (with different goals and objectives) or essentially as a central government that designs and funds the path to follow? We decided to consider the government as a single stakeholder because, although different governmental agencies manage different topics, all of them work to achieve the objectives of the Kingdom's National Development plan (MEP, 2010).

However, we also learned that the rules of Saudi Arabia have been concerned with the decentralization of government. King Saud bin Abdul-Aziz (reigned from 1953 to 1964) established Saudi Arabia's Council of Ministers in 1953. Subsequently, twenty more ministries were created up until 1970 (Royal Embassy of Saudi Arabia, 2011). See Table 1 for a complete list of the ministries (Royal Embassy of Saudi Arabia, 2011). Further, in the last few decades, the government has supported the privatization of industries, as it recognizes that government alone will not be able to create industries that can compete in the international arena, especially after the Kingdom joined the World Trade Organization in 2005 (Ramady, 2010). The current King, Abdullah bin Abdul-Aziz, has highlighted the importance of privatization in the development plans

(eighth and ninth) he has endorsed during his reign (since 2005) (MEP, 2005, 2010).

We invite the reader to recall the general objectives of this thesis: to identify alternatives to shift the energy mix and the mechanisms to follow such alternatives and their tradeoffs. We see then that the interest and historical aim of the government of Saudi Arabia toward privatization of industries suggests that a potential path to increase the atomic and renewable energy industries is privatization.

Moving on, we have mentioned that the national development plans lay out the national policy for the Kingdom for five-year periods. The first national development plan was issued in 1970. Since then, the development plans have focused on building infrastructure in the Kingdom, enhancing the quality of human resources, and diversifying the economy. Most recently, the eighth and ninth development plans have endorsed foreign investment (Royal Embassy of Saudi Arabia, 2011). However, the main topic of this thesis—shifting the energy supply for the production of electricity from oil and natural gas to alternative sources of energy (atomic and renewables)—does not appear as one of the thirteen main directions in the current development plan, the ninth (MEP, 2010). Only its 10^{th} objective mentions the topic broadly, "To develop, conserve and ensure rational utilization of natural resources, particularly water, protect the environment and develop environmental systems within the context of sustainable development" (MEP, 2010). As we can see, such an objective is focused on natural resources conducive to life, such as water, but there is limited emphasis on the current utilization of oil and gas.

Nevertheless, even though the topic of this thesis does not appear as one of the thirteen main directions for the Kingdom, we find in "Chapter 26 – Oil and Natural Gas" of the national development plan the following statement: "the Kingdom needs to start developing future complementary energy sources to ensure energy security, which requires material, technical and human resources to meet the challenges at stake. Given current state of technology, two sources stand out: solar, and nuclear energy. However, nuclear energy is probably the

best option for providing an important share of the energy needs of the Kingdom..." (MEP, 2010).

Currently, KACARE continues working on developing a plan to develop atomic or renewable energy, see Figure 16. We provide more specifics about the royal mandate provided for KACARE in Section 4.3 (because it helps discussing results obtained from the model). The chart presented in Figure 16 was presented by Dr. Khalid Al-Sulaiman, Vice President for Renewable Energy in the Kingdom, during the Third Solar Energy Forum held in Riyadh, Saudi Arabia on April 3, 2011 (Apricum, 2011). Although the figure lacks units, it suggest an electricity production with atomic and renewable energy larger than 25% and smaller than 50% (Al-Sulaiman, 2011). For example, Saudi Arabia targets 41 GW solar Power by 2032 (Nizam, 2012).

Table 1 - List of ministries, Saudi Arabia (Royal Embassy of Saudi Arabia, 2011)

Ministries	
Interior	Commerce and Industry
Defense	Culture and Information
Foreign Affairs	Islamic Affairs
Education	Justice
Municipal and Rural Affairs	Labor
Agriculture	Social Affairs
Water and Electricity	Petroleum and Mineral Resources
Civil Service	Hajj (pilgrimage to Mecca)
Finance	Economy and Planning
Health	Communications and Information Technology
Higher Education	Transport
	Housing

Furthermore, above we introduced that the government is a major shareholder of the most important industries in the Kingdom, see Table 2. As explained in the previous chapter, the government has full ownership of oil and gas in the Kingdom. Further, petrochemicals and mining account for the second and third most important industries for Saudi Arabia. We see that, once more, the

government has a majority of shares in the most important companies of these industries: the Saudi Basic Industries Corporation (SABIC), in the petrochemical industry, and the Saudi Arabian Mining Company (MAADEN), in the mining industry. Finally, the second most relevant industry for the topic of this thesis, electricity, is also almost fully owned by the government, with 75% shares of the Saudi Electric Company (SEC) and 100% of the Saudi Water Conversion Corporation (SWCC).

We can confirm (as mentioned at the beginning of this section) that Saudi Arabia presents a scenario quite different from the ones on which the Systems Architecture Lab by Edward Crawley at MIT has conducted SVNA (Cameron, 2007; Fu & Feng, 2011; Sutherland, 2009). This different scenario is characterized by greater centralization (compared to the cases of our previous studies) of decision-making authority: the Council of Ministers headed by the King.

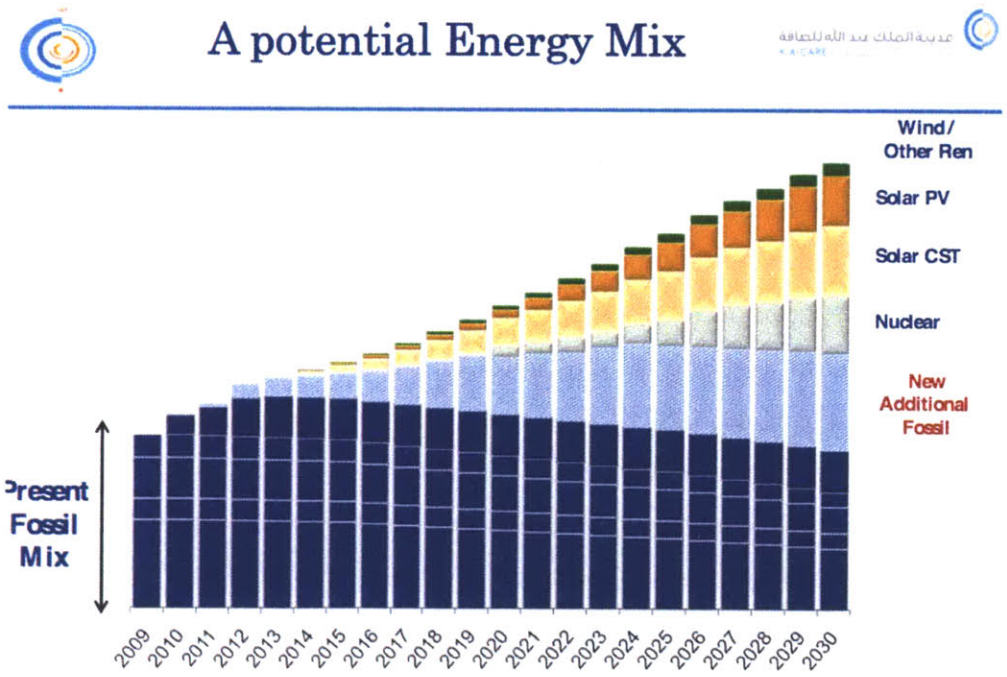

Figure 16 - KACARE desired energy mix for 2030 (Al-Sulaiman, 2011) (the source did not provide units for the chart)

Table 2 - Selected industries and shareholders

Company	Government	Other	Source
Aramco (Exclusive Oil Company in the Kingdom)	100%		http://www.saudiaramco.com/en/home.html#our-company%257C%252Fen%252Fhome%252Four-company%252Fat-a-glance.baseajax.html
SWCC (Saline Water Conversion Corporation)	100%		http://www.swcc.gov.sa/default.asp?pid=56
SEC (Saudi Electric Company)	75%	25%	http://www.gulfbase.com/site/interface/CompanyProfileSummary.aspx?c=129
SABIC (Saudi Basic Industries Corporation)	70%	30%	http://www.sabic.com/corporate/en/binaries/SABICCorporateBrochure_E_tcm4-1610.pdf
Maaden (Saudi Arabian Mining Company)	55%	45%	http://www.maaden.com.sa/eng/pdf/IPO-English.pdf

Second, the Saudi Arabia scenario presents a country in which the bulk of the industry is almost fully controlled by the state. Finally, the scenario presents a planning process that, although revised yearly, is set in stone every five years. Further, Ramady elaborates that wealthy families are a central stakeholder in the future development of Saudi Arabia, as they are an important component of the private industry in the Kingdom (Ramady, 2010). However, because such wealthy families are not public entities, it was not possible to conduct research to understand the structure of these families and the assets they hold in the Kingdom. Nevertheless, despite the centralization of government in Saudi Arabia, the Kingdom has identified that privatization and industrialization are important to successful economic development and management of energy (two of the main concerns of the Kingdom, as developed in the previous chapter).

At this point we come back to the discussion of whether to treat "government" as a single stakeholder or as multiple entity. Because of the dual role of the government as policy maker and asset manager, we decided to create two stakeholders: "Government" and "Manufacturing and Services Industry." We included in the stakeholder "Government" those government ministries and entities that are in charge of policy making relevant to the energy system of the Kingdom. Accordingly, we included in the stakeholder "Manufacturing and Services Industries" the main industries (except the oil and gas industry) for the Kingdom in terms of GDP production.

At this point, although we have started introducing two of the stakeholders involved in our analysis, we will take a step back to properly characterize the stakeholder network and then make use of "maps" with different perspectives or "levels" to introduce the stakeholder network. As we shall see in last two chapters of this thesis, these maps will be instrumental in achieving our general objectives. Sutherland was the first to develop the idea of using maps in his thesis and it has proved to be a useful framework for the understanding and analysis of the stakeholder network (Sutherland, 2009).

2.2. The Stakeholder Network of the Energy System of Saudi Arabia

In the above section, we started developing the specific objectives of this thesis by paying special attention to the focal organization of the stakeholder network: the government of Saudi Arabia. In this section we will introduce the rest of the stakeholders in the network.

First, we call to the reader's attention that there is no single perspective from which to analyze a stakeholder network. As an example, think about the stakeholders that could be involved in the network relevant to the NASA Exploration Program. Without presenting the network in detail, it is easy to see that in such an enterprise (space exploration) there will be a "Commercial Industry" stakeholder in charge of building and selling both the necessary devices for launching space systems and the space systems themselves. However, rather than a single stakeholder, "Commercial Industry," in charge of all the relevant manufacturing, there are a number of manufacturers involved in production of the myriad of single devices used for the construction of (among several components) rockets. Additionally, each of those single devices is a market that has multiple competitors capable of selling the devices to rocket manufacturers. We can see that in such a simple example, there are at least two perspectives from which to analyze the stakeholder "Commercial Industry": one that sees it as a single entity and another that can go deep down to the

manufacturers that make the computer chips used in the control systems of a rocket. Accordingly, we present three different views of the Energy Stakeholder Network.

Taking into consideration the argument we presented in the previous chapter—the importance of the energy industry for the GDP of the Kingdom and the central role of the government to create policy that manage efficiently Saudi Arabian resources—Figure 17 shows the highest level perspective of the Energy Stakeholder Network: the level 0 perspective. Such a figure can be interpreted as follows: for the Kingdom to achieve the shift of energy sources for the production of electricity, *Energy Supply*, from oil and gas to a balanced mix that includes alternative sources, it needs *Policy Making* for both the *Energy Supply* and *Economic Development* arenas of the Kingdom. Further, in order to achieve such a shift and enhance these three areas, Saudi Arabia needs the *Creation of Human Capital and Knowledge – Information.*

At this point we introduce a concept that will be instrumental in the presentation of our framework and the analysis of our results. We will call *arenas* to the four concepts shown in Figure 17:

- *Policy Making*
- *Energy Supply*
- *Economic Development*
- *Creation of Human Capital and Knowledge - Information*

Further, we will format them in italics, as shown above, for easier recognition. Additionally, the arrows in Figure 17 indicate that there is value exchange between such four arenas and, rather than demonstrating a clear path for such value, this exchange is interrelated without definite starting and ending points.

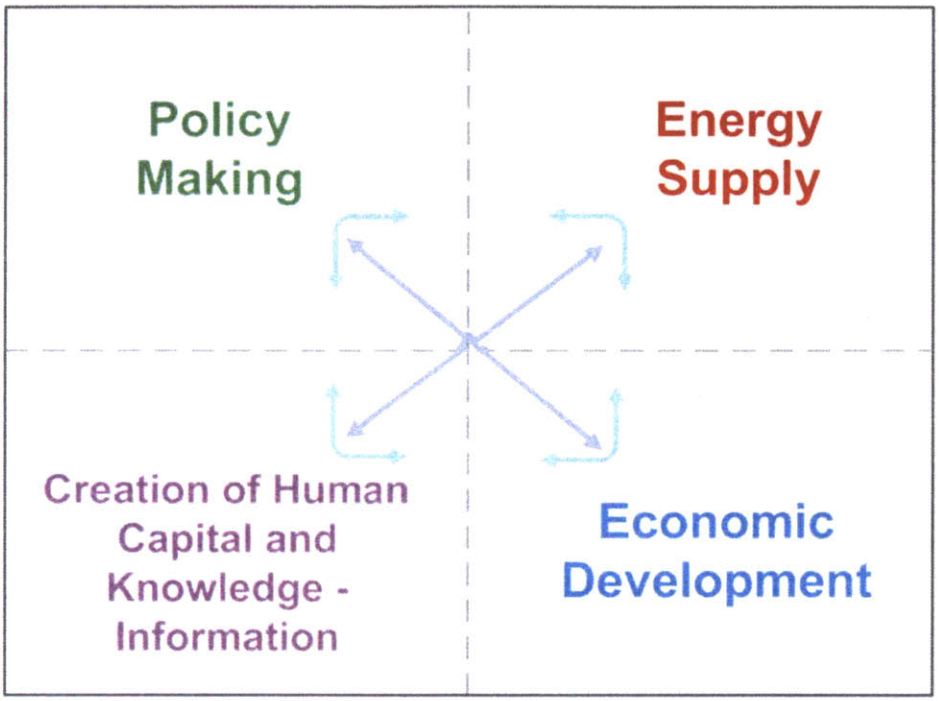

Figure 17 - Level 0 perspective: the four "arenas" included in the stakeholder network of the energy system of Saudi Arabia (arrows indicate value flow)

Going one level down and continuing the use of stakeholder maps, we present 11 stakeholders in the network as shown in Figure 18: this is the level 1 perspective. The 11 stakeholders of this level are not specific entities but a group of them, as we will explain subsequently. Further, we will format the 11 stakeholders shown in Figure 18 in "quotes" for easier recognition.

In the *Policy Making* arena, we have two stakeholders: "Government" and "International Governance." In the previous section we introduced the policy-making role of "Government." "International Governance" refers to those international organizations that the Kingdom of Saudi Arabia must take into consideration during their policy making. Figure 19 shows the specific entities we considered in the *Policy Making* arena.

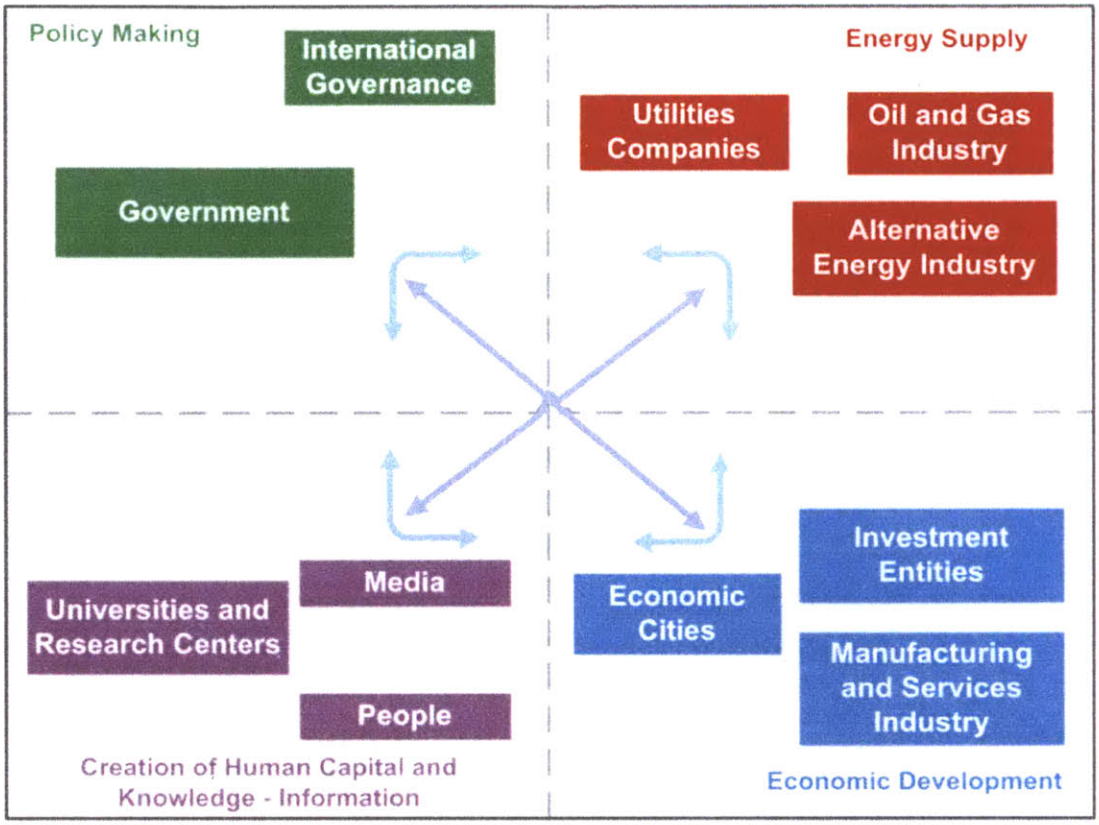

Figure 18 - Level 1, Energy Stakeholder Network (arrows indicate value flow)

In the *Energy Supply* arena we consider "Utilities Companies" (Electricity, Water and Gas) and the industries responsible for providing energy sources for the production of electricity: the "Oil and Gas Industry" and the "Alternative Energy Industry." Alternative sources of energy include atomic energy and renewable energy: wind, solar and geothermal. See Figure 19 for the specific entities included in the *Energy Supply* arena.

In the *Economic Development* arena, we consider the "Manufacturing and Services Industry," the "Economic Cities" of the Kingdom and the "Investment Entities" that have the role of making investments in the development of the first two stakeholders. But especially "Investment Entities" have the potential role of making investments in the successful shift of supplies for electricity production from oil to alternative sources of energy, if the "Government" chooses to make the "Alternative Energy Industry" private.

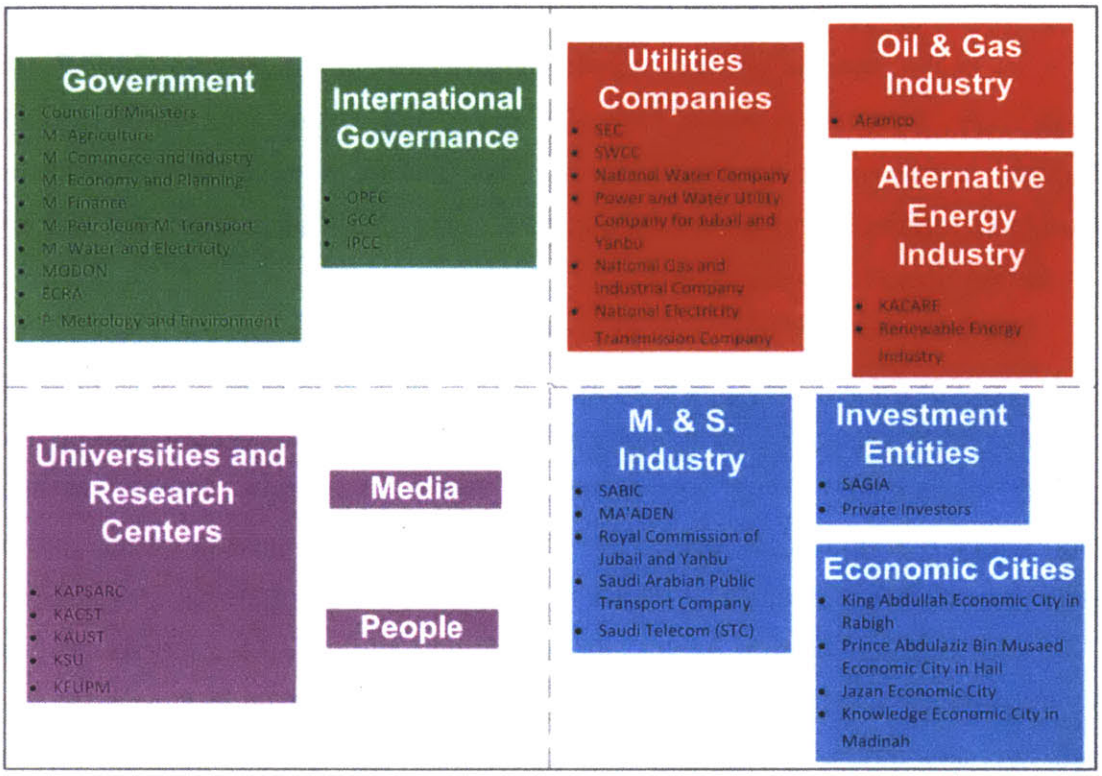

Figure 19 - Level 2, Energy Stakeholder Network

Further, not only are "Investment Entities" aware of their key role in making the change in energy mix happen, but they also see in such an opportunity a good business prospect. Dr. John Sfakianakis, Chief Economist of the Banque Saudi Fransi (a major private investor in the Kingdom), values the opportunity cost for the Kingdom continuing to produce electricity from oil and gas only as 650 Saudi Riyal billion, nominal price (approximately 173 USD billion, assuming $100 per barrel of oil), by 2020 (Sfakianakis, 2011). Further, Sfakianakis states that "renewable energy is not the future, but probably the only future" (Sfakianakis, 2011). See Figure 19 for the specific entities included in the *Economic Development* arena. Thus, providing proper policy for the expansion of "Investment Entities" into the "Alternative Energy Industry" is a potential mechanism for the Kingdom to fill the gap of electricity.

Finally, in the *Creation of Human Capital and Knowledge / Information* arena, we considered "Universities and Research Centers" in charge of educating "People." Additionally, we considered the "Media" because of its key

role of creating informative and timely information for the Kingdom. See Figure 19 for a list of the specific entities included in the *Creation of Human Capital and Knowledge / Information* arena. Naturally, the role of "Universities and Research Centers" is not limited to education only but (among other things) extends to producing research and providing qualified training for the industry, as we will see further down in our analysis.

Further, none of the roles of Level 1 stakeholders shown in Figure 18 is confined to its particular arena (see Figure 17). As we explained in the previous chapter, value exchange in a stakeholder network occurs through direct and indirect transactions, and with different types of values: money, policy, information, human capital, etc. In the next section we will expand on the role of each Level 1 stakeholder as we formally characterize each of them.

But first, we want to explain the importance of the Level 2 perspective of the stakeholder network, containing 40 specific entities, shown in Figure 19, and also its limitations. Regarding the importance of this perspective: it is instrumental in the creation of the Level 0 and Level 1 perspectives. When we qualitatively understand and characterize the network using policy documents (as explained in the previous section), we find specific entities like the Ministry of Economy and Planning, the Saudi Electric Company, the King Abdulaziz City for Science and Technology, etc. From this perspective we characterize the network by understanding the roles, objectives, specific needs, and input of each entity. We then use grouping techniques, namely hierarchy and aggregation, to group those entities into stakeholders that have similar roles and those that perform the same roles but with a narrower scope. Crawley calls this methodology "two down, one up," meaning going two levels down to understand one level up (Crawley, 2011).

Regarding the limitations of such a Level 2 perspective of the stakeholder network: as the specific objectives of SVNA state, a goal of SVNA is to create a quantitative ranking of the most important direct and indirect transactions of value within the stakeholder network. Further, this ranking aids policy makers and planners in their creation of policy and decision making. However, in 1956

George Miller, a psychologist, wrote an essay that explains why human rationale cannot deal with more than 7 +- 2 concepts during the creation of a logical argument (de Weck et al., 2011). We will call Miller's statement Miller's Law. For SVNA, Miller's Law implies that if we deliver a stakeholder study with many more than 9 stakeholders in the network, we actually could end up confusing rather than aiding policy makers and planners. Thus, we conduct SVNA on the Level 1 perspective in order to provide a tool that delivers useful insights to policy makers and planners.

Furthermore, during previous work at the Systems Architecture Lab, we found that the number of value loops that arise in the network is in the hundreds of thousands. We found that it is desirable to reduce "the number of stakeholders to no more than approximately 10" (Sutherland, 2009). This is because of the combinatorial effect on the number of cycles of value within the network by adding an additional stakeholder.

2.3. Stakeholder Characterization Templates

At the beginning of this chapter we mentioned that the qualitative part of SVNA implies a thorough characterization of the stakeholder network. In the previous sections we explained a key characteristic of the Saudi Arabia Energy Stakeholder Network—its focal stakeholder, the government. We also introduced different perspectives on the stakeholder network. Nevertheless, we have not yet presented a thorough stakeholder characterization.

In this section we will formally characterize each of the 11 stakeholders presented in Figure 18—in the previous section we explained why we use this perspective of the stakeholder network rather than either of the other two we presented in Figure 17 and Figure 18. We will characterize the stakeholders by adapting a tool that Sutherland presented in his thesis—stakeholder characterization templates (Sutherland, 2009). Sutherland built this conceptualization tool as a "directional" point from which to characterize the

inputs and outputs of each stakeholder. The information he included in such templates is:

- Role: The highest level responsibility of the stakeholder
- Objectives: The specific goals that stakeholders publish in their mission statement and policy documents
- Specific Needs: The requirements that each stakeholder needs in order to achieve the objectives mentioned above. Such specific needs are the one that characterize the inputs of value that each stakeholder receive
- Inputs: As explained in the above point, these are the value flows that fulfill the specific needs of each stakeholder

We decided to use a slightly modified version of the characterization templates. Sutherland splits "specific needs" and "inputs" based on the argument that a specific needs of a stakeholder does not necessarily map exactly to an input from another stakeholder. Consider the example shown in Figure 20. We can see that "Scientists" requires funding and that such a need gets partially fulfilled by "Science Funding" from the stakeholders "NASA/NOAA" and "Agencies." While Sutherland's distinction is conceptually correct, we found that, in practice, the distinction is not relevant for our analysis, and that putting similar information in the characterization template can actually confuse the analyst.

For these reasons we decided to include the "Level 2 perspective" of the stakeholder in the template and to remove the "Inputs" section. Thus, by following this approach, when an analyst looks at a stakeholder characterization template he will be able to:

- Gain a thorough characterization of the stakeholder at the "Level 1 perspective"
- See the "Level 2 perspective" so that he can look at what specific entities were aggregated into the level 1 stakeholder and make sense out of the information presented in the template
- Review the "objectives" of each Level 1 stakeholder and assess whether the "inputs" are conducive to fulfill them

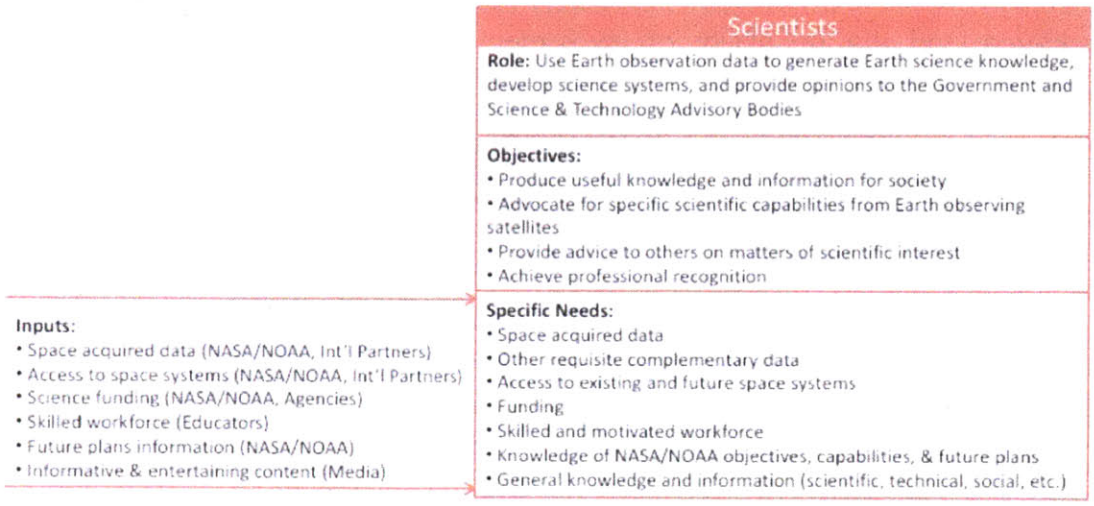

Figure 20 - Characterization template for the "Scientists" stakeholder - NASA Earth Observations Program (Sutherland, 2009)

For an example of our version of the characterization templates, see Figure 21 below. But, before introducing the characterization templates for the complete stakeholder network, we want to comment on the construction of the stakeholder network. As we have been arguing throughout this thesis, a stakeholder network is characterized by a group of stakeholders and the direct and indirect value exchange between them. Thus, as we build the network, we proof-check its "completion" by paying close attention to the "Specific Needs" section of our characterization templates. By following this approach, we make sure that all the needs—of value—throughout the network are being fulfilled by an output from one or more stakeholders in the network. If such is not the case, we must revise our characterization analysis and correct it before proceeding.

With the aforementioned considerations, we present the characterization template for "Government" in Figure 21. As we have discussed in this and the previous chapter, the main role of "Government" is to create and administer the national policy of the Kingdom. Currently, this policy is established under the five-year national development plans. In the Objectives section of the characterization template for the stakeholder "Government," we can see the topics of energy,

privatization and diversification of the industry, enhancement of the Saudi workforce and the necessity of investment for growth. Additionally, as we explained above, on the left side of the template, we can see the Level 2 specific entities aggregated under the stakeholder "Government."

At this point we will deviate from the current course and instead of going though the 11 stakeholder characterization templates, we will shift gears and return to the main goal of SVNA: characterize direct and indirect value exchange (we direct the reader to Appendix A for the rest of the templates). The work developed in this section will be instrumental in the construction of the stakeholder network and its value exchange—the topic of the next section—through the "specific needs" laid out on each of the eleven characterization templates.

2.4. SVNA Value Exchange

In the previous section, we presented a descriptive characterization of the Saudi Arabia Stakeholder Network. Such a characterization provides the "specific needs" of each stakeholder in terms of value for the eleven stakeholders in the network. In this section, we will build the network by using maps that show value exchange of different types. To begin, we direct the reader's attention to Figure 23 for a complete map of value exchange of the Saudi Arabia Energy System Stakeholder Network. The purpose of showing this figure is twofold. First, it illustrates the point that the stakeholder network is built upon value exchange. In other words, the 168 lines in Figure 23, that link one stakeholder to the other, represent value exchanges between those stakeholders. Such a value exchange can be money, policy, knowledge, human capital, etc. We arrived at this representation by using the characterization templates developed in the previous section. Such is a complete characterization of value exchange within the stakeholder network. However, it is evident that more work needs in order to rank value exchange and the importance of each stakeholder. Such work will be presented in the next chapter.

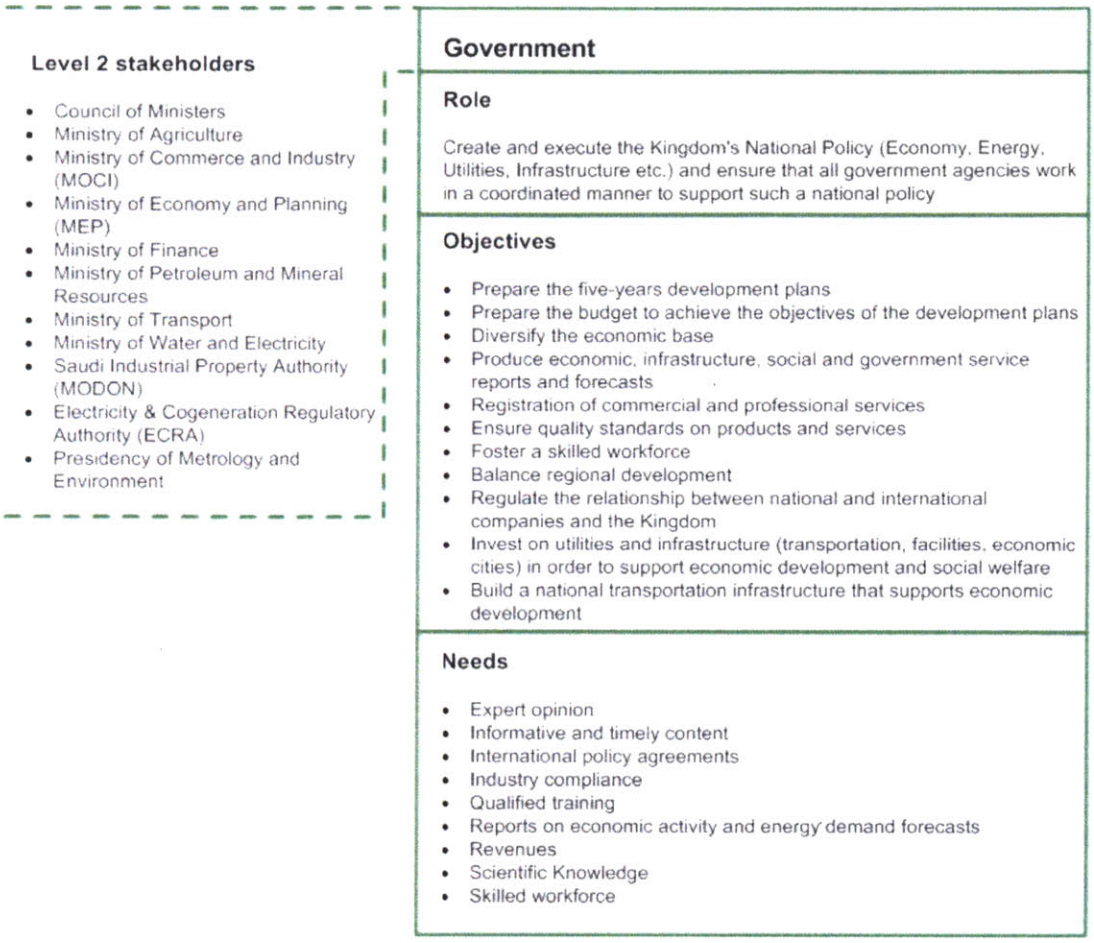

Figure 21 - Characterization template for the stakeholder "Government"

But first, the characterization of value of the stakeholder network provides a crucial understanding of the stakeholder network. Such an understanding can be extracted when we zoom in on each of the stakeholders in order to visualize the inputs and the outputs of each stakeholder. Additionally, as we mentioned above, the value exchange can be of different types. For the Energy System of Saudi Arabia, we found 31 distinct value flows categorized into 6 types of value: policy and opinion, capital, energy, knowledge and information, goods and services and jobs and public benefit. There are a total of 168 direct value exchanges in the energy stakeholder network. Figure 22 shows such categories of value and the color code we use for the value input/output diagrams below.

Additionally, in the next sections we will format the names underscored of the value flow types shown in Figure 22 (for example, policy and opinion and capital).

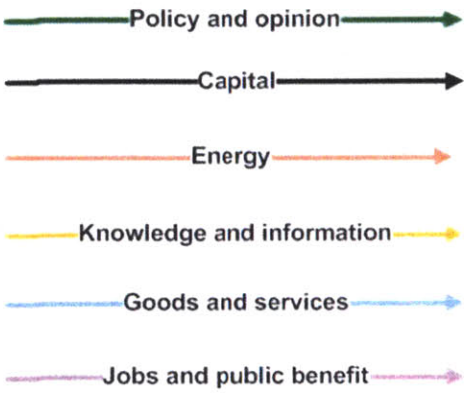

Figure 22 - Value flow types (and color code) for the Energy System of Saudi Arabia

Further, when we zoom in on each stakeholder, the reader is able to appreciate the "white boxes" inside each stakeholder (see Figure 24). These white boxes are a conceptual representation we use to specify which inputs connect to which outputs—we call them "internal assets" (Cameron, 2007). In other words, we use these internal assets to specify what value inputs (specific needs as described in the previous section) are "transformed" into what outputs (objectives of the stakeholder as described in the previous section). This conceptual representation—internal assets—is a key component of the quantitative part of SVNA, as it helps to eliminate connections input-to-output that do not make sense. For example (Figure 24): **scientific knowledge** from the "Universities and Research Centers" does not transform into **economic incentives** for "Utilities Companies." Thus, there is no internal asset connecting these value flows.

Finally, in the value input/output diagrams below, stakeholders are represented by the color we introduced in Figure 17, Figure 18, and Figure 19. In this manner, as we zoom in on each of the stakeholders, the reader is able to make sense of all the valuable information contained in the input/output diagrams:

1. Level 0 *arenas* that each stakeholder belongs to

2. Amount and type of value coming in and out of each stakeholder
3. Sources and recipients of value for each stakeholder
4. Internal assets or mechanisms that transform specific needs into objectives

Points 3 and 4 are an improvement over the work done by Sutherland, since our representation allows us to relate the information visualized in the diagrams to the "Objectives" of the stakeholder, as stated in its characterization template, and the arena to which it belongs (see Figure 17). Moving on, in the rest of this section we will walk the reader through the network by focusing on each of the stakeholders by showing input/output diagrams for each of them.

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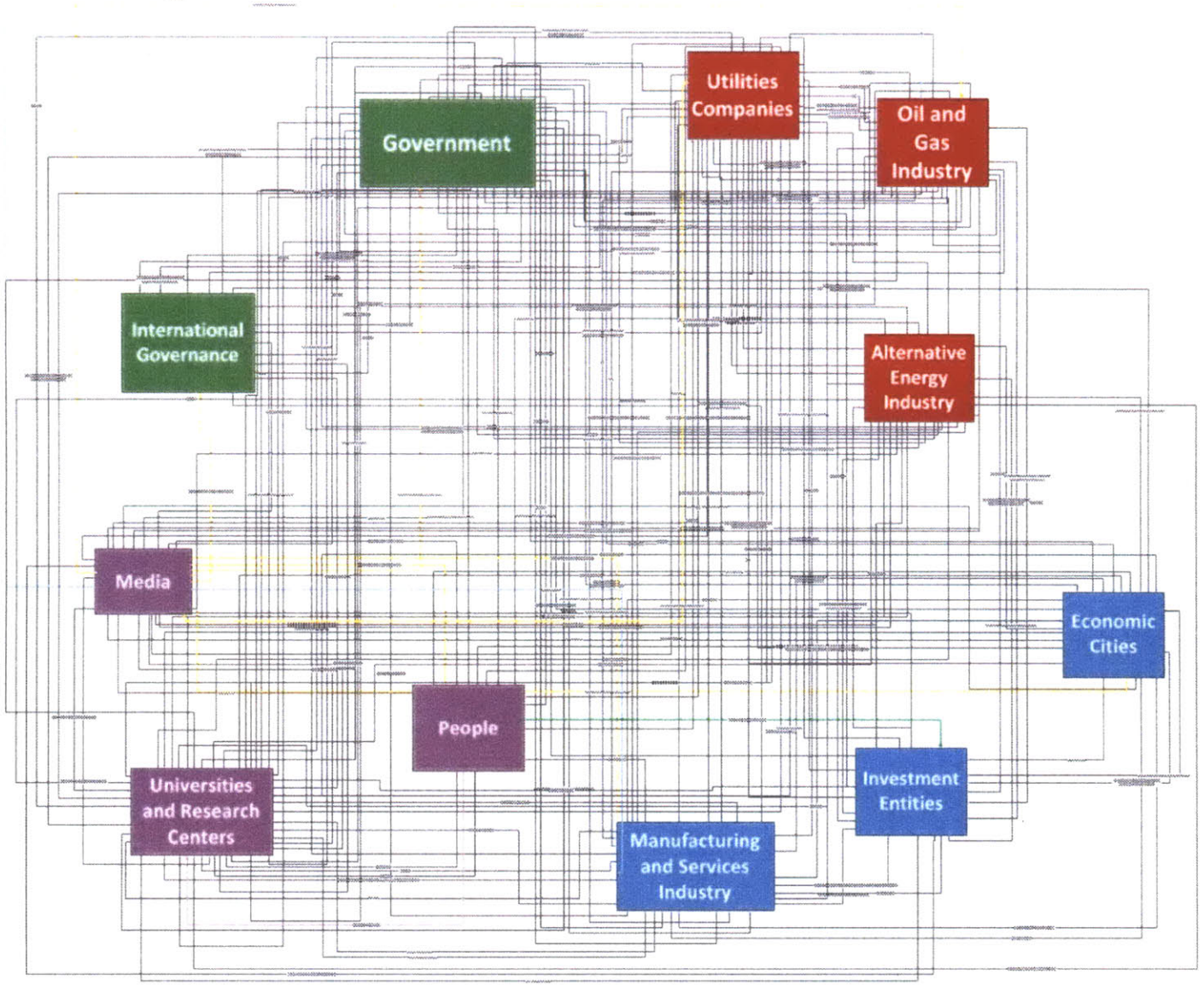

Figure 23 - Full map of value exchange - Saudi Arabia Energy Network

Table 3 - Value Flows Definitions

#	Value Flow	Value Flow Type	Definition
1	Acceptance and recognition	Policy and opinion	Understanding and support from the people of Saudi Arabia that renewable energy is a viable, sustainable and profitable way of meeting the Kingdom's energy needs
2	Advertisement	Goods and services	Advertisement displayed in various media channels (internet, TV, newspapers, radio, physical displays)
3	Attractive opportunities for investments	Capital	Investment opportunities in the manufacturing, services and energy industry. This can vary from investment opportunities in infrastructure, technology, human capital or finance products
4	Education	Jobs and public benefit	Knowledge and information that will provide Saudi Arabian citizens with a better quality of life and the necessary skills to fulfill the Kingdom's human capital needs
5	Electricity and water	Energy	Energy and water that enables its recipients to fulfill their primary objectives
6	Expert opinions	Goods and services	Information, analysis and knowledge in science, politics, industry, society and economics that assist its recipients in their decision making
7	Funding	Capital	Money to support the primary objectives of its recipients. The expectations of its donors are not a direct return on investment.
8	Gas	Energy	Energy that enables its recipients to fulfill their primary objectives

#	Value Flow	Value Flow Type	Definition
9	Industry compliance	Policy and opinion	Compliance by industry with the National Policy's objectives and regulation
10	Collaboration and information exchange	Knowledge and information	Information exchange and human resources that contribute to the fulfillment of all the parties involved in the interaction
11	Informative and timely content	Knowledge and information	Any activity and information covered by the media that is published. It is split into informative and timely because these two characteristics made it valuable for energy stakeholder network; for example, there is a clear difference in knowing a rise in price of oil now versus than an hour later
12	Infrastructure	Capital	Facilities, roads, information-technology and the necessary means that the manufacturing and services industry needs in order to operate and flourish in the economic cities
13	International policy compliance	Policy and opinion	Compliance by the Kingdom's government with the International Policy Agreements created in conjunction with international governments
14	Investments	Capital	Money directed to support a specific development chosen by the investors. The expectation of its donors is a positive return of investment
15	Kingdom's achievements	Knowledge and information	Events that are conducive to the forming of pride, patriotism and motivation to contribute to the Kingdom's development
16	Motivated students	Jobs and public benefit	Students motivated to learn and research a discipline for their personal development and that of the Kingdom

Table 3 - Value Flows Definitions

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4	Education	Jobs and public benefit	Knowledge and information that will provide Saudi Arabian citizens with a better quality of life and the necessary skills to fulfill the Kingdom's human capital needs
5	Electricity and water	Energy	Energy and water that enables its recipients to fulfill their primary objectives
6	Expert opinions	Goods and services	Information, analysis and knowledge in science, politics, industry, society and economics that assist its recipients in their decision making
7	Funding	Capital	Money to support the primary objectives of its recipients. The expectations of its donors are not a direct return on investment.
8	Gas	Energy	Energy that enables its recipients to fulfill their primary objectives

#	Value Flow	Value Flow Type	Definition
17	News and noteworthy information	Knowledge and information	Events, data, reports, speeches, documents and related events information that can provide information to the media to publish news
18	Oil	Energy	Oil for the manufacturing of products and production of utilities
19	International policy agreements	Policy and opinion	Policy agreements made by the Saudi Arabia Government in conjunction with international governments
20	Policy direction for planning and development	Policy and opinion	The National Policy produced by the Kingdom of Saudi Arabia for all sectors
21	Protection and Security	Jobs and public benefit	Protection from harm and threats, including economic ones. A balanced supply of energy will give the Kingdom's citizens a sense of good quality of life
22	Qualified training	Goods and services	Education and training that has the purpose of providing specialized knowledge or updating general knowledge previously acquired
23	Quality jobs	Jobs and public benefit	Well paid, fulfilling jobs
24	Regulation	Policy and opinion	Regulation from the Government on different sectors of the manufacturing industry, energy suppliers, the media, etc.
25	Alternative energy power systems	Energy	Alternative (nuclear and renewable) energy power systems that deliver electricity and thermal power to its recipients

#	Value Flow	Value Flow Type	Definition
26	Reports on economic activity and energy demand forecasts	Knowledge and information	Reports that contain revenues, profits, growth numbers, energy reserves, energy consumption and related figures that communicate the working status of an entity or institution
27	Revenues	Capital	Monetary income
28	Scientific knowledge	Knowledge and information	Scientific research published in papers / conferences / reports / etc.
29	Skilled workforce	Jobs and public benefit	People with the skills that the industry, energy companies and governments are looking for to build their human capital
30	Economic Incentives	Capital	Monetary aid from the Government to reduce the price of products and services
31	Technology systems	Goods and services	Applied research and prototypes that contribute to the development of technology

economic incentives and **funding** to its industries, mainly because it is the main owner of the Kingdom's most important companies (see Table 2). Therefore, for our general objectives, we see that the main mechanisms that "Government" has to achieve potential alternatives to fill the electricity gap are regulation and money providing. Finally, we want to highlight a unique output provided by the "Government" to its "People": **protection and security**. Without this value flow, the "People" of the Kingdom could not have economic welfare, could not get educated, could not contribute to the economic development of the Kingdom, and could not play their role in shifting the inputs for electricity production from oil to alternative sources.

Now we will continue with the input / output diagrams for the rest of the stakeholder network. We will deviate for a while from our general objectives—as they pertain to the focal organization "Government"—and will keep addressing our specific ones: to characterize and quantify all of the value exchanges in the network. We will come back to the general objectives in the next chapter.

The next diagram concerns "International Governance." This is a stakeholder that comprises international "councils" as shown in Figure 19. In Appendix A: Stakeholder Characterization Templates, we provide the descriptive characterization on "International Governance" but it is common knowledge that these organizations often cannot do more than share information and provide international policy. Thus, Figure 25 shows that both the input and output side of "International Governance" is populated with value flows on the "Policy and Opinion" and "Knowledge and Information" categories.

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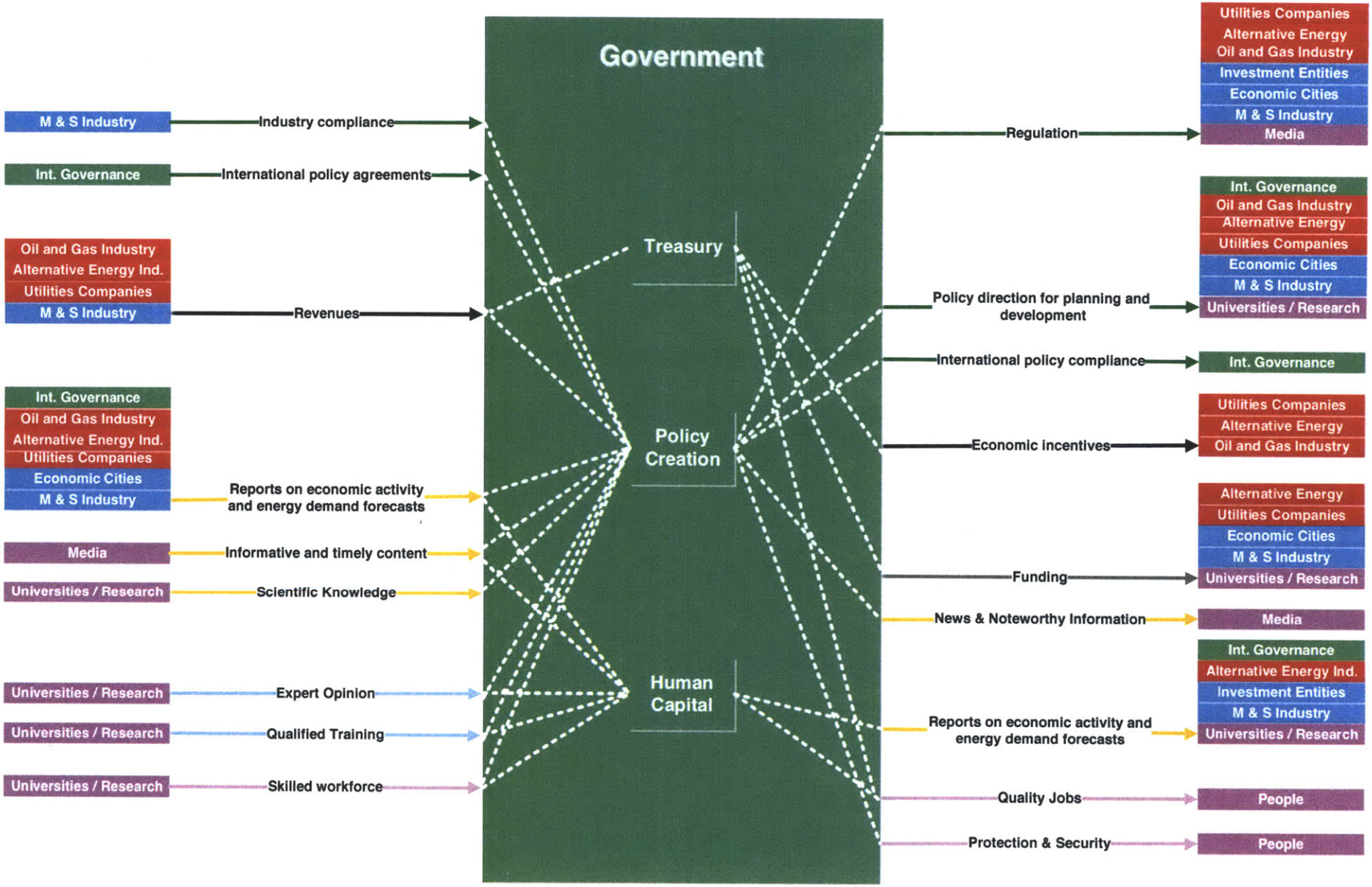

Figure 24 - Input / Output value exchange – Government

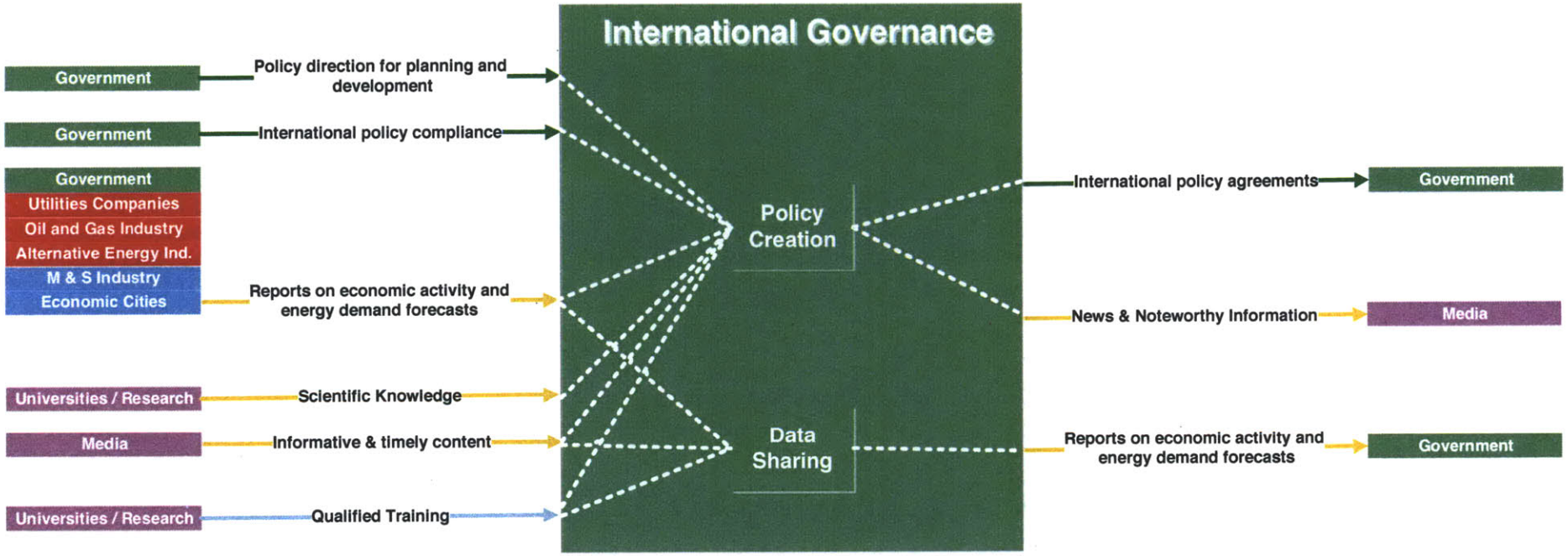

Figure 25 - Input / Output Value Exchange - International Governance

2.4.2. Input / Output value exchange diagram for the Economic Development arena

Here, we move on to the *Economic Development* arena (see Figure 17). We start with the stakeholder "Manufacturing and Services Industry" (see Figure 26). We see a mixture of value flow categories in contrast to those of "Government," as shown in Figure 24. On the input side, we see a collage of Capital, Energy, Knowledge and Information and Goods and Services. These categories of inputs give the sense that it is the "Manufacturing and Services Industry," more than any other stakeholder, that integrates the different types of organization in a country, in particular in the Kingdom of Saudi Arabia.

The output side of "Manufacturing and Services Industry" is more homogeneous. On the one hand, the "Manufacturing and Services Industry" provides considerable Capital to a number of stakeholders, including "Government" and the "Economic Cities" of the Kingdom. On the other hand, we can clearly see that the "Manufacturing and Services Industry" is an important provider of Knowledge and Information for a number of stakeholders, especially in the *Energy Supply* and *Economic Development* arenas. Additionally, as was the case of Protection and Security provided by the "Government" to the "People," there is a single but key output coming out from "Manufacturing and Services Industry": **industry compliance**. As shown in Table 3, **industry compliance** refers to a considerable investment of information, time and human resources—in this case with the "Government." In other words, **industry compliance** is what the "Government" expects from the "Manufacturing and Services Industry" in order to achieve the objectives laid out in the five-year national development plans (MEP, 2010).

Next in line in the *Economic Development* arena, we have the stakeholder "Economic Cities" (see Figure 27). We can see that, as it was the case with the "Manufacturing and Services Industry," the input side is heterogeneous. As we went through our analysis, we realized that this is a characteristic shared by the

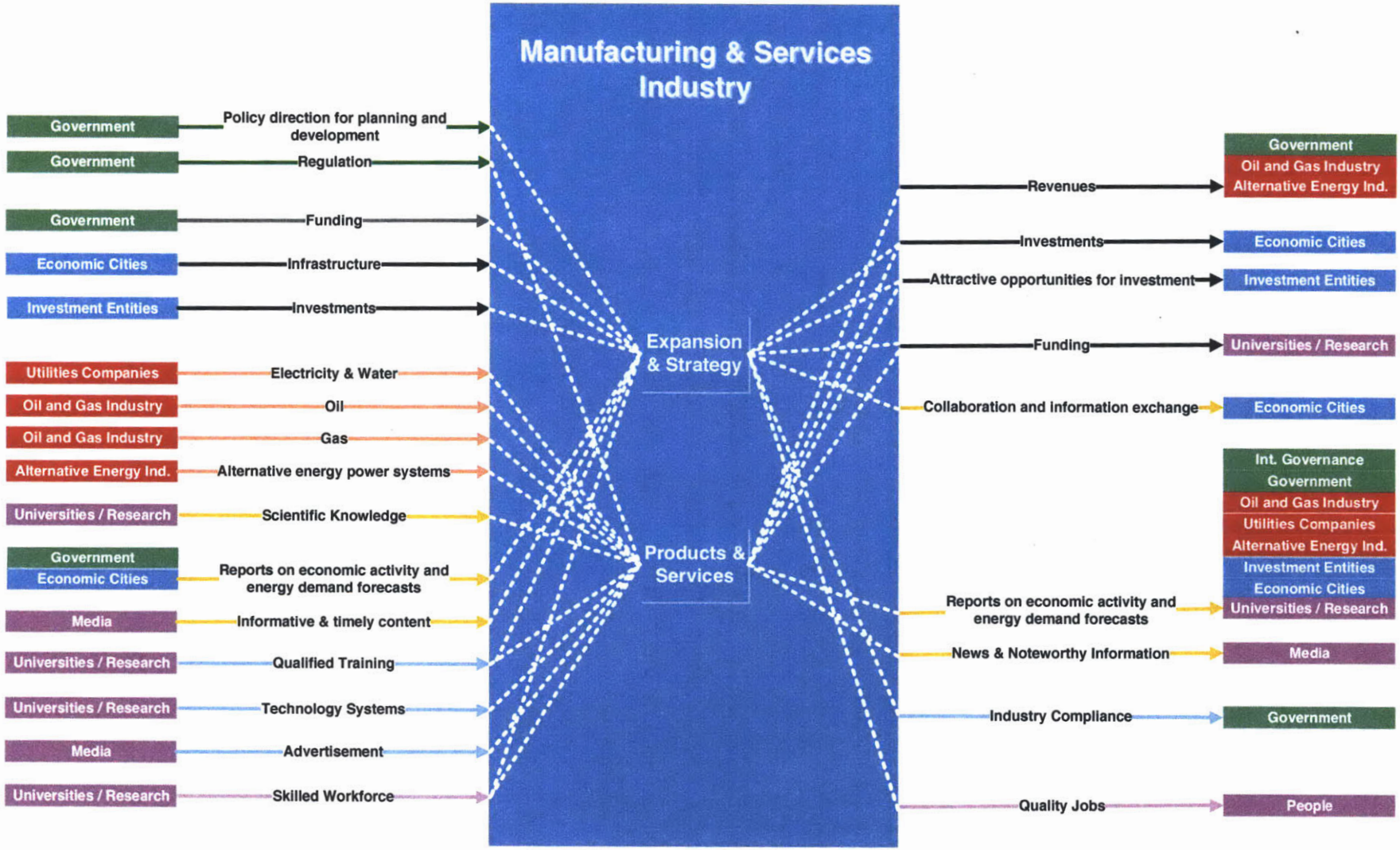

Figure 26 - Input / Output Value Exchange – Manufacturing and Services Industry

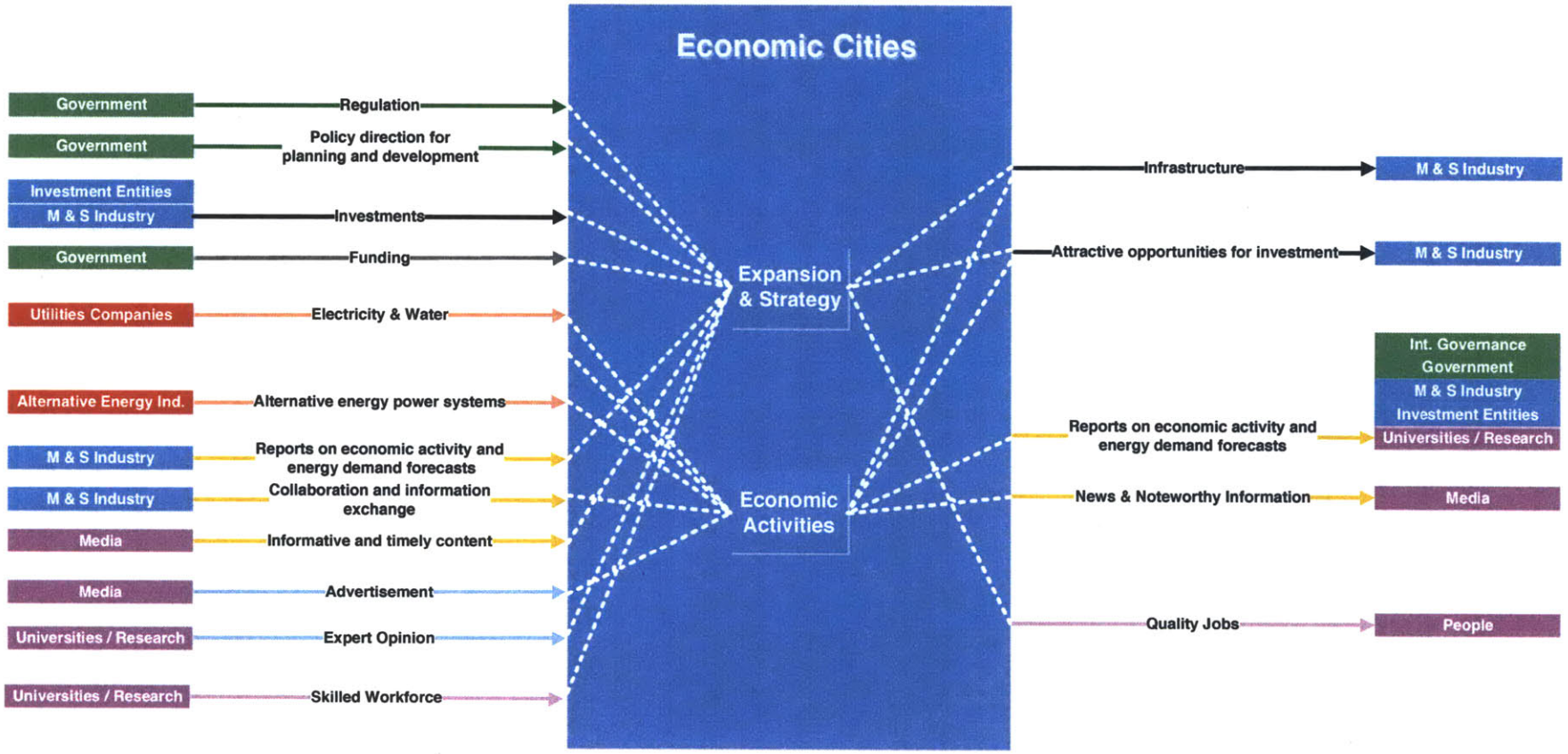

Figure 27 - Input / Output Value Exchange – Economic Cities

stakeholders in the *Economic Development* arena, as they integrate the different types of organizations in a country. If the reader looks again at Figure 26 and Figure 27, he will realize that both stakeholders, "Manufacturing and Services Industry" and "Economic Cities," share the input **expert opinion**. As shown in Table 3, this value flow entails knowledge and information provided by one party to the other. During our visits to the Kingdom, we met with several of the stakeholders, and often they would be accompanied by a "consultant" hired "full-time" to work with the stakeholder on particular subjects. We also want to highlight that for both of the previous stakeholders, the "Government" appears as a provider of Capital with **funding**. Further, on the output side, we see that the "Economic Cities" provide a critical value flow for the "Manufacturing and Services Industry," to achieve its mandate to diversify and grow: **infrastructure** (see Table 3 for its definition).

To complete the *Economic Development* arena, Figure 28 shows the stakeholder "Investment Entities." Here, we want to highlight two Capital value flows: one on the input side—**attractive opportunities for investment**—and one on the output side—**investment**. See Table 3 for the definitions. These two value flows characterize the role of the "Investment Entities" for the Saudi Arabia Energy System: enablers of growth and expansion through capital providing in the form of investments for a number of stakeholders in the "Energy Supply" and "Economic Development" arenas:

- Alternative Energy Industry
- Oil and Gas Industry
- Utilities Companies

Further, we see that the relationship between such stakeholders and the "Investment Entities" is reciprocal: the former must actively utilize the **investments** they receive to offer new **attractive opportunities for investment**. Furthermore, as we mentioned in Section 2.2, "Investment Entities" are aware of the challenge and opportunity of shifting the energy supply for the production of electricity from oil and gas to alternative sources: "renewable energy is not the future, but probably the only future" (Sfakianakis, 2011).

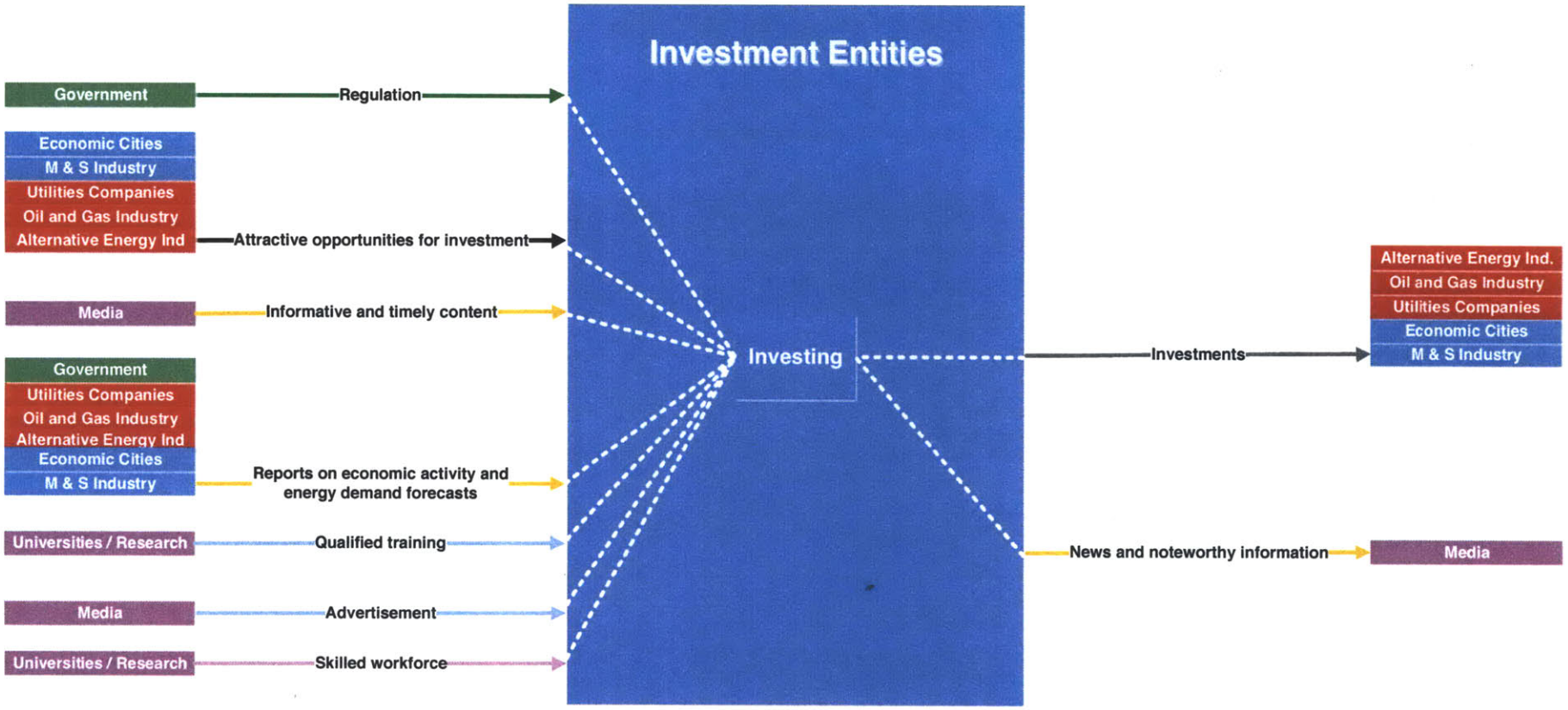

Figure 28 - Input / Output Value Exchange – Investment Entities

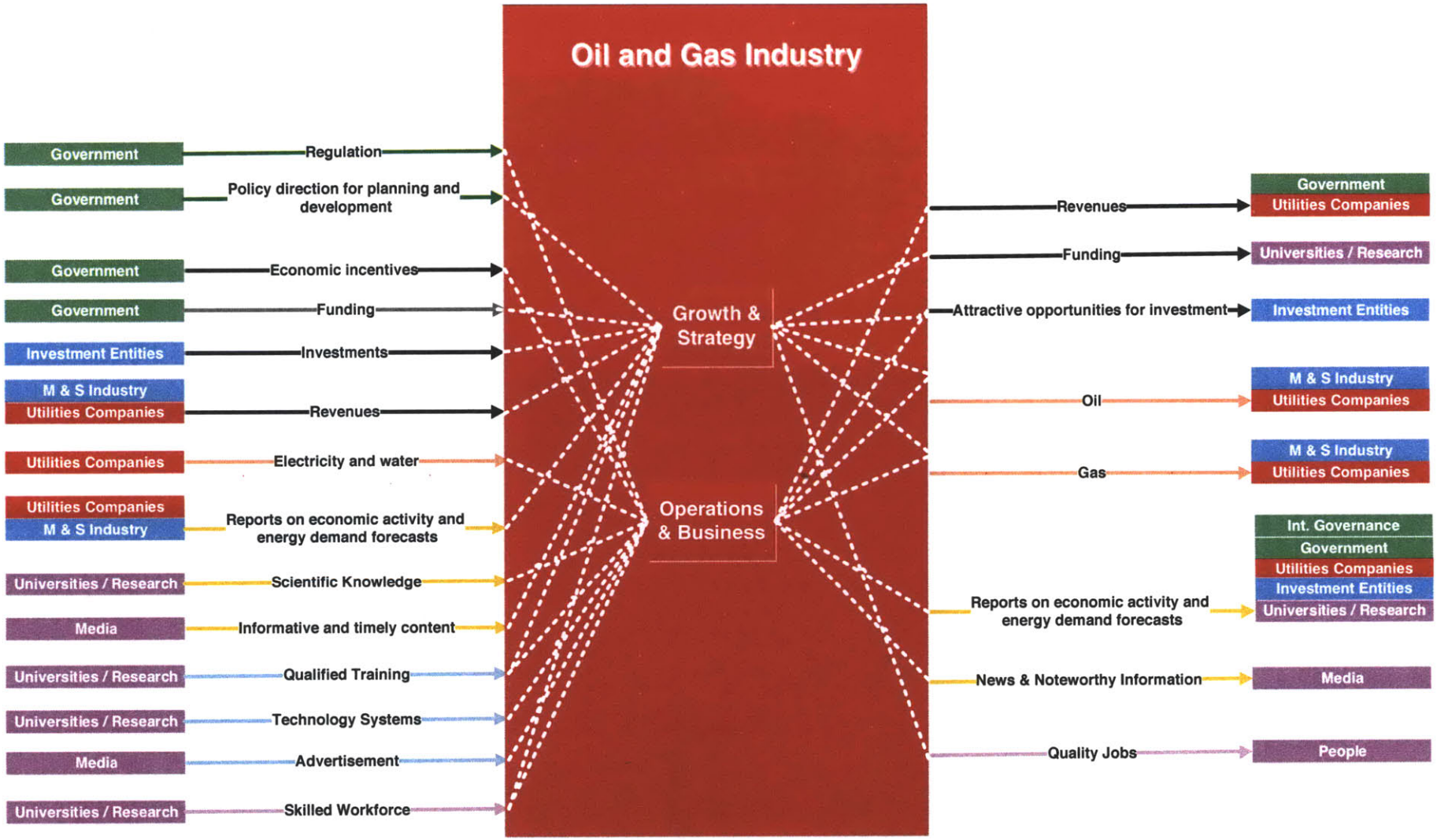

Figure 29 - Input / Output Value Exchange – Oil and Gas Industry

Before we end this subsection, we want to call to the reader's attention the constant appearance of some value flows from "Government" to the stakeholders in the Economic Development arena:

- Regulation
- Policy direction for planning and development
- Capital
- Reports on economic activity and energy demand forecasts

All of these are potential mechanisms for us to investigate to address the general objectives of this thesis.

2.4.3. Input / Output value exchange diagram for the Energy Supply arena

We shift now to the *Energy Supply* arena. We start with the "Oil and Gas Industry," as shown in Figure 29. We can see that, as in the case of the *Economic Development* arena, the input side is heterogeneous, having inputs from all of the six of the categories shown in Figure 22. There are a few inputs we want to call to the reader's attention. First, **economic incentives** (see Table 3 for its definition). As the name suggests, these are incentives for the "Oil and Gas Industry" to do business in the Kingdom. Second, **technology systems**. Aramco, the main specific entity included in "Oil and Gas Industry" stakeholder (as shown in Figure 19), highlights the importance of developing technology in order to stay ahead as a world leader in its industry (Aramco, 2012). Thus, applied research and prototypes—**Technology Systems**—coming from the stakeholder "Universities and Research Centers" are an important need for Aramco to develop technology.

On the output side of the "Oil and Gas Industry," we want to highlight, first, **revenues** provided primarily to the "Government." As we have explained, the

Kingdom of Saudi Arabia is a country economically dependent on the production and international trade of energy, mainly oil. Thus, we see a conflict between the **economic incentives** the "Oil and Gas Industry" needs in order to provide cheap electricity in the Kingdom and the **revenues** the "Oil and Gas Industry" provides to the "Government," as developed in Chapter 1. Next, we see **oil** and **gas** as Energy outputs. Such a value exchange is the central topic of this thesis: the energy sources that move from the "Oil and Gas Industry" to the "Utilities Companies" for the latter to produce electricity. Additionally, we see that such outputs also go to the "Manufacturing and Services Industry" for the manufacturing of products, among them petrochemicals by SABIC. See Figure 2. This energy input is fundamental for the economic development objectives of the Kingdom discussed in Section 1.2

Next in the *Energy Supply* arena, we present the stakeholder "Utilities Companies," in Figure 30. Here, we first want to highlight the Economic Development value flows. We see that, as in the case of the "Oil and Gas Industry," "Utilities Companies" require **technology systems** in order to develop technology that enables them to operate efficiently. Next, we want to highlight the amount of Capital inputs that "Utilities Companies" receive:

- Revenues
- Funding
- Economic incentives
- Investments

Economic incentives in particular are critical for the Kingdom and its people. As we saw in Chapter 1, the consumption of electricity in the Kingdom has increased considerably over the last 30 years. We argued that one reason for this trend is the increasing population. However, others argue that another reason is the low price of electricity, heavily incentivized by "Government" so that the people can get cheap electricity and have the sense of enjoying a high quality of life (Lahn & Stevens, 2011).

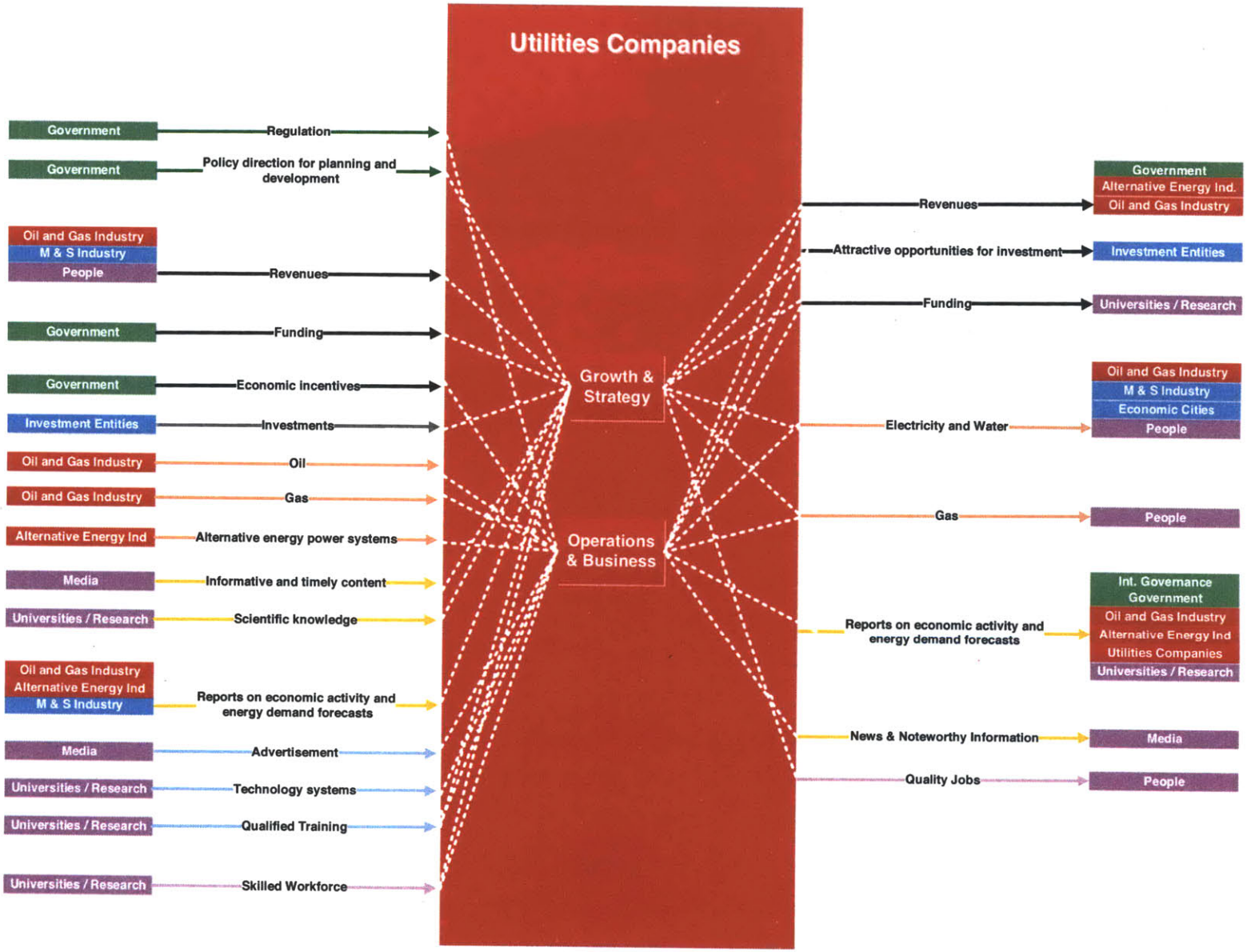

Figure 30 - Input / Output Value Exchange – Utilities Companies

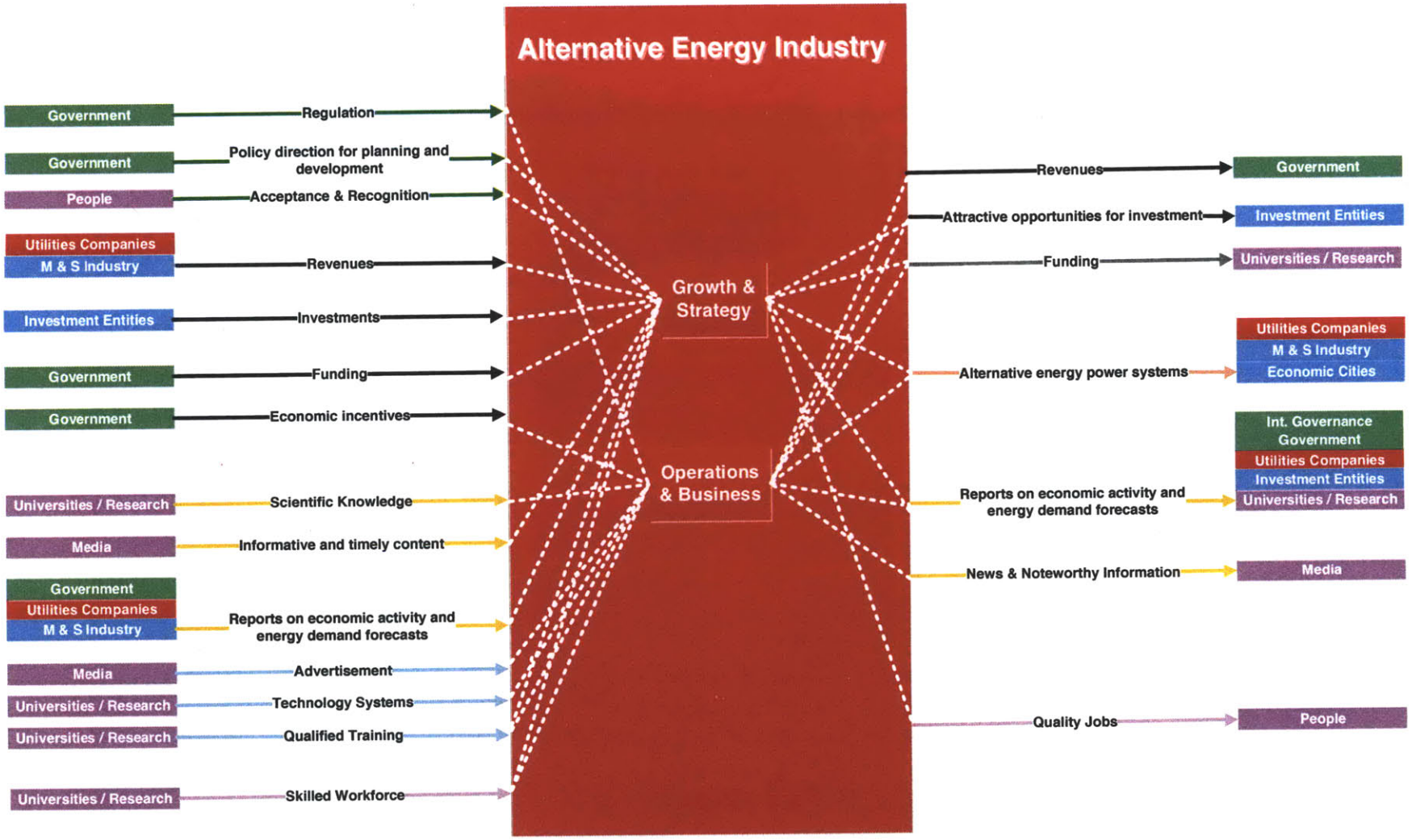

Figure 31 - Input / Output Value Exchange – Alternative Energy Industry

Coming back to the general objectives of this thesis, while "Government" provides **economic incentives** for **oil** and **gas** to be used to produce electricity, "Utilities Companies" will have little incentives themselves to shift the energy supply mix to include atomic and renewable energies. Thus, we see "Government" faces a tradeoff between

- Providing **economic incentives** for the "Alternative Energy Industry" at the same level as they are currently provided for the "Oil and Gas Industry"
- Eliminating **economic incentives** for any supply source for the production of electricity

We will come back to discuss this tradeoff in the final chapter of this thesis.

On the output side of "Utilities Companies" we want to highlight the Energy Supply value flows: **electricity and water** and **gas**. As we have been developing in this thesis, producing **electricity** is the main energy concern for the Kingdom: changing the input sources for its production from oil to alternative sources such as atomic and renewable energies.

Accordingly, we present the stakeholder "Alternative Energy Industry" (see Figure 31). Looking at the input side, we see a scenario similar to that for the "Utilities Companies" but for the absence of **oil** and **gas**. Nevertheless, for "Alternative Energy Industry" the Capital value inputs are even more critical than for "Utilities Companies." That is, in Figure 31 we see **revenues** coming from three stakeholders. However, currently these three stakeholders are still potential customers for the "Alternative Energy Industry" because, as we demonstrated in Chapter 1, no significant amount of electricity is being produced by alternative sources.

Further, we see a unique input coming from "People": **acceptance & recognition** (see Table 3 for its definition). The presence of this value flow follows this rationale. The "Alternative Energy Industry" has the goal of becoming a source of energy for the production of electricity, for both "Utilities Companies"

and "Manufacturing and Services Industry" and an **attractive investment opportunity** for the "Investment Entities." Additionally, the "Alternative Energy Industry" has the goal of getting more **funding** from the "Government" (as shown in Figure 31). To achieve these goals, "People" must accept and recognize the "Alternative Energy Industry" so that when Saudi Arabia's citizens interact with the aforementioned stakeholders, they "keep them in mind." On the output side we highlight **alternative energy power systems** for "Utilities Companies," the "Manufacturing and Services Industry" and the "Economic Cities."

2.4.4. Input / Output value exchange diagram for the Human Capital arena

We continue with the fourth and final arena in Figure 17: *Creation of Human Capital and Knowledge / Information*. We start with the stakeholder "People" (see Figure 32). As was introduced during the presentation of the "Government" input/output diagram, **protection and security** is a critical input for the "People" and the whole stakeholder network itself. Next, we call to the reader's attention **quality jobs** coming from 7 stakeholders. These jobs deliver the economic welfare and quality of life for the "People" to deliver *Human Capital* to the stakeholder network.

Next we present the stakeholder "Universities and Research Centers" (see Figure 33). First, we see on the input side, two value flows that combined contribute heavily to the creation of quality human capital: **funding** and **reports on economic activity and energy demand forecasts**. These two inputs allow for the education of a skilled workforce that has theoretical and practical current knowledge of the Kingdom's challenges and needs. On the output side, we see that the "Universities and Research Centers" contribute heavily to Goods and Services with **qualified training** and to Jobs and public benefit with **skilled workforce.**

We now end this section with the presentation of the stakeholder "Media" (see Figure 34). The "Media" has the major role of distributing **informative and**

timely content throughout the Kingdom. And, in order to be able to produce such an output, they need the input **news and noteworthy information** (See Table 3 for the definitions). Additionally, we call to the reader's attention a single, but key, output: **the Kingdom's achievements**. As defined in Table 3, these are events that help motivate the "People" to contribute to the development of the Kingdom of Saudi Arabia. Without them, it would not be possible for the stakeholder network to function.

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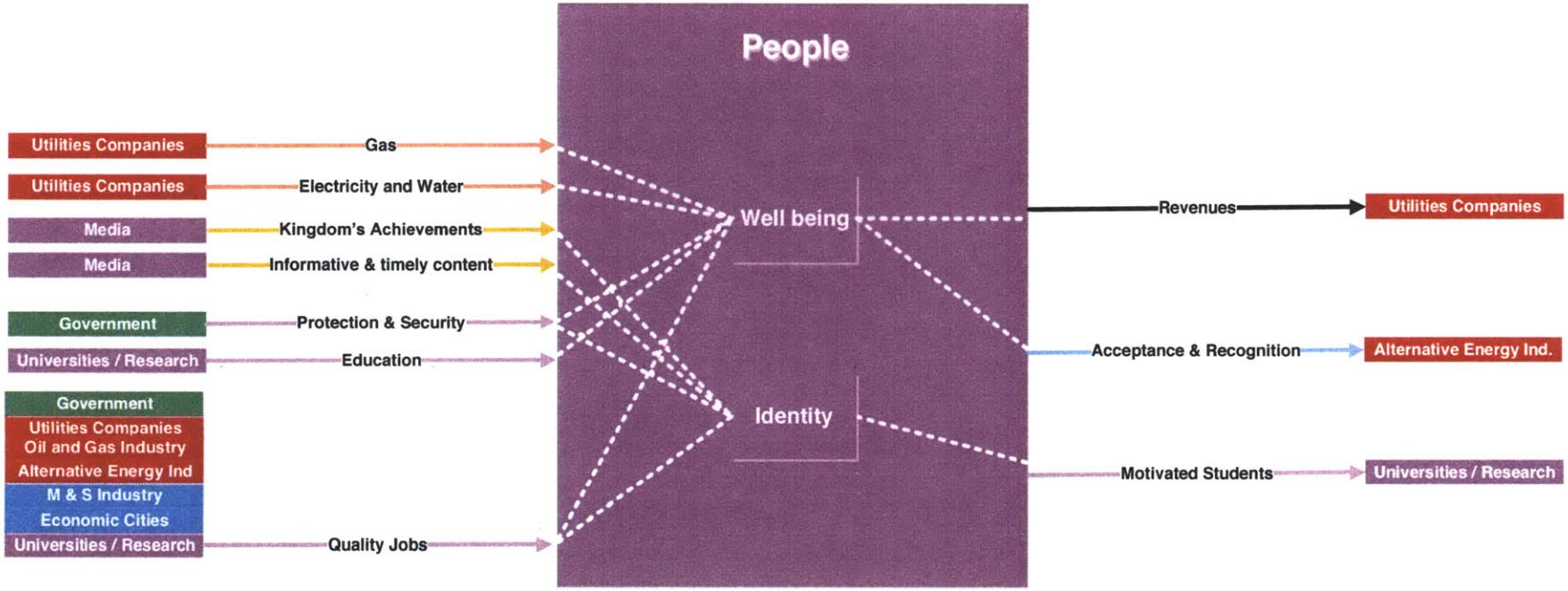

Figure 32 - Input / Output Value Exchange – People

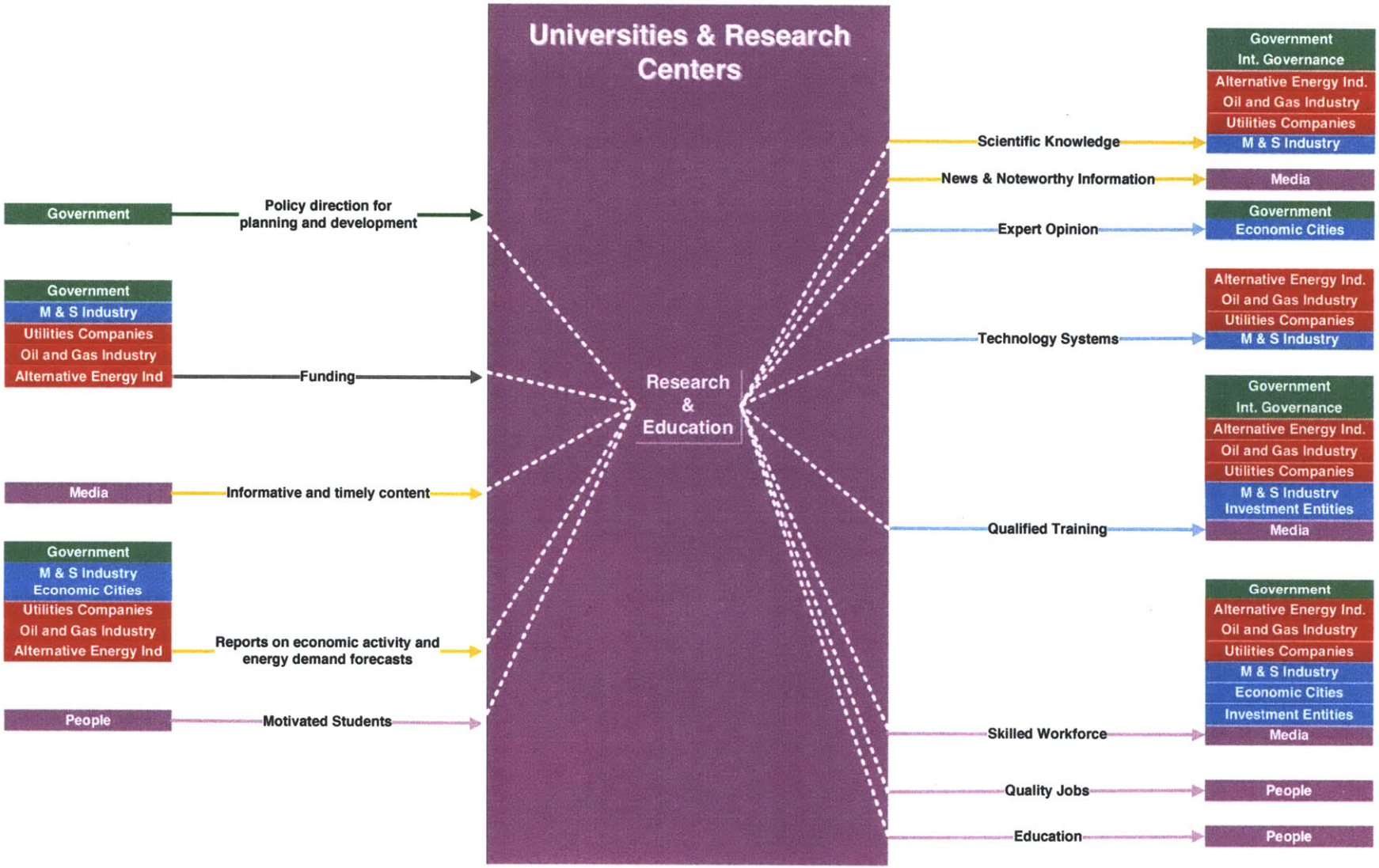

Figure 33 - Input / Output Value Exchange – Universities and Research Centers

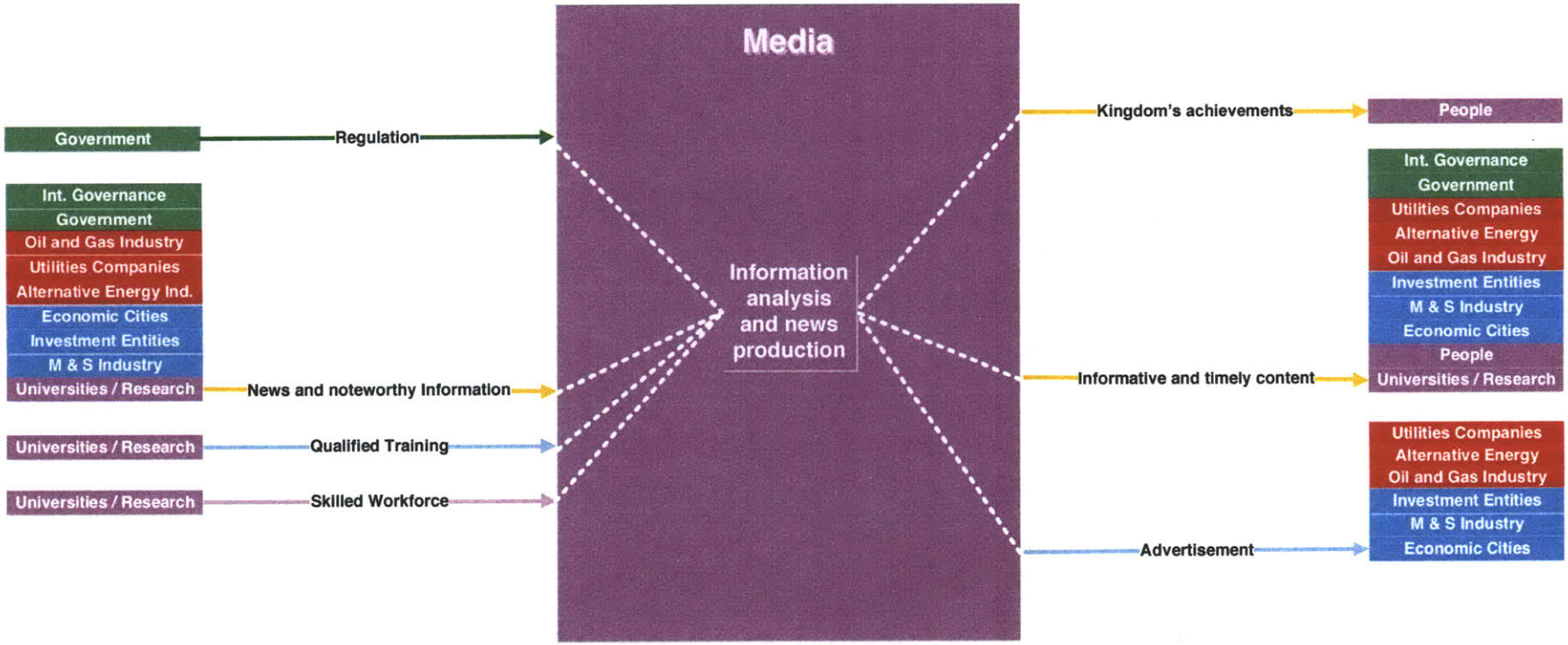

Figure 34 - Input / Output Value Exchange – Media

2.5. The Stakeholder Network by Value Flow Category

Before concluding this chapter, we want to show a final visualization of the Stakeholder Network of the Energy System of Saudi Arabia—value flow maps by category. In Figure 23, we presented the complete map of value flow. At the time, we argued that such representation has a lot of value in terms of information but can be quite confusing for policy makers and planners to use as an aid in their duties. However, after the reader has reviewed Section 2.4, the following maps will tie the material together better.

We start with Figure 35 - Stakeholder Network, Policy and Opinion Value Flow. Here we see the main role of the "Government" as policy maker, as it is the main source of the policy and opinion value flows. In the last chapter we started to discuss the general objectives of this thesis: the mechanisms "Government" can use to propel the Kingdom in the desired direction. Policy and opinion is perhaps the strongest of them, and we will come back to this issue in the final chapter. Only two other stakeholders in the network, "International Governance" and "Manufacturing and Services Industry," deliver the network two additional value flows of policy and opinion type—one each.

Next, we have Figure 36 - Stakeholder Network, Capital Value Flow. Here the "Government" is not only a source of capital but also serves a dual function. On the one hand, it collects **revenues** from the "Oil and Gas Industry," "Utilities Companies," "Manufacturing and Services Industry," and "Alternative Energy Industry." Then the "Government" delivers back such Capital in the form of **funding** and **economic incentives**. Additionally, we want to highlight that "Universities and "Research Centers" only receives Capital but does not deliver it back to the network. However, we want to remind the reader that throughout this thesis we have developed:

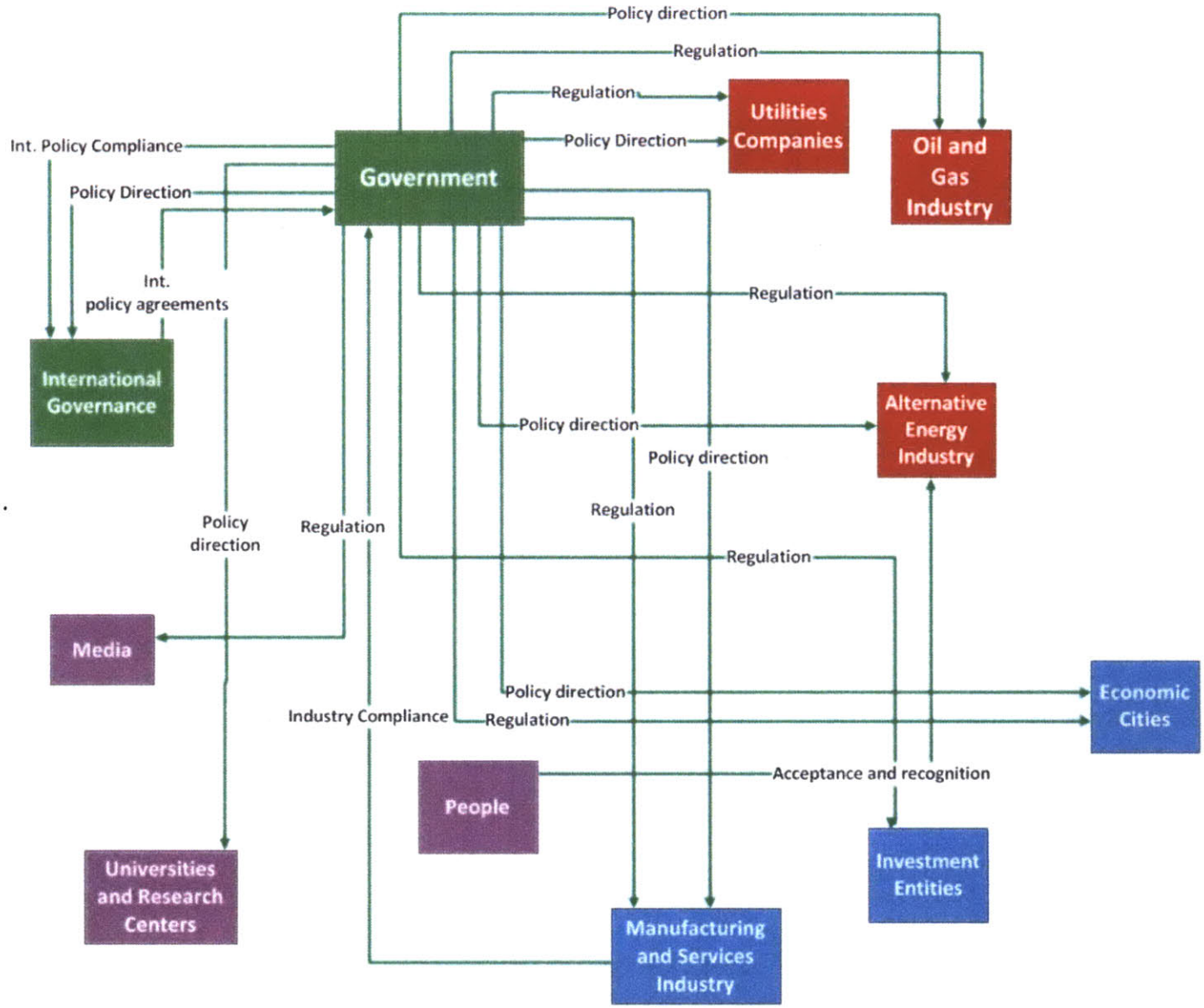

Figure 35 – Stakeholder Network, Policy and Opinion Value Flow

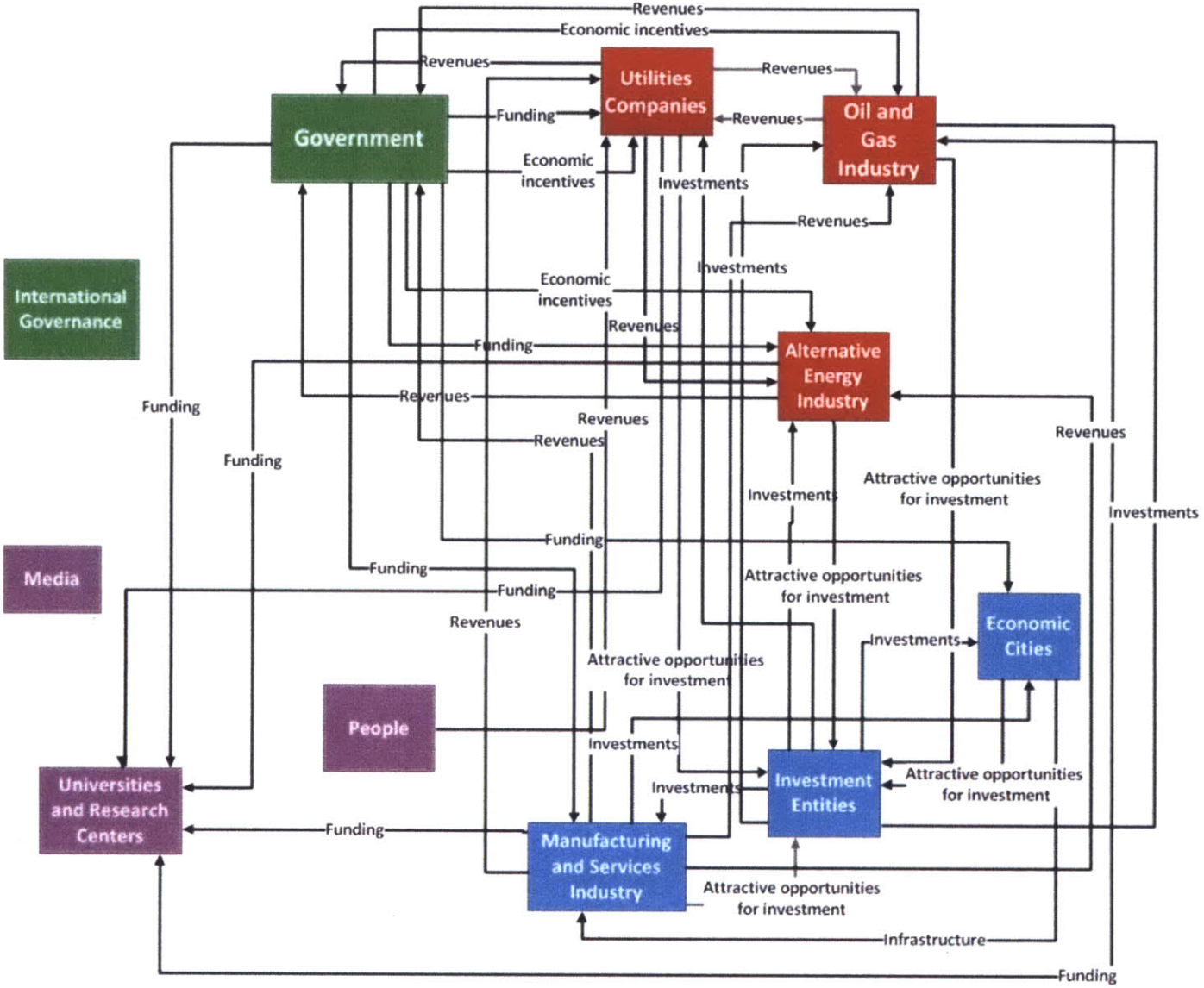

Figure 36 – Stakeholder Network, Capital Value Flow

- The idea of different categories of value flow, see Figure 22 and Table 3
- The transformation of one category of value flow into another. For example: **capital** into **skilled workforce**—through education
- The conceptual representation of such transformations by the "internal assets" explained in Section 2.4

Therefore, if the reader refers again to Figure 33, he will realize that all the Capital that "Universities and Research Centers" takes, in the form of **funding**, is transformed through an internal asset (research and education) into **skilled workforce**. In other words, "Universities and Research Centers" does deliver the Capital it received back to the network—but the delivered value is of different types, not Capital.

Continuing on, we have Figure 37 - Stakeholder Network, Energy Value Flow. We see that the main sources of Energy are the stakeholders in the *Energy Supply arena*. The reader will observe that we did not include the flow of **gas** and **electricity and water** to five of the stakeholders in the network. This is not because such delivery does not exist, for example: **electricity and water** to "Universities and Research Centers." Rather, the reason is that such consumption of energy is not central to the challenge of the high consumption of electricity in the Kingdom. As explained in Chapter 1, the central consumption comes from the population, urban centers, and industry. These Energy value flows are included in the network, as shown in Figure 37.

In the next map, Figure 38 - Knowledge and Information Value Flow we want to make only one main point. That is, the importance of *Knowledge and Information* for all the rest of the objectives of all the stakeholders included in the network. In other words, for the stakeholders to attain the objectives shown in the characterization templates in Appendix A: Stakeholder Characterization Templates, they need, in one form or another, Knowledge and Information (as also seen in Section 2.4). In the above, we mentioned Knowledge and Information as a potential mechanism for "Government" to exercise the desired change. (continues below)...

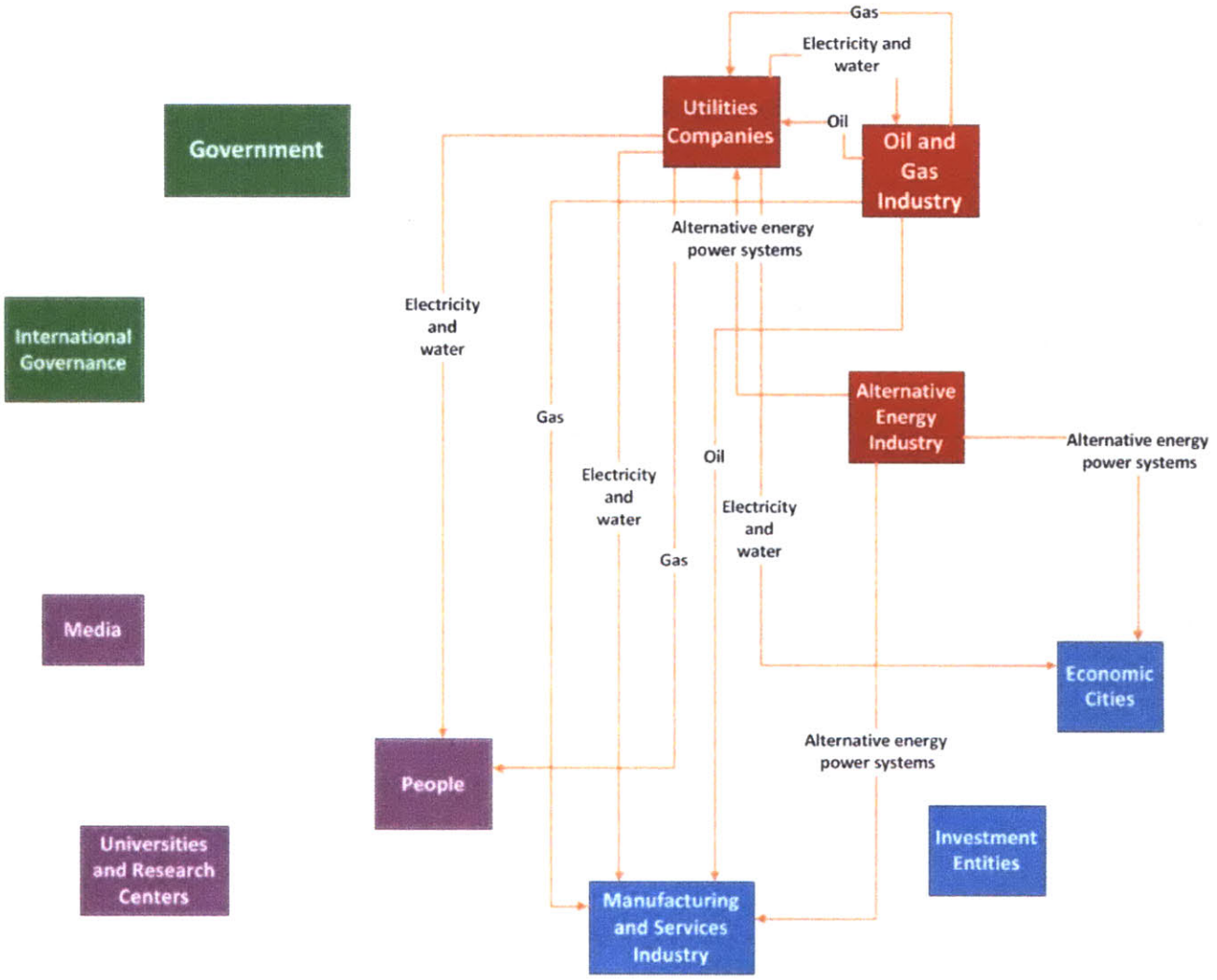

Figure 37 – Stakeholder Network, Energy Value Flow

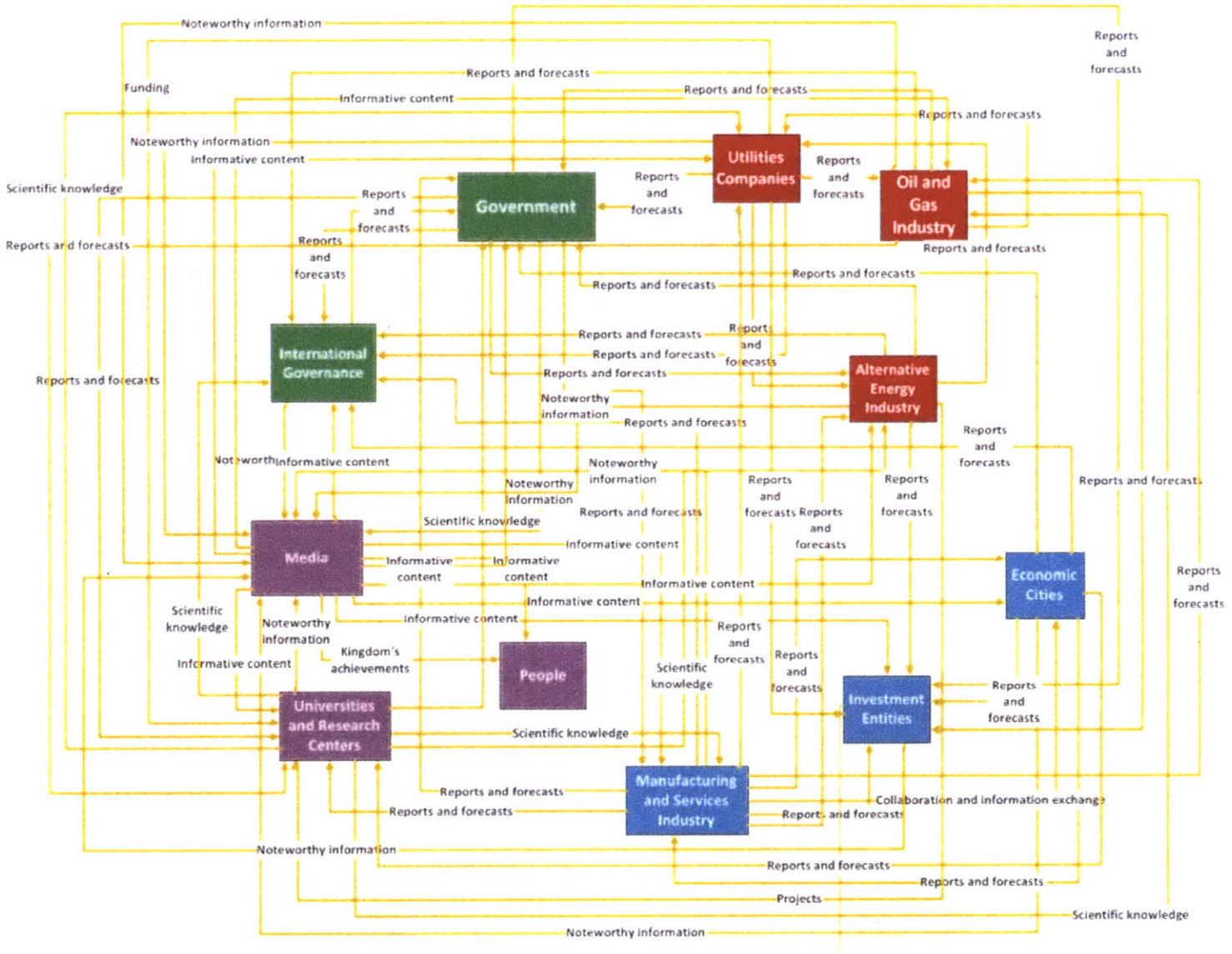

Figure 38 - Knowledge and Information Value Flow

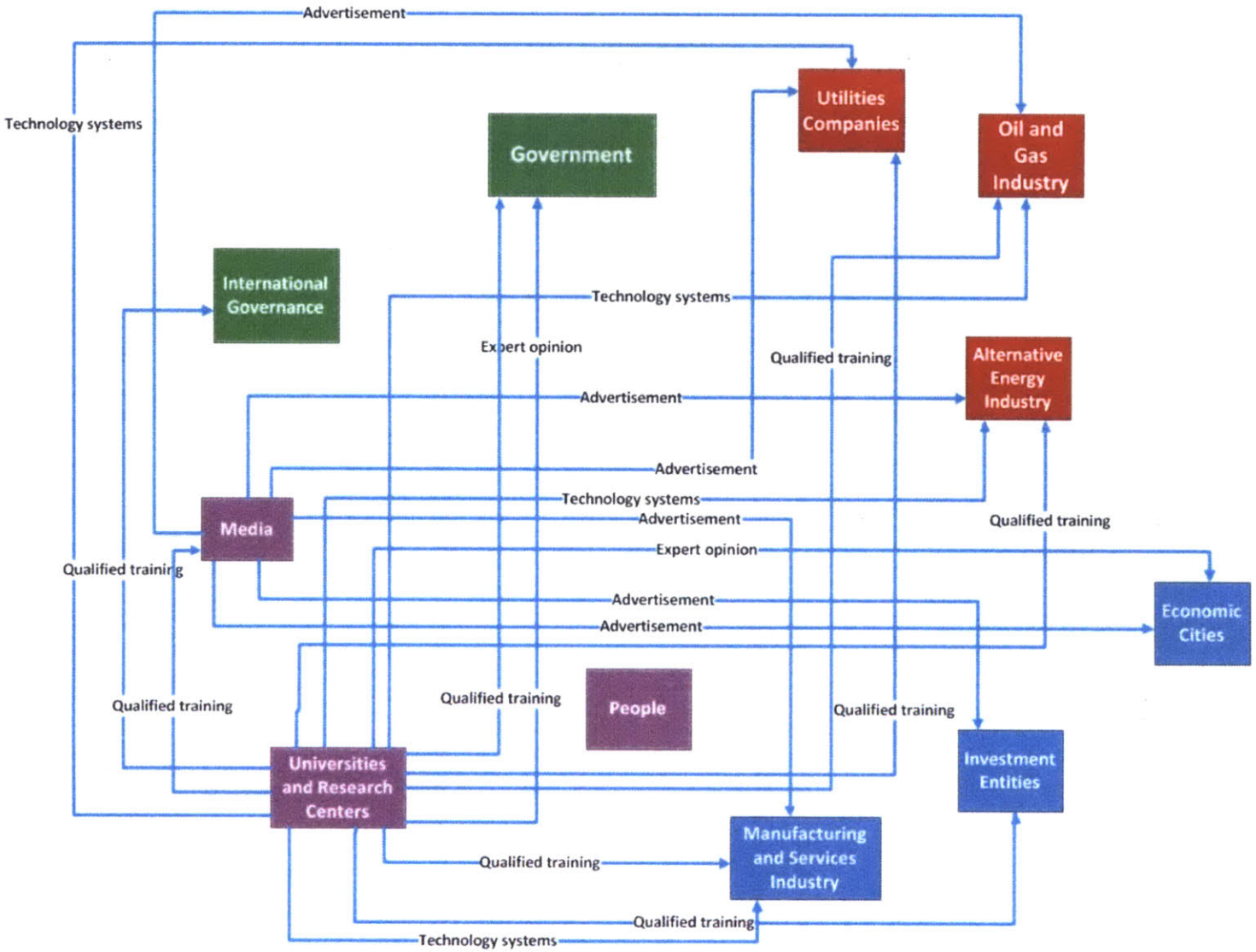

Figure 39 – Stakeholder Network, Goods and services Value Flow

However, such a mechanism is not necessarily direct in the sense that "Government" could provide more information in quantity and quality to exercise a change. Rather, the mechanisms could be to install the institutions and procedures to collect the myriads of data that potentially exist in the Kingdom.

Continuing on, we have Figure 39 – Stakeholder Network, Goods and services Value Flow. Here we see that "Universities and Research Centers" and "Media" are the main sources of value delivery. The "Universities and Research Centers" provides **qualified training** to several of the stakeholders in the network. As seen in Table 3, such a value flow refers to education and training for its recipients to increase the skills of their human capital. Additionally, we again call to the reader's attention the **technology systems** delivered to "Manufacturing and Services Industry" and "Alternative Energy Industry." "Media" provides a different value flow but is instrumental in the economic development of the stakeholders that receive it, in the form of **advertisement**. For example, it would be hard for the "Alternative Energy Industry" to grow in the Kingdom without proper **advertisement**.

We close this section with Figure 40 - Jobs and Public Benefit Value Flow. Across the map, we can see the presence of **skilled workforce** and **quality jobs**. These two value flows serve each other since a stakeholder will provide a quality job to a skilled worker only, in contrast to an unskilled or qualified one. Further, we remind to the reader that enhancing human development is one of the main directions of the Kingdom and a fundamental step in shifting the energy mix for the production of electricity. Thus, in other to motivate its People, "Government" must use mechanisms that deliver directly or indirectly to them—to "People"—a combination of proper compensation and fulfilling work. We will come back to this topic in the final chapter.

2.6. Summary

In this chapter we presented the particular role of the Government of Saudi Arabia and we explained why we treated it as a single stakeholder. We also explained its distinction from industry despite being the main owner of industry's assets. Then we characterized the energy system stakeholder network in terms of value exchange. Finally, we created and presented value flow maps that show how direct and indirect transactions of value happen in the network. Such maps also show the importance of such value flow types in terms of appearance. These maps will be instrumental in the fulfillment of the general objectives of this thesis and its recommendations. All of the above serve mainly the specific objectives of this thesis. But throughout the chapter we introduced the discussion of the general objectives that will be addressed in the final chapter.

In the next chapter we will take necessary step to address such general objectives. We will quantify the importance of each value flow in terms of satisfaction and the source providing the value flow. We will also quantify the importance of each stakeholder and rank the inputs and outputs to and from "Government" in terms of how much value deliver to the whole network. Such inputs and outputs will be translated into the mechanisms we will be addressing in our general objectives.

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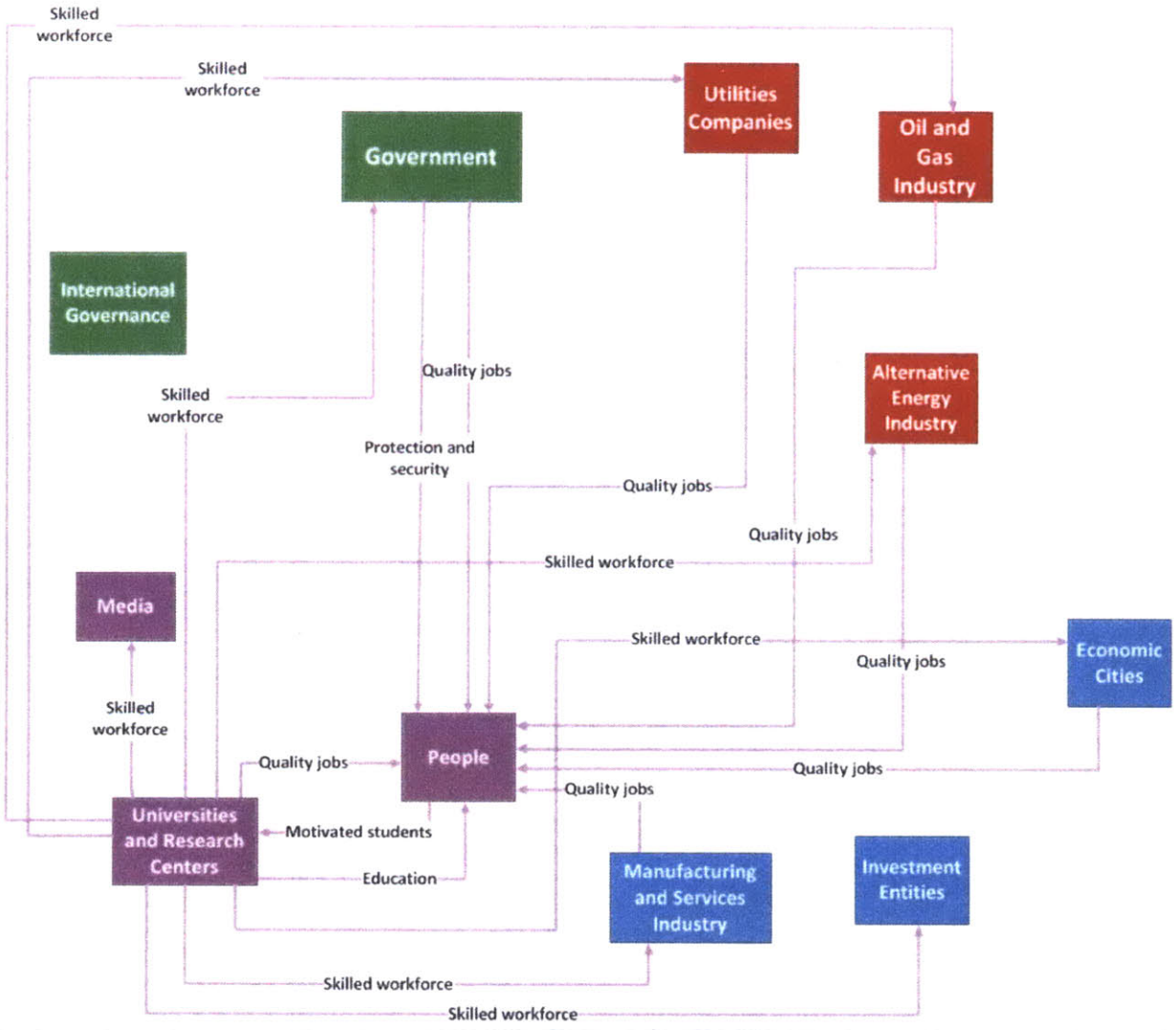

Figure 40 - Jobs and Public Benefit Value Flow

3. Stakeholder Surveys and Quantitative Metrics

In the previous chapter we developed in detail the qualitative part of SVNA. During the course of Chapter 2 we focused on characterizing the stakeholder network, choosing a level or perspective to conduct our analysis (see Figure 18), and building the network from the point of view of value—of different categories—exchange. Further, we presented different visualization diagrams to carry the reader through important value exchanges.

Nevertheless, such use of different visual representations of the network reflects that using the stakeholder network in its current state to inform policy analysis and decision taking is not a straightforward task. A quantitative approach must be followed in order to reduce the complexity of the network and provide a research-grounded roadmap that policy makers and planners can use to inform their work in a straightforward manner. The quantitative part of our specific objectives state:

- To identify the most important stakeholders, the highest value-producing interactions among stakeholders, and most important outputs of the System

In other words, the quantitative part of our specific objectives calls for a ranking—based on the value delivered to the network—of:

1. The most important stakeholders
2. The most important outputs from the "Government"
3. The most important inputs from the "Government"
4. The most important direct (one-to-one) value exchanges
5. The most important value loops (chain of value exchange that begins and ends with the same stakeholder)

All of the above rankings are simply different representations of a common thing: the value contained and flowing in the stakeholder network. As we will show in the following sections, we define metrics that provide such rankings, but all of the metrics compute in one way or another the concentration and flow of value. The rankings mentioned in goals 1 – 3 will be the main matter with which we will address the general objectives of this thesis. Goals 4 and 5 will facilitate the "Government" and the analyst to understand how the direct mechanisms implemented by "Government" truly propagate throughout the network to achieve the intended objectives.

Until now we have characterized the network only in terms of qualitative measures. In this chapter we will describe how we transform such a qualitative description of the Energy System of Saudi Arabia into a quantitative one. The rest of this chapter addresses the specific objectives of this thesis only. It is a necessary step for the completion of our SVNA model. We then continue to analyze the stakeholder network. For a step-by-step process to achieve the specific objectives of this thesis, which can be applied to any complex system, the reader should review Chapter 6 in Sutherland's thesis (Sutherland, 2009).

3.1. SVNA Questionnaires

In order to transform our qualitative analysis into a quantitative analysis, we basically ask stakeholders, experts in the field and literature, how important is each value exchange shown in Figure 23. However, asking open-endedly about the importance of value exchange could lead us to a more complex representation of the network rather than to a more concise one. For this reason SVNA asks two specific questions that are grounded on the work of Professor Noriaki Kano. Kano carried out research to measure customer satisfaction—quality—when acquiring products and services (Walden, 1993). First Cameron and then Sutherland have adapted Kano's method to measure not only "satisfaction" of receiving a product—in the case of this thesis, value exchange—

but also the "importance of the source" that provides such a product (Cameron, 2007; Sutherland, 2009)

We call to the reader's attention that degree of "satisfaction" upon receiving a product and the "importance of the source" are questions that can be answered only by the recipient of value. Accordingly, we remind the reader that we built the network based on how value delivery helps a stakeholder achieve its objectives (see Appendix A: Stakeholder Characterization Templates). Therefore, we built the network based on the satisfaction of the recipient of value, rather than that of the provider of value. For this reason, for every value exchange shown in Figure 23, we ask its recipient two questions:

1. What is your level of satisfaction with receiving such value delivery?
2. How important is for you that such delivery was provided by a specific source?

As shown extensively in Chapter 2, a particular value flow can be provided by more than one stakeholder. Thus, by asking question 2 above, we take into account such an important factor. Additionally, as the survey theory explains, the available answers to a question in a survey can help or undermine a person's ability to answer "correctly" (Fowler, 2008). By "correctly" we do not mean providing the correct answer. Rather, we mean answering what a person has been asked and extracting from such an answer the insight the interviewer requires. We now present Sutherland's adaptation of Cameron's version of the Satisfaction / Regret questionnaire of SVNA, see Figure 41.

We want to note that in the above question we ask about "needs." In other words, we are asking about the "specific needs" (as developed in Section 2.3) of a stakeholder in order to achieve its objectives and thus fulfill its goals. Second, our question asks about the "presence" or "absence" of the specific need. With this approach, we are taking into account that some people build their logical arguments from a "positive" and others from a "negative" point of view. For example, some people see the glass as half-full and others see it as half-empty

Satisfaction / Regret Questionnaire

How would you characterize the presence or absence of fulfillment of this need?

A. I would be satisfied by its presence, but I would not regret its absence
B. I would satisfied by its presence, and would somewhat regret its absence
C. I would be satisfied by tis presence, and I would regret its absence
D. Its presence is necessary, and I would regret its absence
E. Its presence is absolutely essential, and I would regret its absence

Figure 41 - Satisfaction / Regret Questionnaire of SVNA

Third, we provide a five-scale answer (rather than three-scale, originally proposed by Kano) so that the interviewee has more room to "characterize" his level of satisfaction, and a middle point to use in case it is not clear for him the strength of his answer. Finally, Table 4 shows the numeric score for each answer shown in Figure 41.

Table 4 - Numeric Score for the satisfaction / regret question of SVNA

Response	Numeric Score
A	0.11
B	0.19
C	0.33
D	0.57
E	0.98

For the "source importance" question of the questionnaire, we follow a similar approach, as shown in Figure 42. The question asks "if this need were to be fulfilled." In other words, we are asking the interviewee to assume the certainty of receiving the value flow in question. Thus, instead of being concerned with how important it is to receive the value flow, we focus on how important is to receive the value flow from a particular stakeholder. Additionally, as in the "regret / importance" question, there are five available answers for the "source importance" question. As argued before, this range allows wider room for an interviewee to transform his "feelings" into a choice. Also, he can choose a middle point if unsure of his preference.

Source Importance Questionnaire

If this need were to be fulfilled, how important would this source be in fulfilling the need?

A. Not important – I do not need this source to fulfill this need
B. Somewhat important – It is acceptable that this source fulfills this need
C. Important – It is desirable that this source fulfills this needs
D. Very important – It is strongly desirable that this source fulfills this need
E. Extremely important – It is indispensable that this source fulfills this need

Figure 42 – Source Importance Question of SVNA Questionnaire

Finally, in Table 5 we present the numeric score for the five available answers shown in Figure 42. The reader will observe that the numeric scores in Table 4 are different from those shown in Table 5. The latter follows a linear scale, whereas the former follows a logarithmic scale. Sutherland explains the selection of a logarithmic scale for the "satisfaction / regret" question: "This provides greater differentiation between the "absolutely essential" needs (response E) and the less- essential "necessary" needs (answer D) than a linear scale would provide" (Sutherland, 2009).

Table 5 - Numeric Score for the source importance question of SVNA

Response	Numeric Score
A	0.11
B	0.33
C	0.55
D	0.78
E	0.98

We present an example in Figure 43 to help the reader understand how we asked the "satisfaction / regret" question and the "source importance" question for each of the 170 value flows shown in Figure 23.

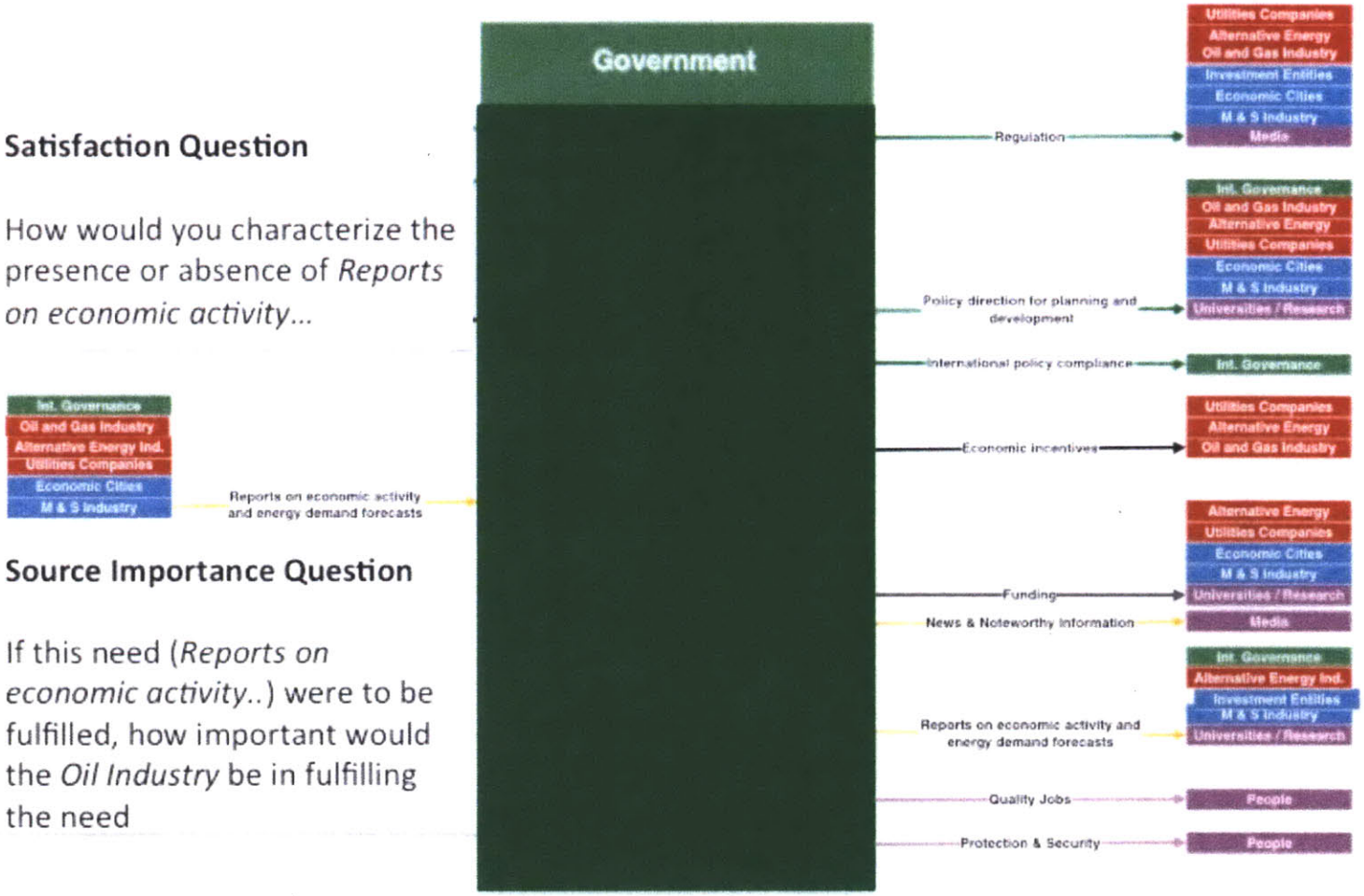

Figure 43 - Specific Example of the usage of SVNA Questionnaire

The example concerns the input **reports on economic activity and energy demand forecasts**. Thus, the "satisfaction / regret question" reads "How would you characterize the presence or absence of reports on economic activity and energy demand forecasts?" (see Figure 41). Accordingly, **reports on economic activity and energy demand forecasts** come from six different sources for the "Government." Thus, the "source importance question is asked six times. The questions read: First, "If reports on economic activity and energy demand forecasts were to be fulfilled, how important would 'International Governance' be in fulfilling this need." Second, "If reports on economic activity and energy demand forecasts were to be fulfilled, how important would the 'Oil and Gas Industry' be in fulfilling this need," and so on.

Finally, the combined score for each value flow is obtained by multiplying the score for the "satisfaction / regret" question by the score for the "source importance" question. This calculation is done for all of the value flows shown in Figure 23. The range of possible results of such multiplication is shown in Table 6. In the next section we will introduce the people we interviewed.

Table 6 - Range of values for the combined score of each value flow

		Satisfaction / Regret Score				
		A = 0.11	**B = 0.19**	**C = 0.33**	**D = 0.57**	**E = 0.98**
Source Importance Score	**1 = 0.11**	0.01	0.02	0.04	0.06	0.11
	2 = 0.33	0.04	0.06	0.11	0.19	0.32
	3 = 0.55	0.06	0.1	0.18	0.31	0.54
	4 = 0.78	0.09	0.15	0.26	0.44	0.76
	5 = 0.98	0.11	0.19	0.32	0.56	0.96

3.2. SVNA interviews

In this section we will present the people that we—the author, research specialist Jumana Almahmoud—were able to interview for this study. Although we will keep their identities concealed, we will talk a little about their affiliation and their relevance to the Energy Stakeholder Network.

Before proceeding, we want to make a key distinction between this study and the work done by Sutherland. He performed the full SVNA survey on members of his research group and experts in the NASA Earth Observations Program (Sutherland, 2009). Afterwards, he averaged their responses and considered the output of the resulting analysis as the "given" result of SVNA. Then he conducted interviews with stakeholder representatives to validate the "relative ranking" of his results. That is, rather than asking stakeholder representatives to answer the SVNA survey, Sutherland asked them to validate the ranking of stakeholders and value flows that SVNA produced.

In this thesis, we interviewed three different groups (in the rest of this thesis we will format these three groups of interviewees with italics for easier distinction):

1. *Researchers*: We interviewed two researchers at the Center for Complex and Engineering Systems on the Saudi Arabia side
2. *Experts*: We interviewed two experts in the Energy System of Saudi Arabia. These two people have worked in different specific entities of the network (see Figure 19) for an accumulated total of more than 20 years
3. Stakeholder representatives (*Stakeholders*): We interviewed a total of 10 stakeholder representatives from these specific entities (see Figure 19)
    - Alternative Energy Industry. 1 representative from KACARE: Member of the Strategy Team
    - Oil and Gas Industry. 1 representative from Aramco: Employee

- Government. 1 representative from ECRA: Director General; 1 representative from MOWE: Senior Advisor; one representative from SEEC: Senior Executive
- Investment Entities. 1 representative from SAGIA: Senior Executive
- Media. 1 representative from the media: Editor in Chief of a news network
- Universities and Research Centers. 1 representative from KAPSARC: Director of a research program; 1 representative from KSU: Professor - Electrical Engineering Department
- Utilities Companies. 1 representative from SEC: Employee
- People. 1 representative

As shown above, we were able to obtain direct input for 8 of the 11 stakeholders in the network. For the other stakeholders:

- Economic Cities
- International Governance
- Manufacturing and Services Industry

we took an average from the "Experts" and "Researchers" answers. When interviewing *Researchers* and *Experts,* we asked them to take an objective point of view and answer based on the broader point of view of the Energy Stakeholder Network. In contrast, when we interviewed stakeholder representatives, we did not ask them to take an objective point of view because the "subjective" point of view of their organizations is what we are looking for.

Finally, it is worth noting that the sample size of 11 interviewees is relatively small. Although the methodological logic of the Stakeholder Value Network Analysis (described in Chapter 1) is not reliant on an average of respondent answers (as in a survey), it does rely on using interviewees and expert opinions to achieve completeness of the model as well as to present representative viewpoints. More interviews would have helped boost the level of

confidence achievable from this model. If this analysis is extended in future with more interviewees, attention must be paid to saturation and the level of heterogeneity in responses where large organizations are represented as single stakeholders in this model.

That said, even when we will keep the identities of the interviewees concealed, we can see that they are a mix of high-level positions and advisory positions in their organizations. True, people with high-level positions often miss details that are important for an organization. Nevertheless, we want to remind the reader of our discussion on Section 2.2 about the level of analysis of this thesis. We are conducting this analysis from a high level point of view: by using policy documents and other sources that provide a macro point of view—which is the decision makers' point of view.

3.3. Computation of scores for value loops

In the previous two chapters, we introduced the concept of a value loop as a "chain of value exchange that begins and starts with the same stakeholder." Now we will provide a specific example for a better illustration, see Figure 44. Starting with "Government" we show the following value loop: The "Government" provides **economic incentives** to the "Oil and Gas Industry," which provides **gas** to the "Utilities Companies," which provide **electricity and water** to the "Manufacturing and Services Industry," which provides **revenues** to the "Government." Therefore, this is a value loop with a length of four value exchanges beginning and ending with "Government." Additionally, we show numbers for each value flow. Such numbers are hypothetical; the actual values would be the result of multiplying the answer for the "satisfaction / regret" question by the answer for the "source importance" question, as described in the previous section. Finally, the score of the value loop is obtained by multiplying the combined score of each value flow included in the value loop. This computation is shown in the red box in Figure 43.

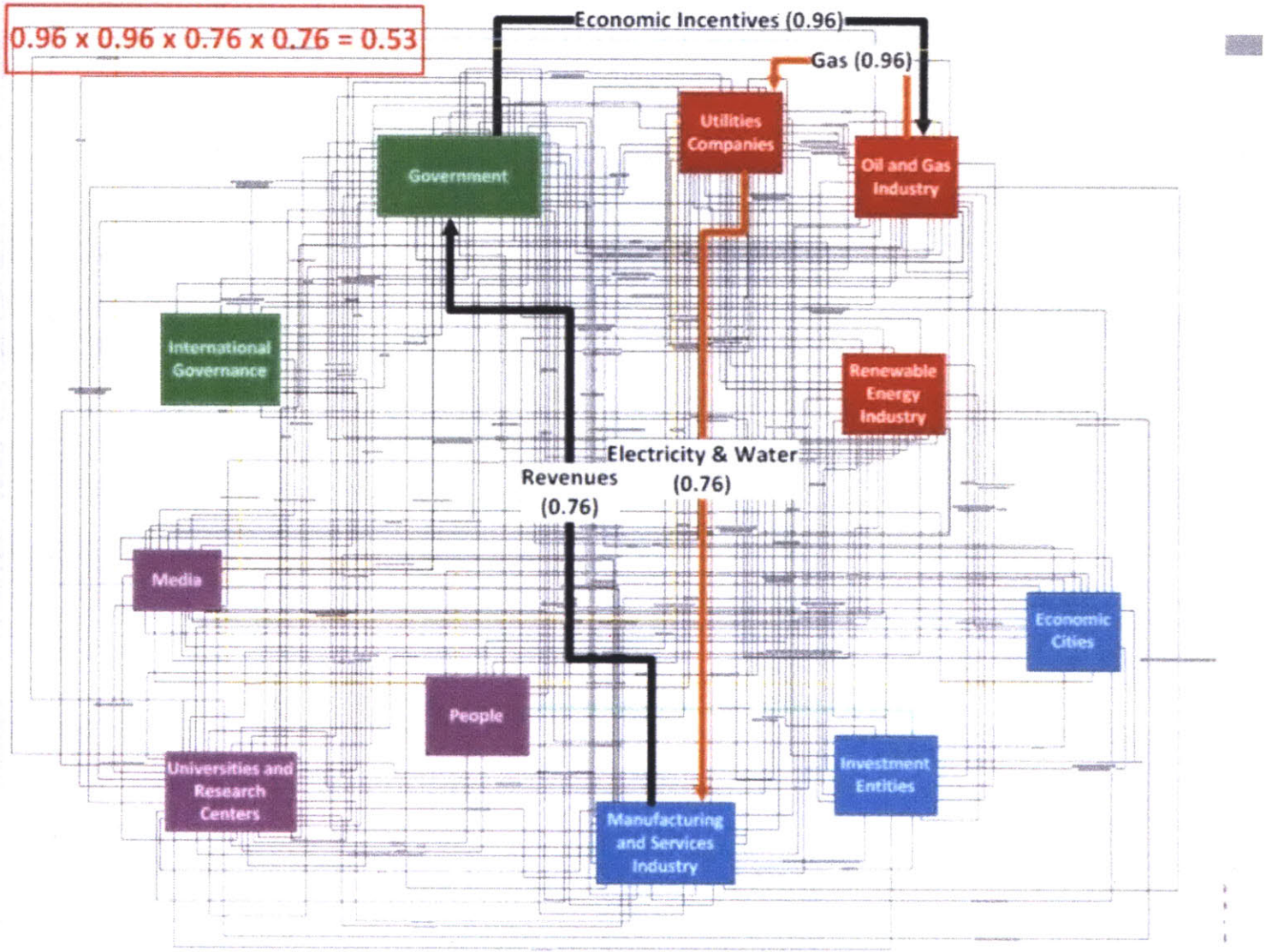

Figure 44 - Example of a value loop and its quantification for SVNA: in the red box (the specific numbers are just for illustration)

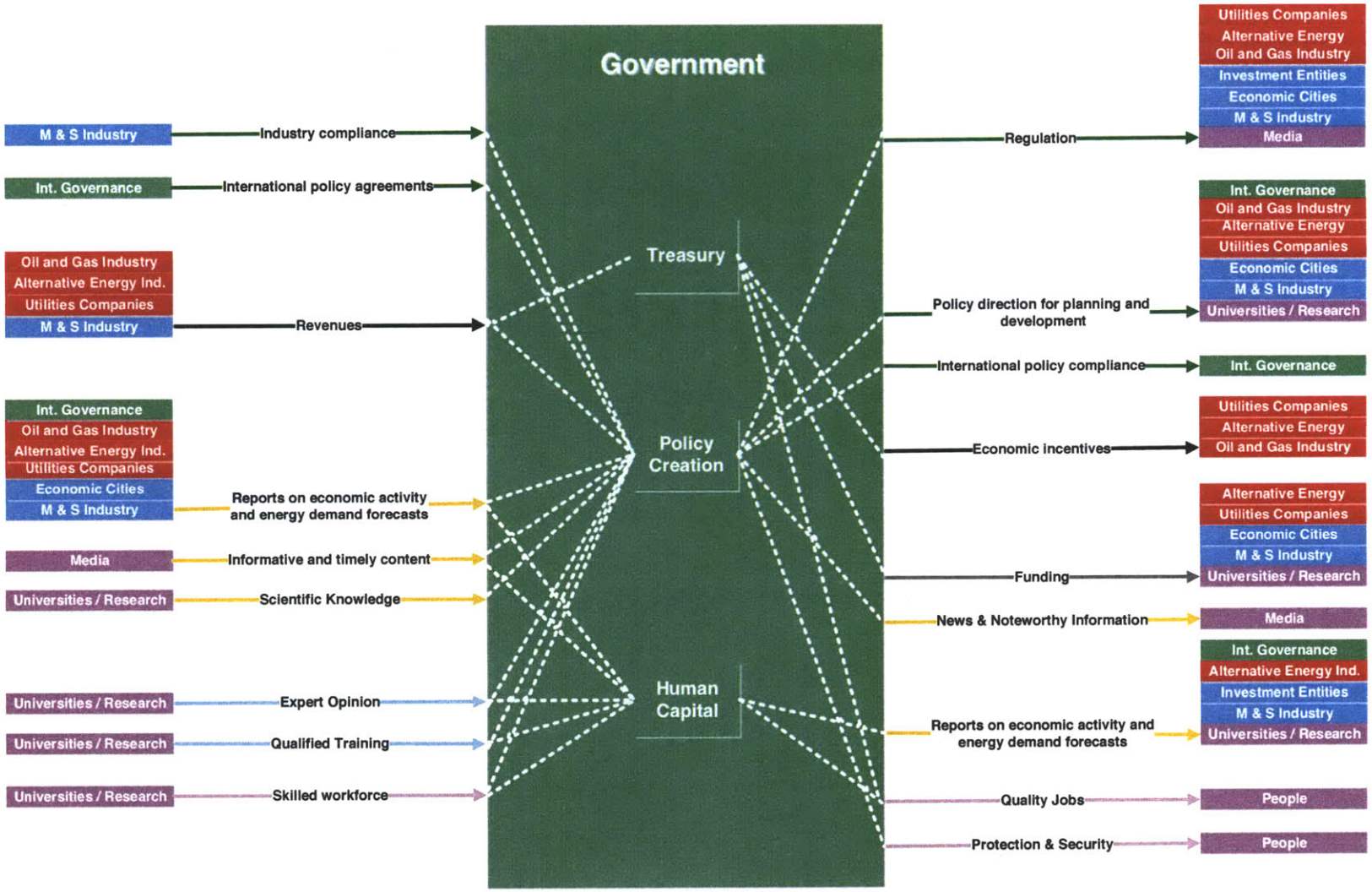

Figure 45 - Input / Output diagram for Government

Accordingly, we must compute the value loop score for every loop in the stakeholder network (see Figure 23). Nevertheless, the reader will easily observe the combinatorial problem that arises. To illustrate, we invite the reader to consider the 17 inputs for "Government" as shown in Figure 45 (for the diagrams for all of the stakeholders the reader should review Chapter 2). For each of these 17 inputs, there are 31 outputs. That makes 527 possible paths. Then we must consider all the possible paths that the outputs could follow. Without going through the specific numbers for the Saudi Arabia Energy network, we invite the reader to remember that there are 11 stakeholders in our network, and there are 9 left to consider in our example. Consider the simple case where there are 10 paths to consider for each stakeholder. Then we have (10) to the power of 9 (1 billion) value loops. Granted, not all of the value loops are going to have length 11 and thus the number of loops will be smaller.

However, suppose that the actual number is 1% of our calculation. That is 100 million loops, which requires considerable computational power to perform the calculations. For this reason we use "internal assets" as developed in Section 2.4. As a reminder of this concept, consider the input to "Government," **scientific knowledge** as shown in Figure 45. Such value will be transformed in several outputs but it is unrealistic to expect that it will be transformed into **economic incentives**. Thus, we disregard such transformation of value by including the internal asset "policy creation" and not connecting **scientific knowledge** to it.

3.4. Quantitative Metrics of SVNA

In the previous section we explained how SVNA computes the value flow score for value loops. However, this metric is not the only one that SVNA uses because (as explained at the beginning of this chapter) it delivers five types of ranking. In this section we will introduce the five metrics that SVNA uses. However, to illustrate these metrics, we will present examples and not the actual results of the Saudi Arabia Energy System. The reason for this is that in the next section we

will explain our framework for analysis and thus do not want to introduce our results before that. The SVNA five metrics are:

1. Weighted Stakeholder Occurrence (WSO) ("raw" version and normalized)
2. Weighted Value Flow Occurrence (WVFO)
3. Most Significant Value Loops
4. Weighted Government Output Occurrence
5. Weighted Government Output Occurrence

In the following sections we describe each of these metrics.

3.4.1. Normalized Weighted Stakeholder Occurrence (NWSO)

As we have developed throughout this thesis, we built the stakeholder network in terms of value delivered. Thus, we will determine the importance of a stakeholder based on how much value it delivers to the network. Equation 1 presents the definition of the Weighted Stakeholder Occurrence. WSO adds all of the value-score for all the loops containing a stakeholder—all of the loops that pass through such a stakeholder—and then divides by the total value-score of all of the loops included in the network.

Equation 1 - Weighted Stakeholder Occurrence

$$WSO = \frac{Sum\ of\ the\ value-score\ of\ all\ of\ the\ loops\ containing\ the\ stakeholder}{Sum\ of\ the\ value-score\ of\ all\ of\ the\ value\ loops\ in\ the\ network}$$

Sutherland explains that such a definition decreases the importance of stakeholders included in a small number of value loops—even if these are high score value loops—as compared to stakeholders that are included in many more value loops with smaller value-score (Sutherland, 2009). Thus, Sutherland

introduces a "normalized" version of WSO so that the importance of a stakeholder relative to the importance of the former type of stakeholder increases. This Sutherland defines as the "Normalized Weighted Value Flow Occurrence," as shown in Equation 2.

Equation 2 – Normalized Weighted Stakeholder Occurrence

$$NWSO = \frac{WSO}{Number\ of\ value\ loops\ containing\ the\ stakeholder}$$

We see that NWSO will be higher for those stakeholders included in a reduced number of high-scored value loops than stakeholders included in many low-scored value loops.

3.4.2. Weighted "Government" Input and Output Occurrence (WIO and WOO)

As we explained at the beginning of this chapter, the decision to look at the inputs and outputs of the "Government" in particular, arises from the central role of the government of the Kingdom of Saudi Arabia in the challenge of changing the sources of energy for electricity production from oil to renewable resources.

We define the Weighted "Government"; Input Occurrence (WIO) in Equation 3. Similarly, we define the Weighted "Government"; Output Occurrence (WOO) in Equation 4.

Equation 3 - Weighted Government Input Occurrence

$$WIO = \frac{Sum\ of\ the\ value-score\ of\ all\ of\ the\ loops\ containing\ a\ value-input}{Sum\ of\ the\ score\ of\ all\ of\ the\ value\ loops\ that\ contain\ the\ Government}$$

Equation 4 - Weighted Government Output Occurrence

$$WIO = \frac{Sum\ of\ the\ score\ of\ all\ of\ the\ loops\ containing\ a\ value - output}{Sum\ of\ the\ score\ of\ all\ of\ the\ value\ loops\ that\ contain\ the\ Government}$$

In other words, each input / output is ranked in terms of how much of the total value provided by the "Government" to the stakeholder network is carried out by such input-output.

3.4.3. Weighted Value Flow Occurrence (WFVO)

This metric is computed in a fashion similar to NWSO above. It determines the most important value flows in terms of how much value they are carrying in the stakeholder network (see Equation 5).

Equation 5 - Weighted Value Flow Occurrence

$$WFVO = \frac{Sum\ of\ the\ value - score\ of\ all\ of\ the\ loops\ containing\ the\ value\ flow}{Sum\ of\ the\ value - score\ of\ all\ of\ the\ value\ loops\ in\ the\ network}$$

We see that WFVO provides a percentage of the value flow each individual value exchange carries.

3.4.4. Most Significant Value Loops

This metric is even more straightforward than the two above. We determine the most significant value loops in terms based on how much value each value loop carries compared to the rest of value loops in the network. In other words, we rank all of the value loops by comparing the value-score—obtained by multiplying the combined score of each value flow as developed in Section 3.3—of each individual value loop against the whole set of value loops.

3.5. Summary

In this chapter we described how we transformed the comprehensive but overwhelming qualitative description of the stakeholder network into a quantitative description that allows us to analyze the network in a more straightforward manner. We introduced the SVNA surveys through which we can perform such transformation and we presented the five metrics we used to analyze the stakeholder network. These five metrics will allow us to construct a simplified version of the energy stakeholder network that facilitates planning and policy making. In the next chapter we will present the results of such five metrics. This five metrics will allow us to build simplified versions of the stakeholder network that includes the most important stakeholders from the point of view of the focal organization, the most important value exchanges and the most important value loops—by building these simplified versions we will be completing our specific objectives. Later, such simplified versions will be stepping stones from which we will achieve the general objectives of this thesis.

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4. Quantitative Analysis of the Stakeholder Network

In the last chapter we described how we transformed the comprehensive but complex representation of the stakeholder network, result from the SVNA quantitative analysis. We also introduced the five metrics that will help us build a simplified version of the stakeholder network. In the next and final chapter we will use this simplified version to achieve our general objectives.

First, we will introduce the results for the five metrics described in the previous chapter. Then we will build a simplified version of the stakeholder network.

4.1. NWSO Results

Here we present the results for the Normalized Weighted Stakeholder Occurrence (NWSO) as defined in Equation 1. Figure 46 shows the NWSO for the stakeholder network. The reader will observe that "Government" does not appear in the results. The reason for this is that, as explained in Chapter 2, "Government" is the focal organization of our analysis. Therefore, we consider value flow across the network as it begins and ends in "Government." See Sutherland for further explanation of how SVNA software computes SVNA metrics for a focal organization (Sutherland, 2009). Thus, we will not find "Government" listed in the NWSO results since by definition—because every direct and indirect value exchange passes through "Government"—"Government" will have a NWSO score of 1.

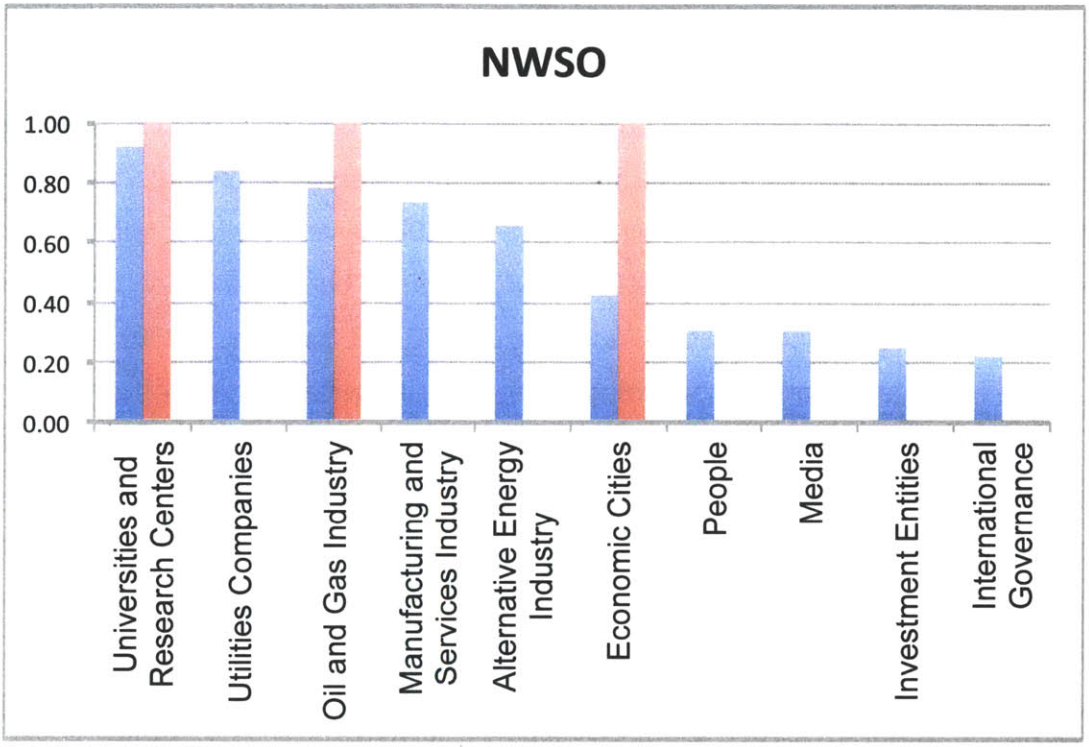

Figure 46 - NWSO for the Stakeholder Network (the red bars show .25 percentiles of value, remind that "Government" has a NWSO of 1)

However, it is surprising to find "Universities and Research Centers" as the second most important stakeholder—even though enhancing human development is currently a main direction of the Kingdom (MEP, 2010). The surprise comes form the fact that when trying to improve about a complex system that has social, economic and technological implications, decision makers usually emphasize investment in infrastructure and technology but not human development (de Weck et al., 2011). Potentially, such a result could be biased based on our sample of interviewees (see the previous chapter). Saudi Arabia, though, has a different perspective on the importance of human development. Actually, this finding could point to a possible mechanism—necessary to achieve the shift in energy mix for the production of electricity yet not sufficient—for the government of Saudi Arabia to implement the change in energy mix: a considerable investment in their education system.

We invite the reader to recall Section 1.2 and to realize that it is a priority of Saudi Arabia to enhance human development and to increase the rate of Saudi employment in the Kingdom. According to the International Labor Office (which obtained the data from the Central Department of Statistics in Saudi Arabia), in 2009 50% of the labor force in the Kingdom was foreign: 7% foreign females and 43% foreign males (ILO, 2010). Aramco itself (the entity representative of the "Oil and Gas Industry") seems to be an exception with more than 80% of employees being Saudi as if 2000 (Al Bawaba, 2000). Further, Aramco restricts its contract awarding companies "to certain quotas of Saudis: 35 per cent for construction companies, 50 per cent for services companies and 60 per cent for importers, industrialists and engineering offices" (Al - Dosary & Rahman, 2005). Further, they are very much aware that in order to shift the supplies for the production of electricity from oil and gas to atomic and renewables—and make it a sustained change—they must develop and keep the necessary knowledge at home. In contrast, with the aforementioned figures for Saudi Arabia, the United States, a country that is a leader in the development of technology, had a 15.9% foreign employment rate in 2011 (BLS, 2012).

Throughout the course of this chapter we will be moving back and forth between the metrics' results because the score of one metric may inform the scores of another one and vice versa. For example, we will find strong direct value exchanges and strong value loops that contribute to high ranking of "Universities and Research Centers."

Next in Figure 46 we find "Utilities Companies" as the second most important stakeholder from the point of view of the focal organization: "Government." In the stakeholder characterization template (Figure 64) for "Utilities Companies" we see that two of their main objectives are to meet the energy demand and to do it in an efficient fashion. Thus, by ranking "Utilities Companies" second, the stakeholder network is acknowledging that, as the main producers of electricity in the Kingdom, they carry considerable value for the energy system.

Ranked third in importance, we find "Oil and Gas Industry," the current main suppliers for the production of electricity. They are the direct beneficiaries of producing electricity with alternative sources since the cost opportunity of keep running business as usual is high as shown in Figure 2 to Figure 5. Next, we find "Manufacturing and Services Industry," which consumes 35% of the electricity produced in the Kingdom, see Figure 4. Further, we should consider that if Saudi Arabia succeeds in their economy-growth plan (as seen in Section 1.2), it is possible that consumption will increase. In the next sections, we will see the importance that the stakeholder network puts on the value flow **alternative energy power systems** provided by the "Alternative Energy Industry," ranked fifth in Figure 46.

We see that "Alternative Energy Industry," is ranked relatively low. However, recall that until 2011 Saudi Arabia produce 0% of electricity by alternative sources (either atomic or renewable), as reported by the Electricity & Cogeneration Regulatory Authority (ECRA) in the Kingdom, see Figure 5 (ECRA, 2011). Thus, the stakeholder network acknowledges that the "Alternative Energy Industry," is a nascent industry that will 'need' the push of other stakeholders to establish itself in the energy system of the Kingdom. In fact, since 1981 in a village 20 miles outside Riyadh (Saudi Arabia's capital) the Saudi Solar Village Project has been serving 3,000 people with electricity generated by solar energy (Huraib, Hasnain, & Alawaji, n.d.; NY Times, 1983). Nevertheless such type of efforts are small compared to the Kingdom's objectives.

The last stakeholder included in the top 75% of accumulated value is "Economic Cities." We do not have specific numbers for the consumption of electricity by "Economic Cities." However, as shown in Table 7, in 2010 SAGIA forecasted that by 2020 the "Economic Cities" were expected to add 23% of the 2010 GDP produced by "Manufacturing and Services Industry" (SAGIA, 2009). Further, we see a correlation between the ranking in Figure 46 and the ranking in Table 7 for those stakeholders that directly contribute to the creation of Gross Domestic Product even when we did not take an economic development focus during the interviews with stakeholders.

In the below sections we will use the aforementioned 6 top stakeholders—and the focal organization "Government"—that together comprise 75% of value for the energy system of Saudi Arabia, to build a simplified model of the stakeholder network that facilitates the achievement of our general objectives.

Table 7 – Estimated contribution of each stakeholder to Saudi Arabia's 201 GDP (billion). Data added to each stakeholder based on stakeholder definitions in Chapter 2 of this thesis. For stakeholders with "n/a" there is no clear disaggregation of GDP. For Economic Cities, the figures are a forecast for 2020, Source of data: (MEP, 2011; SAGIA, 2009, n.d.-a)

Stakeholder	GDP 2010 (SAR)	GDP 2010 (USD)
Total GDP	**1679.10**	**447.76**
Manufacturing and Services Industry	643.84	171.69
Oil and Gas Industry	201.43	53.71
Economic Cities	150.00	40.00
Utilities Companies	16.16	4.31
Government	N/A	N/A
Univesities and Research Centers	N/A	N/A
Alternative Energy Industry	N/A	N/A
Media	N/A	N/A
People	N/A	N/A
International Governance	N/A	N/A

4.2. Weighted Government Inputs and Outputs

In the previous section we presented the most important stakeholders for the energy system of Saudi Arabia. In this section, we present the most important inputs and outputs for "Government," the focal organization. As shown in the last chapter, these metrics quantify the how much value each input and output in and out from "Government" carries throughout the stakeholder network. As we discussed in the last chapter, the metrics included in this section are most relevant to the fulfillment of our general objectives. Figure 47 again shows an unexpected outcome. The stakeholder network considers that the input that

delivers more value to the network and to "Government" is **reports on economic activity and energy demand forecasts** coming from "International Governance." Indeed, the member countries of the Gulf Cooperation Council consider energy and water scarcity to be security issues (Bachellerie, 2012). Further, in the US, we find that, regardless of the topic at hand, politicians and institutions will always defer to security issues, as it is politically expected.

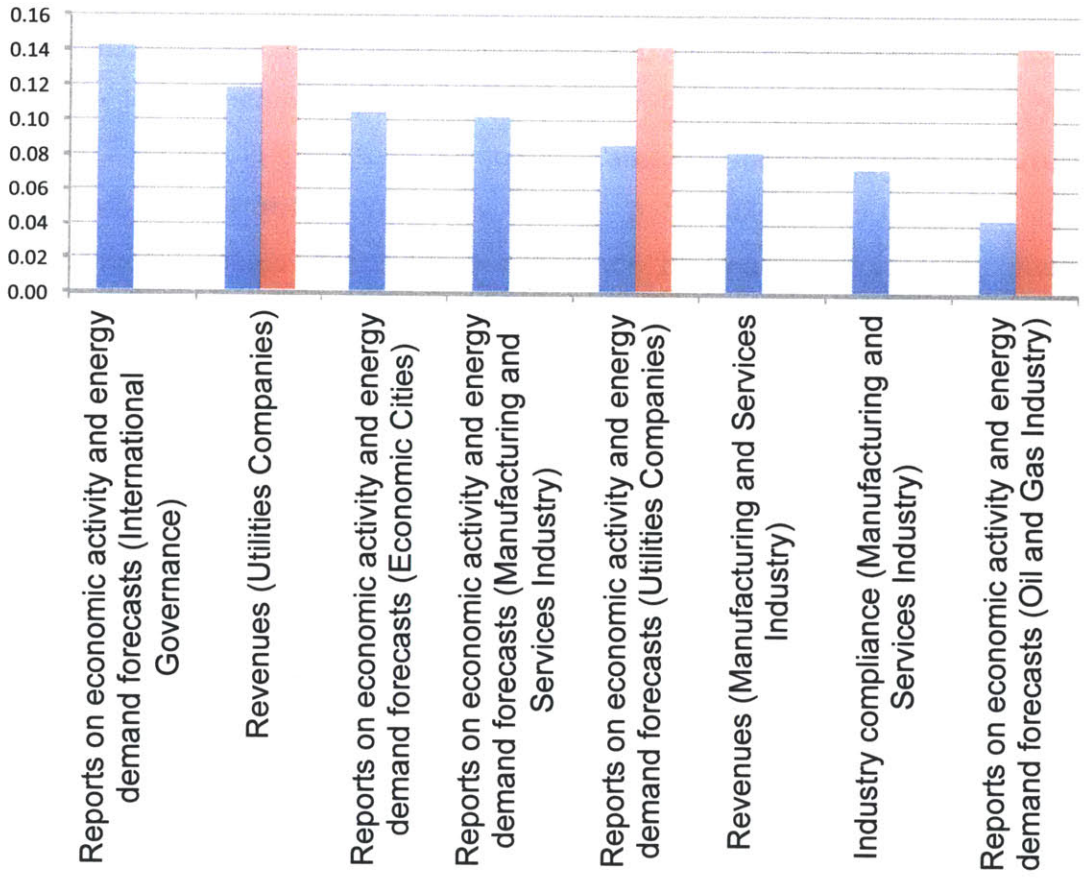

Figure 47 - Weighted Input Occurrence (to Government) (the red bars show .25 percentiles of value)

Therefore, rather than considering this input to "Government" as a potential mechanism for our analysis, it is just a reminder to consider the energy challenge of Saudi Arabia not only as an economic and well-being issue for the Kingdom but also as a matter of national security.

Ranked second, we find **revenues** from "Utilities Companies." However, the reader must recall that "Utilities Companies" receive considerable **economic incentives** from "Government" and thus represent negative **revenues** rather than positive. Thus, the stakeholder network is signaling two things here: first, the cost of opportunity of keeping producing electricity using mostly **oil** and **gas**; second, the relevance that **economic incentives** have for the Kingdom to keep increasing the electricity demand (Bachellerie, 2012). As we mentioned in Chapter 2, the Kingdom faces two options regarding the "Renewable Energy Industry": to incentivize them as they incentivized the "Oil and Gas Industry" or to remove the incentives to the latter. Otherwise, "Utilities Companies" will not seek **alternative energy power systems** as an option to produce electricity.

Next we find ranked third, fourth, and eighth, **reports on economic activity and energy demand forecasts** coming from different sources. All included in Table 7; thus they are the stakeholders that mostly contribute to the economic output of the Kingdom. Further, this finding suggests an indirect mechanism for the government of Saudi Arabia to address the energy challenge: to establish procedures and institutions that properly collect and distribute data throughout the Kingdom. Furthermore, the high importance of data for "Government" reinforces a topic we have been engaging throughout this thesis: the central role that the "Government" has in the Kingdom as a policy maker and funding provider. In order to do this, "Government" needs the right data.

Finally, ranked sixth and seventh in Figure 47, we find **revenues** and **industry compliance** from "Manufacturing and Services Industry." Recall that enhancing economic development is the main Saudi Arabian direction. The "Government" wants to increase the size of the private industry and growth at a rapid pace. As mentioned in Chapters 1 and 2, this direction poses a challenge for the "Government" energy goals. A change in the energy mix for the production of electricity will potentially slow down the economic development of the "Manufacturing and Services Industry." Further, we cannot assume that the Kingdom can use all the **oil** and **gas** that no longer would be used to produce electricity for international trade, and thus counteract the slow down of the

economy. This is because, as we saw in the previous section, energy is a commodity that has considerable political and security ramifications. Rather, the "Government" has the option of thinking medium and longer term, in that they will have bigger reserves of **oil** and **gas** to backup the development of the Kingdom.

Now we move on to the results of the Weighted Output Occurrence. Figure 48 shows the outputs from "Government" that comprise 75% of the total value flowing through the stakeholder network. We find policy, in the form of **regulation** and **policy direction for planning and development**, as the mechanism that delivers most of the value to the network. Ranked second, we find **reports on economic activity and energy demand forecasts** delivered to "Universities and Research Centers." This highlights the importance that "Government" has in terms of delivering proper data for "Universities and Research Centers" both to provide a quality education to Saudi citizens—and thus enhance human development in the Kingdom—and to use in research, which in turn could be commercialized. Ranked third we find **news and noteworthy information** delivered to "Media." The high ranking of this value flow is interesting and reinforces the consideration we gave to **acceptance and recognition (**in Chapter 2) delivered to "People." In other words, even though advertisement and opinions about "Renewable Energy Industry" cannot directly propel the Kingdom to a new energy mix, the stakeholder network recognizes both as necessary components of the effort.

Now we point out the outputs in Figure 48 of type capital: **funding** and **economic incentives**. We find funding delivered to "Utilities Companies" ranked fourth in the results. As we saw in Table 2, "Utilities Companies" are mostly owned by "Government" and thus rely on their **funding** for their operations and development. Additionally, the "Alternative Energy Industry" currently is being structured under the same model of financing from the state. KACARE, a specific entity included in the "Alternative Energy Industry" has the mandate of implementing the policy and delivering funding for the growth of atomic and renewable energy industries (KACARE, 2010).

To conclude this section, we summarize our findings. On the input side we learned that "Government" must establish procedures and institutions to collect and deliver data to "Government" itself and to the stakeholder network. We also learned that the goal of changing the energy mix for the production of electricity will face the drawback of economic slowdown. On the output side, we found evidence in our model that the main mechanisms "Government" has to propel the Kingdom in the new direction are policy and funding to the stakeholder network.

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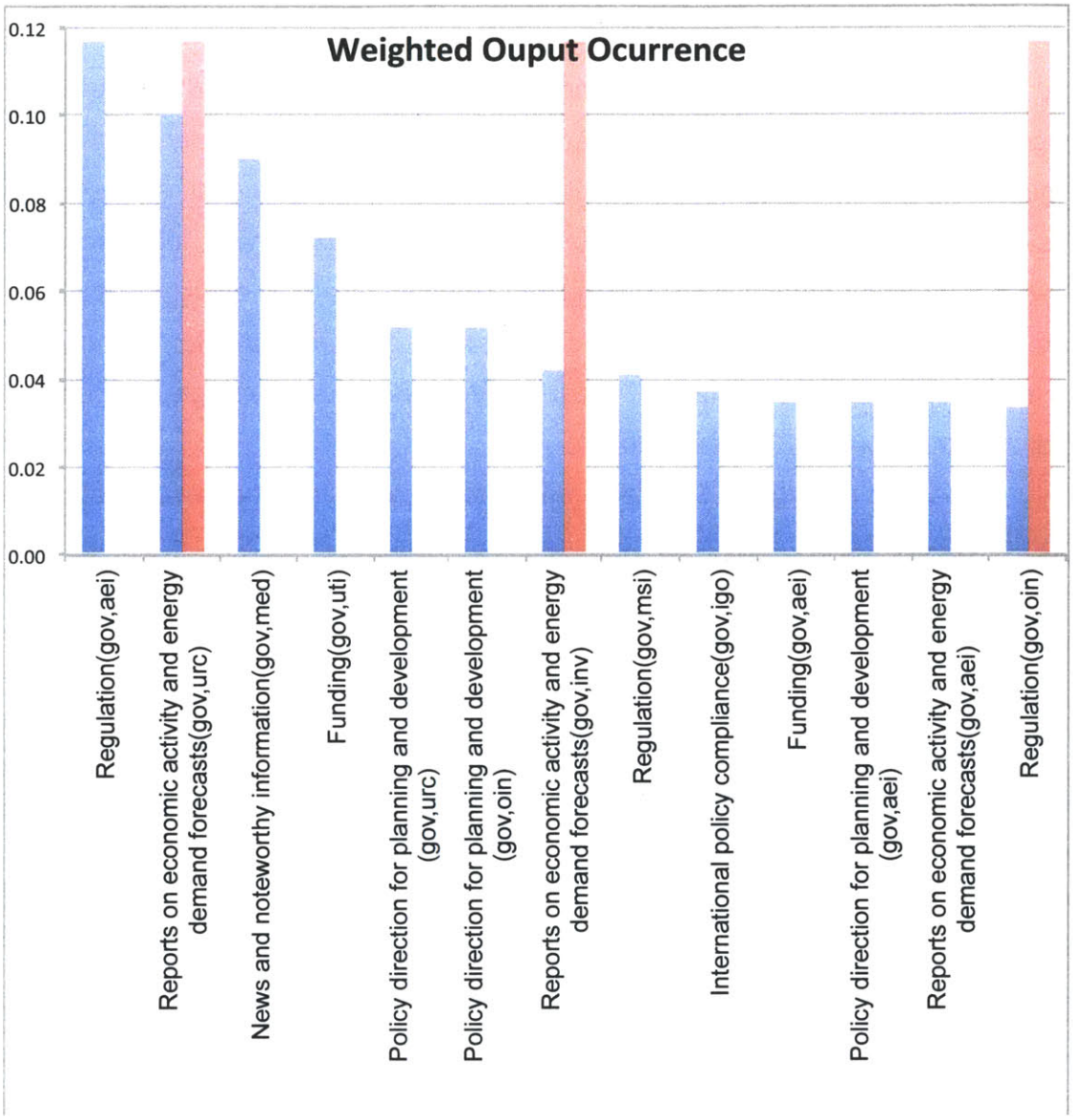

Figure 48 - Weighted Output Occurrence (from Government). (The red bars indicate .25 percentiles of value)

In order to continue on our general objectives we must identify how "Government" should direct policy and funding in order to propel and efficient and sustainable change for the production of electricity with alternative sources. In the following sections we look at the value delivered to the stakeholder network from the point of view of direct transaction of value and from the point of view of value cycles starting and ending with "Government."

4.3. WVFO Results

In this section we will present the results for the Weighted Value Flow Occurrence (WVFO) as defined in Equation 5 (see Figure 49, the red bars in the figures represent .25 percentiles of value). These results will allow us to determine which mechanisms—from the mechanisms we identify from "Government" as potentially propelling the Kingdom in a new energy direction—are more likely to deliver the intended result because of the transformations that a mechanism from "Government" must undergo as it flows through the network before it gets back to "Government."

The first finding we want the reader to notice is that the accumulation of value is exponential. That is, nine value flows carry the first 25% of value, then seventeen value flows carry the second 25% of value, then thirty five value flows carry the third 25% of value.

Moving on, rather than talking about each individual value flow in Figure 49 we will discuss them as they relate to the mechanisms that we have started to identify in our analysis: data collection, economic incentives, policy support for a rapid growth of the renewable energy industry (whereas public or private) and enhancing human knowledge. First, we find **motivated students** from "People" to "Universities and Research Centers." This unexpected finding backs up our previous unexpected finding of "Universities and Research Centers" being ranked first in Figure 47. Both findings argue in favor of making a medium to long term investment in improving the quality of human capital in the Kingdom: from its origins, "People," to its formation, "Universities and Research Centers." Further, the topic of enhancing human development gest an additional boost as we find the delivery of **technology systems** from "Universities and Research Centers" to the two most important creators of economic output in the Kingdom: "Oil and Gas Industry" and "Manufacturing and Services Industry"

Next, we find several value flows—seven—of type energy contained in the first 50% of accumulated value. These value flows are the inputs for the production of electricity (**oil**, **gas** and **alternative energy power systems**) and **electricity** itself. These value flows are the central issue of this thesis: shifting

the supply mix for the production of electricity from **oil** and **gas** to alternative sources of energy. Additionally, we find yet more evidence of the call from the stakeholder network for the creation of procedures and institutions for the collection and distribution of data. There are seven instances of **economic reports and energy demand forecasts** in the top 50% of accumulated value, six of which are connected to "Government." This finding calls for "Government" to make the collection of information a key mechanism to succeed in their energy challenge.

Finally, we want to discuss two topics that are contained explicitly and implicitly in Figure 49. The first topic, economic development, is shown explicitly. We find four value flows of type capital and policy between "Government" and the main producers of economic output: "Oil and Gas Industry" and "Manufacturing and Services Industry." That is the stakeholder network keeps in sight that as the Kingdom tries to breakthrough their energy challenge it must do their very best to affect the least the growth of these two industries.

The second topic, regulation and investments for the "Alternative Energy Industry," is implicitly contained in Figure 49. On the one hand, the stakeholder network, are focused in the impact that the change of the mix of sources for the production for electricity, and electricity itself, have for the stakeholder network. But the network is not focused on the direct interaction between "Alternative Energy Industry" and the rest of the network. Figure 49 shows no value flow of type policy or capital that involves the "Alternative Energy Industry." During the construction of our model we build the network with KACARE as an entity belonging to the "Alternative Energy Industry" rather than to "Government" and during our visit to the Kingdom the stakeholders validated such construction. In fact, KACARE is mandated to perform various activities as stated by King Abdullah ("Royal Decree establishing King Abdulaziz City for Atomic and Renewable Energy," 2010):

1. Proposing the national atomic and renewable energy policy and setting plan and strategy for implementation of such policy and proposing the relevant bylaws and regulations
2. Implementing applied scientific research programs in its fields of specialization, whether independently or jointly with others inside and outside the Kingdom

3. Motivating the private sector to develop research on medical, agricultural, and industrial products, and on mining, power generation, desalinated water, rationalization of water uses to preserve natural resources and increase the efficiency of use of the same
4. Providing scholarships and training programs for developing the necessary capacities to prepare and execute the scientific research programs
5. Issuing regulations related to protection against hazards of atomic radiation for the specialized employees and for the public
6. Representing the Kingdom before the International Atomic Energy Agency and other relevant international organizations
7. Encouraging research conducted by individuals, institutions and authorities appointed in universities and research centers approved by the City, through the following means:
8. Providing financial assistance under various research contracts
9. Providing facilities, experts, and necessary materials for conducting such research with or without consideration
10. Establishing institutes necessary for training specialists in the atomic activity and health protection fields
11. Establishing and operating projects that achieve the purposes of the City or establishing joint projects with others
12. Cooperating with peer organizations and entities in other countries and with the international organizations and global research centers

We will come back to this issue as we discuss the dilemma of making the "Alternative Energy Industry" public or private for the final chapter.

4.4. Most Important Value Cycles

In the last section we looked at the value contained in the stakeholder network from the point of view of view of individual transactions of value. We ranked such transactions in terms of how much total value they carry based on the number of value cycles from which they are a link, as defined by WFVO in the last Chapter. In this section we will take the perspective of value cycles: paths of transactions of value that start and end with "Government." This is because "Government" is our focal organization as describe in Chapters 2 and 3. The results found in Sections 4.1, 4.2 and 4.4 (the current one) will be instrumental for the completion of our general objectives as we have been discussing throughout this Chapter.

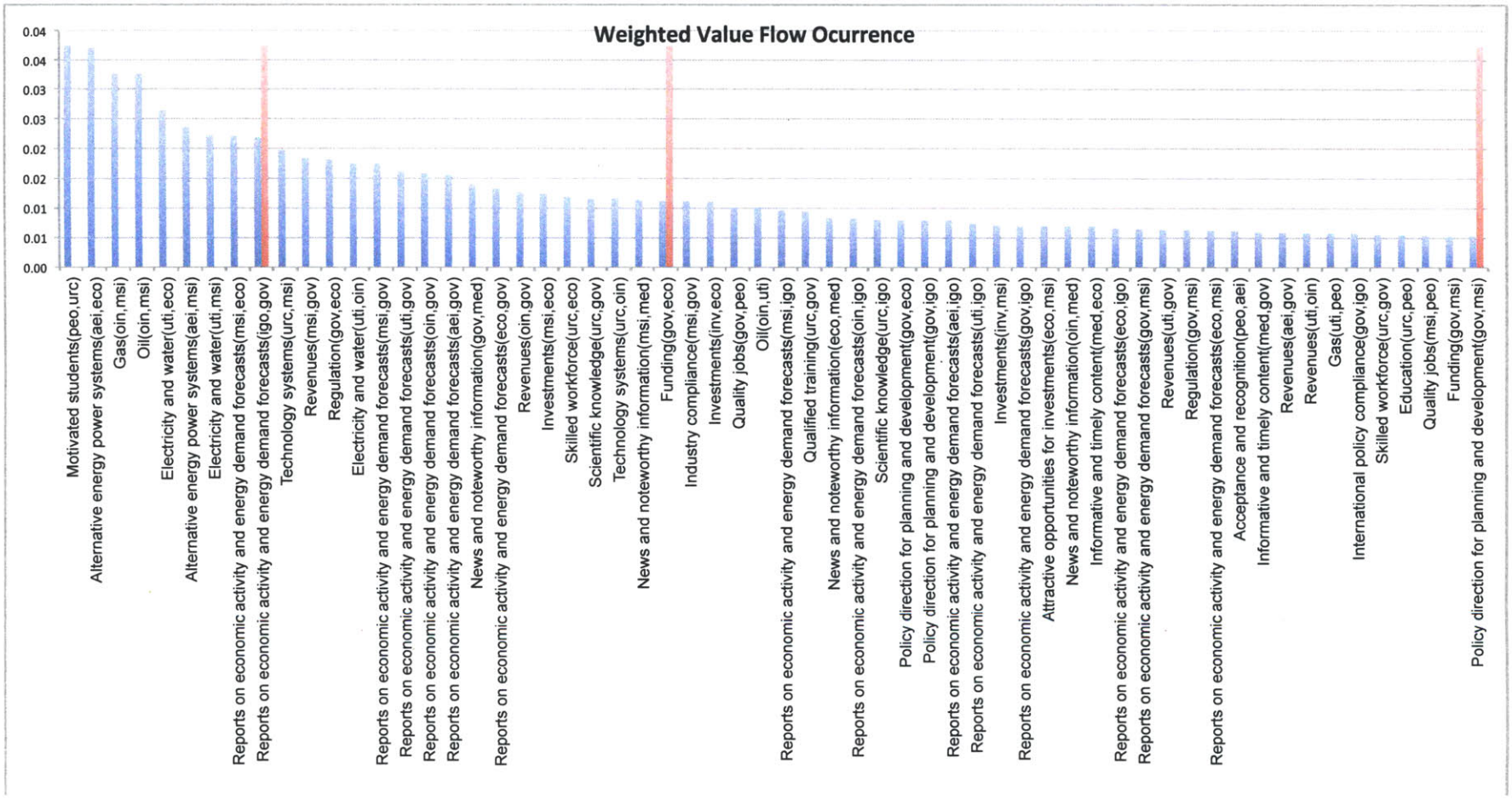

Figure 49 - Weighted Value Flow Occurrence for the stakeholder network (red bars represent .25 percentiles)

By looking at the most important value cycles we look not only to the stakeholders and transaction of value that are instrumental for "Government" to propel the Kingdom in the new direction, but also (in the case of value cycles with length longer than 2) at what challenges a mechanism might find as it flows through the stakeholder network to deliver the intended result.

As described in Section 3.4.4, we determine which are the most important value cycles by simply multiplying the combined score of the individual value flows that form the cycle. To start Figure 50 shows the top 5 most important value cycles for the stakeholder network. On top, we see that the stakeholder network considers that the most important value cycle is that between "Government" and "Alternative Energy Industry" on which the former provides **regulation** and the latter provides **reports on economic activity and energy demand forecasts**. Hence the discussion we have been developing about "Government" choosing between creating regulation to establish an industry controlled by the state, as in the case of "Oil and Gas Industry," or creating regulation to establish a private industry. This should be the first question to answer.

Tied with ranking 2, we find two value cycles that deliver revenues to "Government," coming from the "Alternative Energy Industry." In the first case "Government" uses **economic incentives** and on the second case it uses **regulation** to manage the **revenues** that come back from the "Alternative Energy Industry." In other words, the second stance we must take as we pursue our general objectives, is to choose the scheme with which the "Alternative Energy Industry" will function in terms of **economic incentives**. And, if possible from the perspective of SVNA, what level such **economic incentives** such have so that "Utilities Companies" are encouraged to shift the energy supply for the production of electricity. In other words, if **oil** and **gas** remain the cheaper options for the production of electricity, atomic energy and renewables will not be considered.

In fourth place we see the **funding** coming from "Government" to "Utilities Companies." We are not sure about how the cash flows between these two stakeholders, but this transaction reflects that "Government" is the majority share holder of "Utilities Companies," as seen in Table 2, and thus must manage their

Capital. This finding is directly correlated to the finding discussed in the above paragraph. If "Government" decides to provide a lower level of economic incentives to the "Alternative Energy Industry" so that the cost of producing electricity with atomic and renewable energy is larger than for oil and gas, then "Government" must take into account the level of funding they will have to provide to "Utilities Companies". Otherwise, "Utilities Companies" will not be able to pay for the cost of electricity. Additionally, the value cycle with ranking 5 reflects that the **funding** must be able to deliver the energy assets that "Oil Industry" needs for its operations. We see in Figure 51 that the value cycle with ranking 8 reflects a similar concern with the **revenues** that "Government" receives from the "Alternative Energy Industry."

As just mentioned, Figure 51 shows the second batch of top value cycles for the stakeholder network. The two value cycles with ranking 6 and the one ranked 9 (in addition to the one found in Figure 52) are adding stress to our unexpected finding in Section 4.1: "Universities and Research Centers" as the most important stakeholder for the network. Such two cycles show that even the "Oil and Gas Industry," the main pillar of the Saudi economy, is in need of **skilled workforce**. In Section 4.1 we introduced numbers that reflect how dependent the Kingdom is on foreign human capital.

In Figure 52 we show the third batch of top value cycles in the stakeholder network. Both of the cycles with ranking 11 reveal an interesting fact. Previously we saw how the stakeholder network values the importance of a Saudi **skilled workforce** for the "Oil and Gas Industry," which is a mature industry. As we have discussed in this thesis, the "Alternative Energy Industry" is a nascent industry in the Kingdom and, until 2011, 0% of electricity was produced through its means (ECRA, 2011). Thus, Figure 52 shows that the stakeholder network acknowledges that the product—the alternative energy product—must mature before a skilled workforce can be put into place to develop expertise and improve it. The network indicates that **scientific knowledge** and **technology systems** are needed to ramp up the "Alternative Energy Industry." The value cycles with

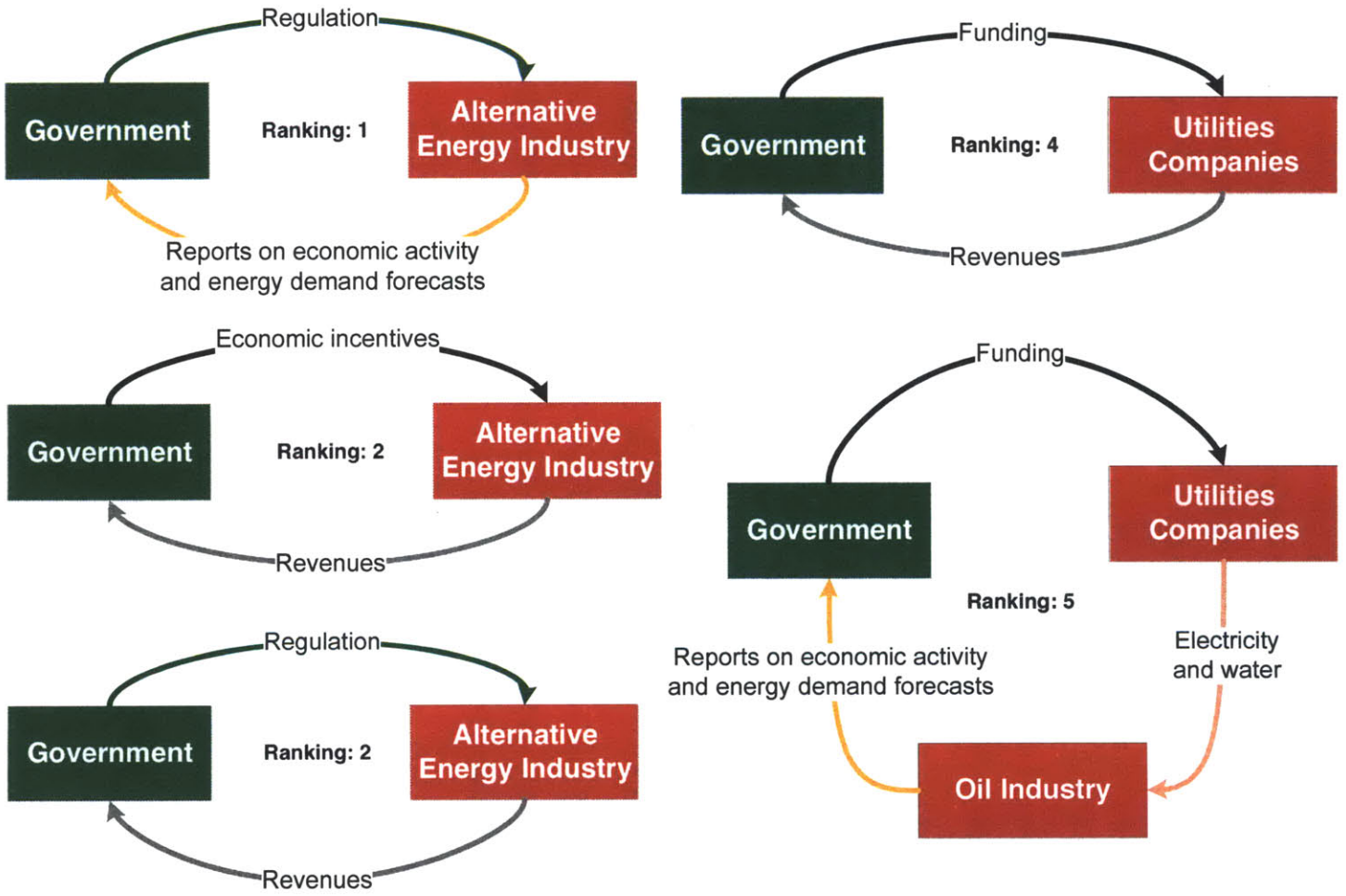

Figure 50 - Top value cycles part 1

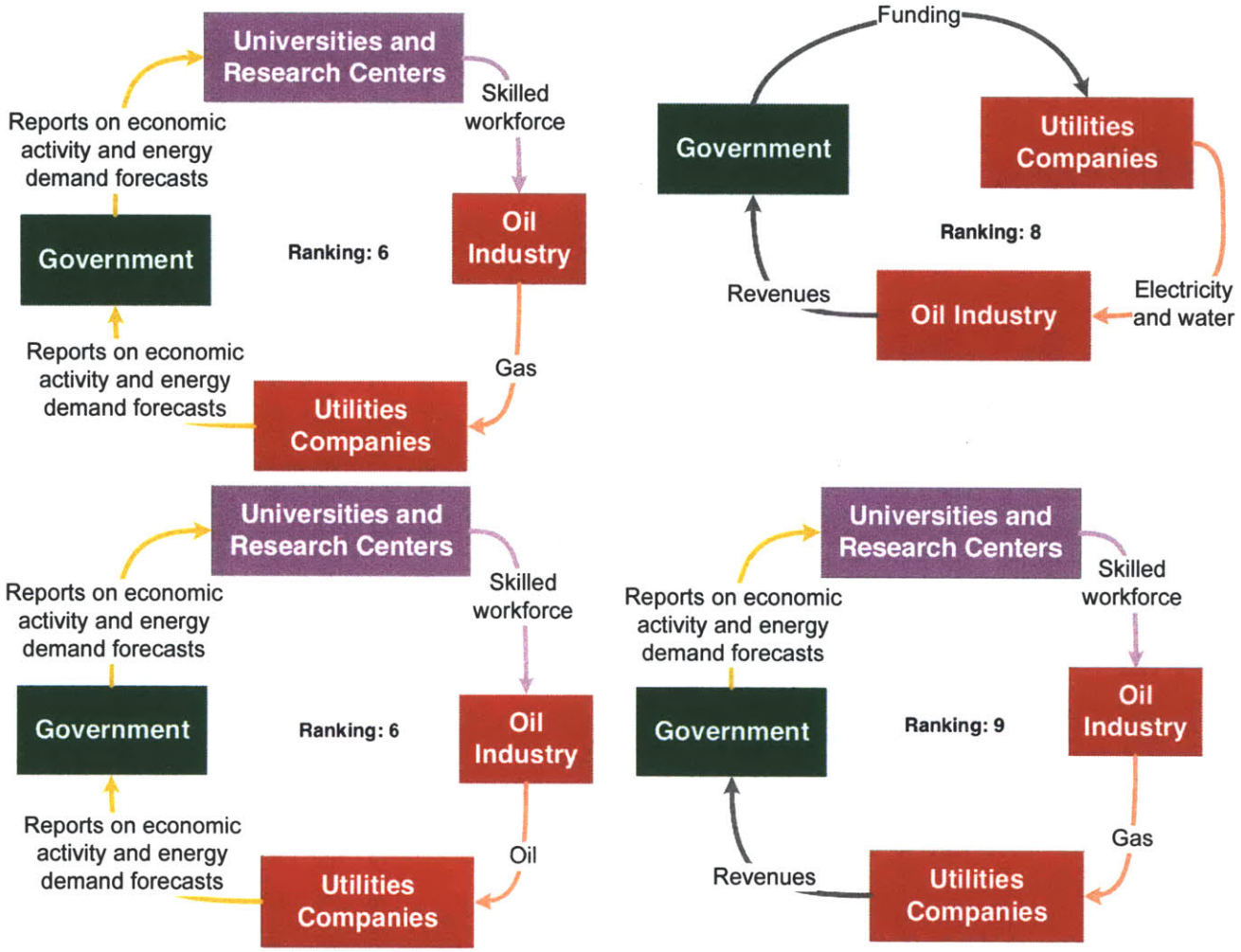

Figure 51 - Top Cycles, part 2

ranking 13 in Figure 52 and Figure 53 reinforce the importance of Saudi human capital for the Kingdom's industries.

Finally, in Figure 53, ranked 14 we find that "Government" also finds important the creation of human capital from "Universities and Research Centers" as an input to update the skills of its workers. The value cycles ranked 15 show again that the stakeholder network calls for the development of the "Alternative Energy Industry" product through **scientific knowledge** and **technology systems** before they are able to impact the **revenues** of the Kingdom. Based on the above evidence, it is clear that another mechanism for the "Government" to carry the Kingdom in the new energy direction will be a medium to long term investment in education: both in professional and practical programs and in the creation of scientific knowledge and practical applications of it.

4.5. Summary

In this chapter we fulfilled the specific objectives of this thesis: a through characterization of the value flow throughout the stakeholder network and a quantitative ranking of the most important stakeholders and the most important value transactions in the network. Now we have the tools we need to fulfill the general objectives of this thesis: to identify alternatives to fill the energy gap and to identify mechanisms for the government to achieve such a feat. In the next chapter we will present a simplified—yet extensive—version of the stakeholder network and offer our policy recommendations.

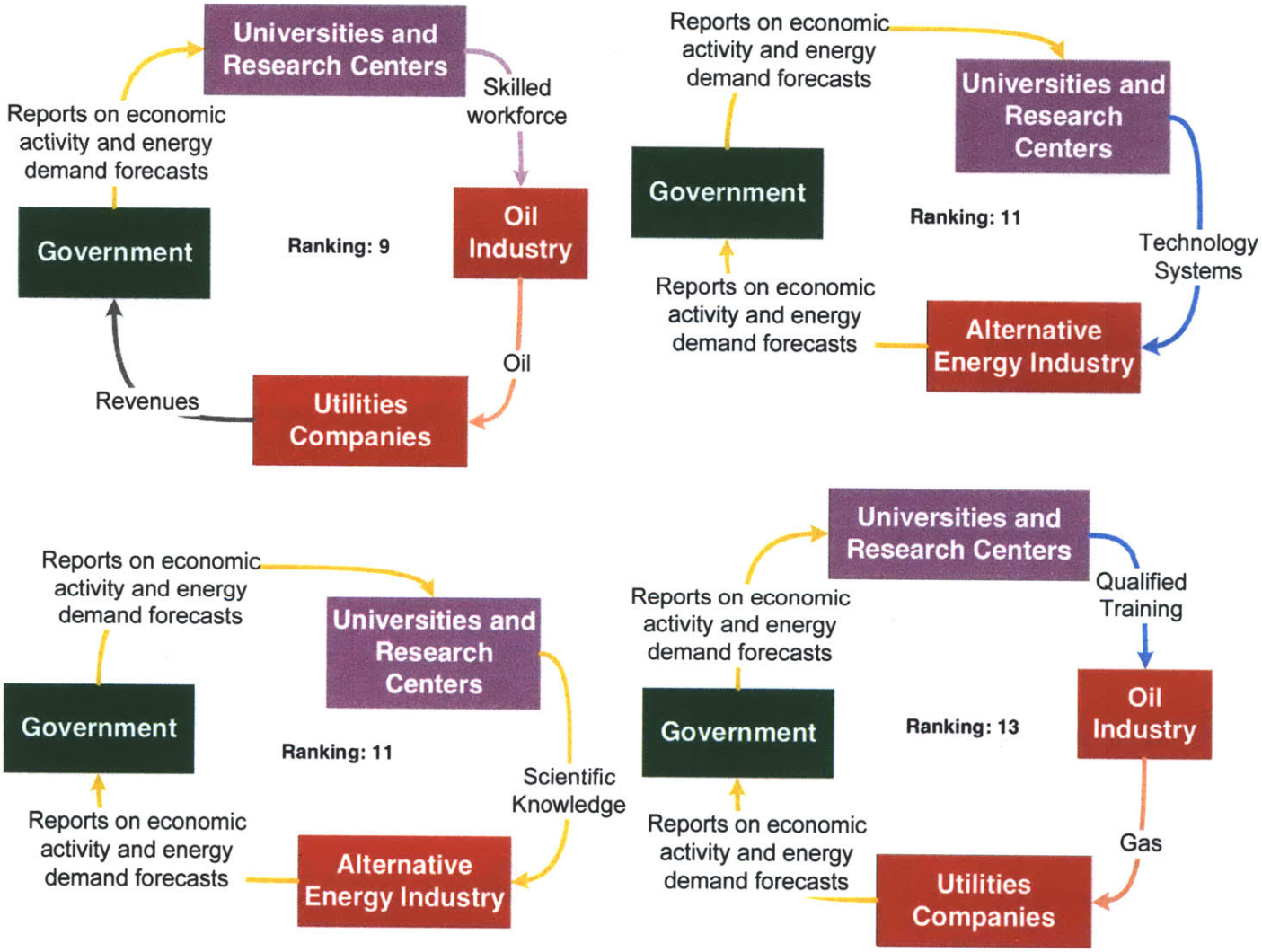

Figure 52 - Top value cycles part 3

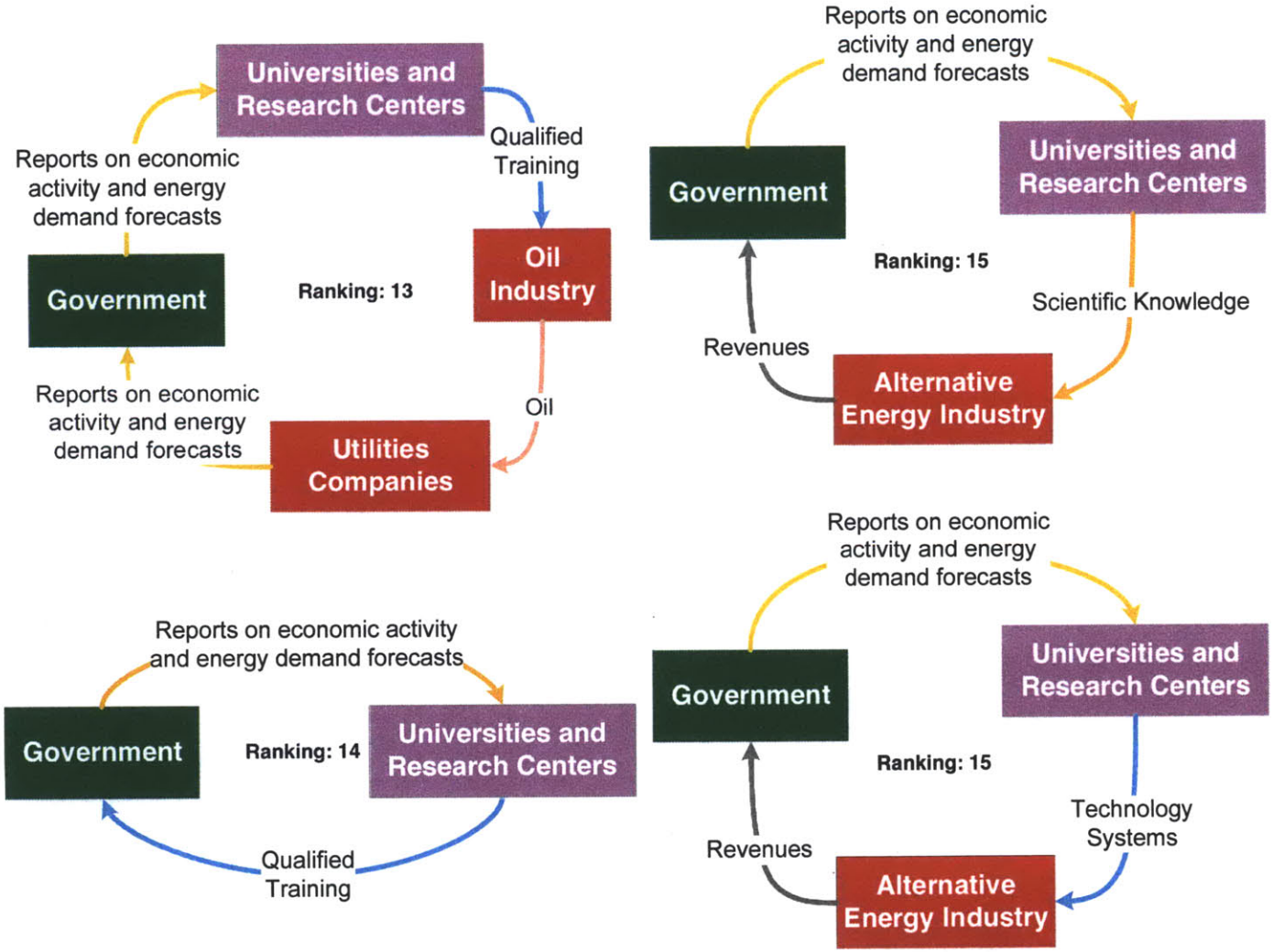

Figure 53 - Top value cycles part 4

5. Simplified Stakeholder Network and Policy Analysis

In the last chapter we presented the quantitative results of SVNA for the stakeholder network of the energy system of Saudi Arabia. Throughout the chapter we discussed the general objectives of this thesis. In this chapter we will present simplified versions of the stakeholder network that will help us prioritize our policy analysis and fulfill the general objectives of this thesis.

First, we recall our general objectives:

1. Identify what mechanisms does Government have to influence and propel the stakeholder network in the new direction
2. Identify what tradeoffs each of those mechanisms have

To complete these we will present two simplified versions of the stakeholder network combining the results obtained in Sections 4.1 and 4.2 and 4.4. Recall that such quantitative results were obtained from the point of view of the focal organization: "Government."

To present these simplified versions we selected the stakeholders that together comprise 75% of accumulated value in the network (see Figure 46). For the first simplified version, Figure 54, we also selected the "Government" inputs and outputs that are connected to such stakeholders. The size of the stakeholders indicate its ranking (see Figure 46) and the thickness of the arrows indicate the importance of the input or output to "Government" (see Figure 47 and Figure 48). For the second simplified version, Figure 55, we selected the most important stakeholders and the most important value cycles in the stakeholder network. However, in contrast with Figure 54, Figure 55 shows only five stakeholders. This is because neither "Economic Cities" nor "Manufacturing and Services Industries" participate in the most important value cycles presented in Section 4.4. As before, the size of the stakeholders indicate its ranking. The thickness of the arrows are not varied in Figures 54 and 55, as one value flow

could be part of more than one value flow and thus using a specific thickness would not be consistent.

In the following sections we will analyze the mechanisms—and tradeoffs—the Government of Saudi Arabia has to cope with their energy challenge. We will use the above two simplified versions of the stakeholder network to prioritize our discussion of such mechanisms.

5.1. State Owned versus Private Industry regulated by the Government

In Figure 54 we see that the most important output from "Government" is **regulation** for the "Alternative Energy Industry." Additionally, we see in Figure 55 that while "Government" provides **regulation** for the "Alternative Energy Industry," the latter provides in return **economic reports and energy demand forecasts** and **revenues**. In other words, **regulation** from "Government" will determine the economic success of "Alternative Energy Industry" and thus it's viability as an alternative to produce electricity. There are a number of different options to implement **regulation** for the "Alternative Energy Industry":

- Feed-in Tariff. These are incentives based on the performance of the producer of renewable energy. It implies a fixed price for the electricity produced that takes into account production costs. This is the most common policy and has been implemented in at least 50 states (REN21, 2010). One of the reasons of its popularity, and a potential attractive for the Kingdom, is that is setup on a case-by-case basis. In other words, the fixed price is set for a contract but a different contract is setup per project based on region conditions for the use of alternative energy (for example, photovoltaic and wind currents vary across regions) and the technology at use
- Quotas (Renewable Portfolio Standard, Renewables Obligation, Mandatory Market Share. These, as it names suggest, are quotas that a

government assigns to selected produces with the intention of achieving cost-efficient generation. The quota is assigned on a market assessment by the government. Nevertheless, it leaves companies at the expense of market fluctuations and pressure to reduce their costs if prices are too low. It is recommended that a minimum and maximum price are setup to protect companies. Because of a highly incentivized fossil-fuel electricity, we believe this is not a good option for the Kingdom (Mezher, Dawelbait, & Abbais, 2011)

- Centralized Bidding. In this scheme, government calls for bids from investors for renewable energy projects. The purpose is to produce renewable energy at the least possible cost with the intent that a low price creates a market. Nevertheless, in the absence of additional measures by the government to create a market, this is too risky an option to propel the renewable energy industry in the Kingdom (Mezher et al., 2011)
- Investment Tax Credits. This type of measure helps alleviate initial capital costs of renewable energy infrastructure. Mostly, it helps large developers that see a big saving through such a tax credit, which can be as low as 10% and rarely equals the total cost of capital investment. If the Kingdom wants their own private industry to develop the renewable energy sector, this likely will be done through small to medium size companies across regions. This is because, as we saw in Chapter 1, the industry is a nascent one and has a considerable risk (Mezher et al., 2011)

Further, as we introduced above, Saudi Arabia has the option of using a combination of the above policies and targets for the private industry to take over the alternative energy industry (Al-Saleh, 2009). The alternative is to take the industry under its wing as a national company owned and managed by the state, as with "Oil and Gas Industry" and "Utilities Companies" (see Table 2).

On the one hand, Saudi Arabia is doing well by handling the "Oil and Gas Industry" as a national company. For 22 consecutive years, and at least until 2010, Aramco has been ranked the top oil company by the Petroleum

Intelligence Weekly's annual ranking (Petrolleum Intelligence Weekly, 2011) On top of this, Aramco has been the top oil producer for more than 35 years, see Figure 56. This is an interesting finding since often the reason for privatizing an industry is to improve its revenue. However, it is true that if the "Oil and Gas Industry" could set its own price for trade inside the Kingdom, it potentially it could increase its revenues. This is because, although there is no public information specifying the level of economic incentives for the "Oil and Gas Industry" to sell oil and gas to "Utilities Companies" for the production of electricity, such incentives do not equal the international price of oil and gas.

Additionally, in the case of "Utilities Companies," which are mostly owned by the state, we received no comments about operation problems during our interviews with stakeholders in the Kingdom (although we did not make specific questions in this regard). ECRA reports that in 2011, 38% of the outages in the Kingdom were because of cable damages, 23% were because of weather conditions and only 11% were because of network transmission failures (ECRA, 2011).In contrast, India recently experienced major blackouts that affected 600 million people, including in Delhi, India's capital. Analysis of India's blackouts indicate that the power generation section in India functions properly but that "the rest of the supply chain is a mess" (The Economist, 2012). In contrast, the Kingdom is restructuring their "Utilities Companies" through the "Saudi Electric Company Restructuring Program" to improve efficiency and performance (SEC, 2012).

Thus, we see that Kingdom has learned to successfully run and manage its most important industries. In fact, they have more than 36 years of expertise managing "the crucial aspects of Aramco's oil operations—production, conservation and so on" (Nawwab, 1995). Such a finding suggests that an "Alternative Energy Industry" owned by the state is aligned with the expertise of the Kingdom.

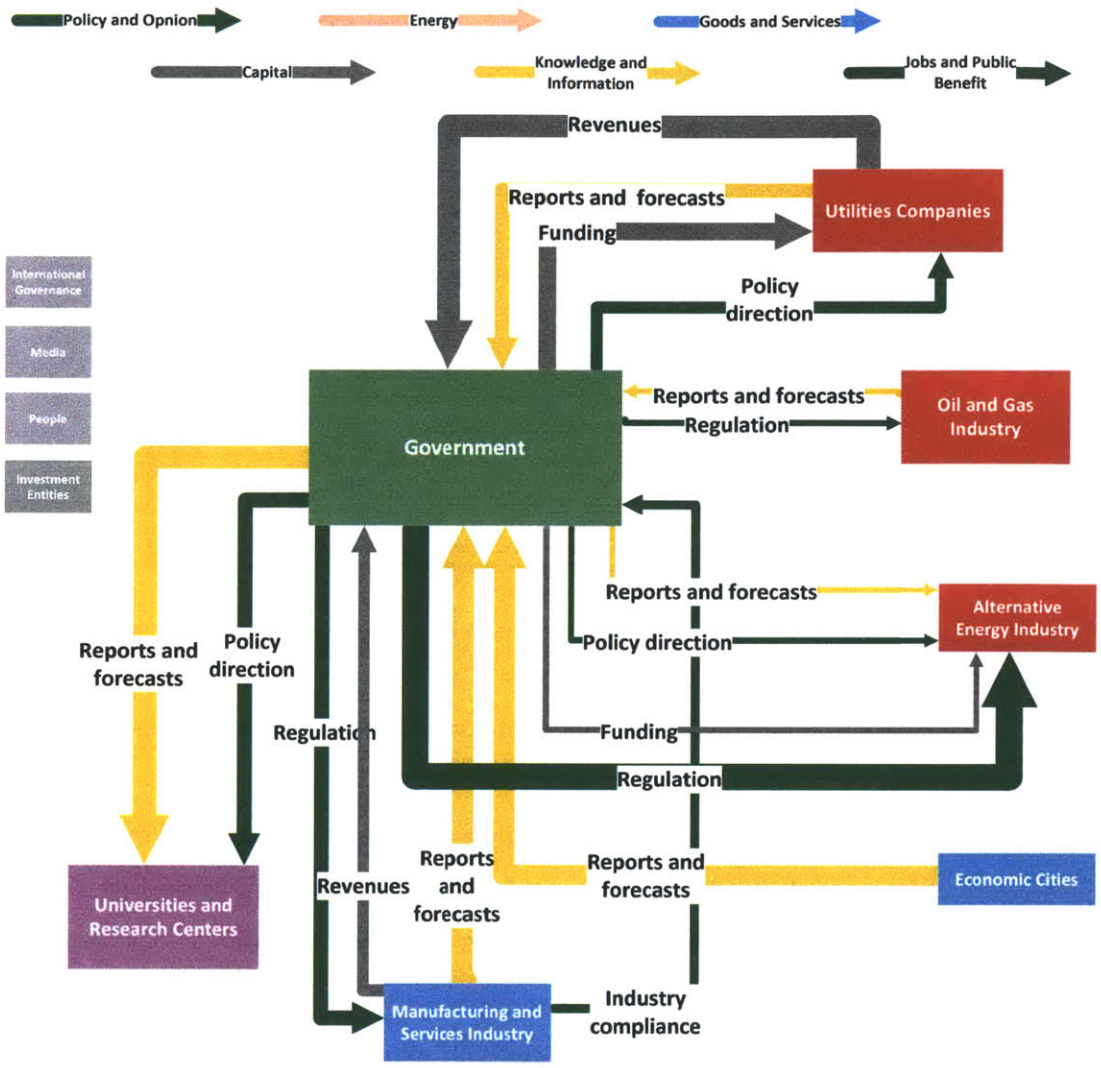

Figure 54 - Simplified stakeholder network from the point of view of Government

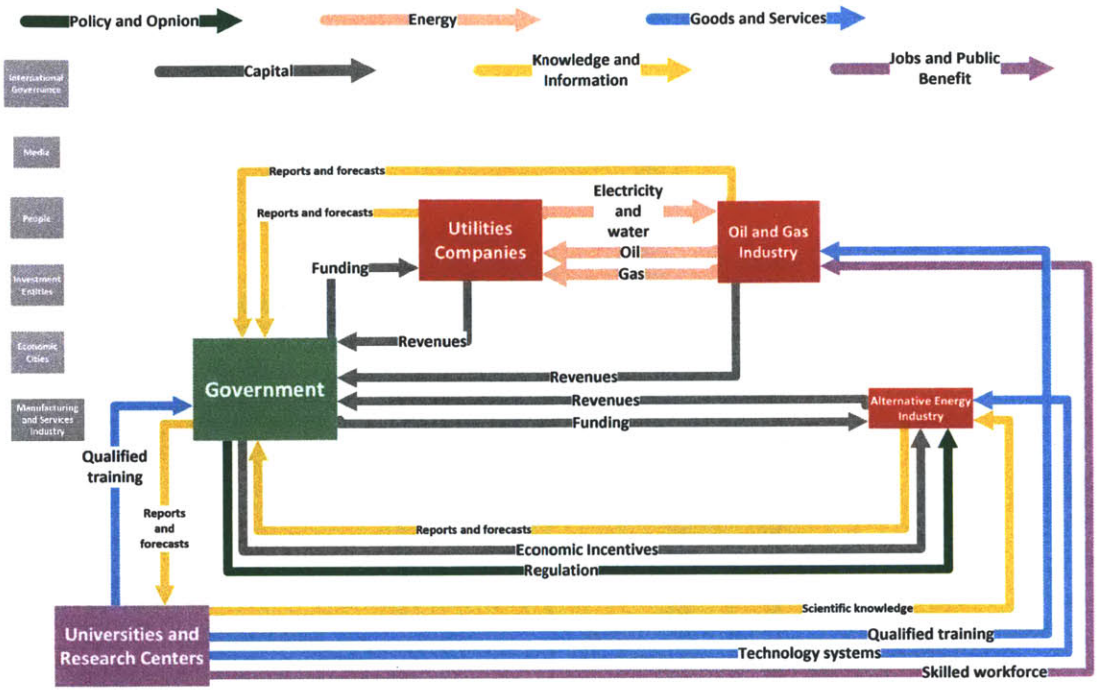

Figure 55 - Simplified stakeholder network with the top value cycles

Nevertheless, the Kingdom is pointing in an opposite direction. As we saw in Chapter 1, it has created KACARE. But KACARE is not meant to be the national industry for atomic and renewable energy, as ARAMCO is for the "Oil and Gas Industry." In contrast, KACARE was created to draft and execute the regulation for the alternative energy industry and deploy funding mechanisms for the private efforts on this industry ("Royal Decree establishing King Abdulaziz City for Atomic and Renewable Energy," 2010). That is, Saudi Arabia is following an approach similar to that of the United States for the electric grid that has evolved over more than 100 years. In this approach, the US government sets up the regulation and private companies take charge of the generation and distribution of electricity (MIT, 2011). Nevertheless, it is well known that the US has extensive knowledge about how to create and support private industries. In contrast, the Kingdom of Saudi Arabia has a strong interest to expand the private industry. However, although successful examples of privatization of government industries exist, like that of the Saudi Telecom company, the private industry in

Saudi Arabia has considerably slowed down compared to government as seen in the next section.

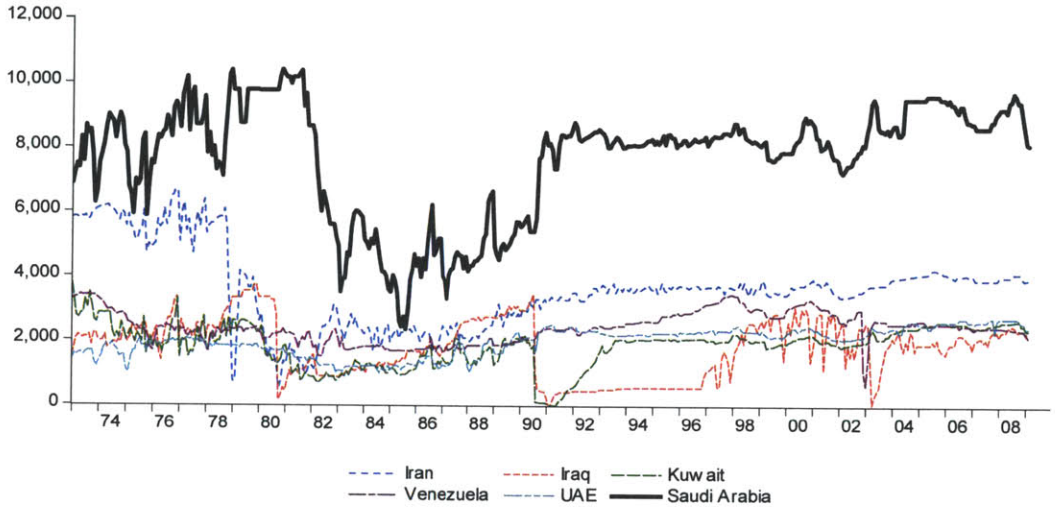

Figure 56 - Oil output (tbpd) by six large OPEC producers (1973 - 2009) (Nakov & Nuño, 2011)

Furthermore, it is clear that the sustainable production for electricity is a matter of economic and social stability and thus a matter of national security (Cordesman, 2011). But, the Kingdom is proceeding cautiously on the effort of changing the energy mix for the supply of electricity. Our recommendation is that the "Alternative Energy Industry" should be owned and managed by "Government" so that the latter can use its expertise—expertise it has developed running and expanding Aramco's operations (Nawwab, 1995). In other words, the SVNA results and simplified models presented above contain a choice of mechanisms to influence the growth of the "Alternative Energy Industry." The author believes that a combination of regulation, direct funding and ownership by the government is the strongest alternative.

Granted, one of the main directions of the Kingdom, seen in Chapter 1, is to expand the private industry. However, if the venture of a private alternative energy industry fails, the other two main directions of the Kingdom, enhancing economic development and human capital, could also fail. The main reason for

such a potential causality lies on the amount of capital available to support the aforementioned two directions. Put in the words of the Minister of Petroleum and Mineral Resources of the Kingdom "the use of alternative sustainable and reliable resources for generating power and producing desalinated water reduces dependency on hydrocarbon resources and thereby is considered an additional guarantee for producing water and generating power in the future and at the same time saves the hydrocarbon resources, which by turn extends the life of such resources and keep them as a source for income for a longer period of time" ("Royal Decree establishing King Abdulaziz City for Atomic and Renewable Energy," 2010).

Further, above we mentioned that the sustainable production of electricity is a matter of national security and social stability. The Kingdom of Saudi Arabia has been able to keep social stability in spite of unrest in neighboring Gulf countries. In 2011, the King announced "a further US $110bn in economic stimulus measures" because of "the government's growing concerns about the need to shore up its key bases of support given the growing threat of public unrest" ("Saudi Arabia Business Forecast Report," 2012). The Center for Strategic and International Studies (CSIS), "a bipartisan nonprofit organization headquartered in Washington D.C." has studied why (CSIS, 2012). CSIS found that the following measures taken by the current King—King Abdullah bin Abdul Aziz—found that the following measures "provided a multi-billion dollar investment in stability by meeting the people's needs" (for the full list of measures see the report by CSIS) (CSIS, 2011):

- $10.6 billion (SR 40 billion) in new funding for housing loans through the Real Estate Development Fund.
- $266 million (SR 1 billion) to enable social insurance to increase the number of family members covered
- $319.9 million (SR 1.2 billion) to expand social services.
- $933 million (SR 3.5 billion) to help the needy repair their homes and pay utility bills

- $126.9 million (SR 476 million) to support programs for needy students at the Ministry of Education.
- $3.9 billion (SR 15 billion) to support the General Housing Authority

In the above list, we see that all of the measures contribute to generate **motivated students** (a value flow in our SVNA model) which in turn create **skilled workforce**—human capital—which in turn contributes to economic development.

Therefore, the objective of establishing and growing an "Alternative Energy Industry" that allows the use of oil and gas for other purposes other than the production of electricity, should be treated with equal importance as the "Oil and Gas Industry" and initially be managed as a national company.

5.2. Economic Incentives for the Alternative Energy Industry

In the last chapter, Section 4.3, we discussed the low importance the stakeholder network placed on **economic incentives** from "Government" to the most relevant industries of this thesis: "Oil and Gas Industry," "Utilities Companies," and potentially, the "Alternative Energy Industry." Accordingly, we do not find economic incentives ranked as one of the main outputs from "Government" in Figure 54. There is a reason for such a low importance. During our conversations and interviews with stakeholders we learned that most, if not, all of them see **economic incentives** as a barrier for rational utilization of electricity and economic development. As discussed in Chapter 1, the low price of electricity in the Kingdom allows their citizens to increase electricity consumption almost freely. Nevertheless, we do find **economic incentives** ranked important when we look at the results found in Section 4.4 most important value cycles. Figure 55 shows that **economic incentives** are instrumental for the "Alternative Energy Industry" to give back **revenues** for "Government."

The fact is that the **economic incentives** that "Government" provides for the "Oil and Gas Industry" and "Utilities Companies" to keep a low cost of producing electricity and low selling price of it—that make the "Alternative Energy Industry" costly in comparison—are major barriers for the introduction of atomic energy and renewable energy as alternatives to produce electricity. But even further, the "Alternative Energy Industry" in the Kingdom is a case of natural monopoly. "A market is a natural monopoly if, at the socially optimal quantity, industry cost is minimized by having only one firm produce" (Viscusi, Vernon, & Harrington Jr., 2005). Further, "natural monopolies are likely to exist when there is a large fixed-cost component to cost" (Viscusi et al., 2005). As we mentioned in the previous section the "Alternative Energy Industry" development will require huge capital investment. Additionally, the government will be able to acquire, for example, solar panels for national distribution at a better cost than multiple private companies would. Thus, because of the two aforementioned reasons, "Alternative Energy Industry" in the Kingdom is a natural monopoly.

Further, for natural monopolies a government has three options (Viscusi et al., 2005):

1. Control price and entry—of new companies—regulation. This is better recommended when the industry fits the definition above
2. Full deregulation—neither to price nor to entry. A condition for this option is that the industry is no longer a natural monopoly. In other words, that the cost of producing a good or service is no longer optimal with one company
3. Pursue a cost of partial deregulation. This option entails relaxing the restrictions for entry of new companies

For options 1 and 3, the price regulation can take one of the schemes described in the previous section.

Furthermore, exploring more in depth the cost of producing electricity, in a recent publication we found that the Gulf Research Center (GRC), "a non-

partisan think tank, education service provider and consultancy specializing in the Gulf region," (privately funded) provided comparisons of producing electricity with alternatives versus fossil fuels (Bachellerie, 2012). GRC found that the cost of producing electricity in the Kingdom, by current means, is as low as $0.036/KWh and the price for the residential sector is as low as $0.0133/KWh (Bachellerie, 2012). In contrast, studies done by research centers at the Kingdom have found that the cost of producing electricity with a hybrid system of photovoltaic energy (solar energy) and diesel fuel amounts to $0.149/KWh (the system must be hybrid so that the diesel input compensates peak hours where solar energy is not available). That is more than four times the current cost of producing electricity (Bachellerie, 2012). Wind energy has a more promising scenario, the Gulf and Research Center also reports that the cost of producing electricity with wind energy—without storage—is as low as $0.0234/KWh. This is a more competitive price against the cost of producing electricity with fossil fuels, $0.036/KWh (Bachellerie, 2012).

In a similar study, Reuters found that cost of producing electricity with incentivized gas is $0.02 per kWh, and that with a price of gas "closer to world market prices" the cost of electricity would be $0.09 per kWh (McDowall & Shamseddine, 2012). Similarly, Reuters found that the cost of producing electricity with incentivized oil is $0.03 per kWh and with "oil valued closer to world levels" the cost is $0.16 per kWh (McDowall & Shamseddine, 2012). Reuters finds that electricity produced with PV would be $0.12 and with CSP would be $0.18 per kWh (McDowall & Shamseddine, 2012).

In both of the above studies we find that electricity produced by renewable energy is more costly than electricity produced by fossil fuels, even at international prices. Nevertheless, Reuters study goes further and states that "solar power should work out cheaper when the cost of keeping large oil and gas plants on standby for delivering peak-load power are factored in" (McDowall & Shamseddine, 2012). In other words, these studies were done on small scale and are not fully considering the capital costs of installing alternative energy capabilities on a large scale.

Thus, our previous recommendation of having a national "Alternative Energy Industry" acquires more strength, as the industry will need huge initial investments. And, although the "Investment Entities" in the Kingdom have expressed their interest on investing in the industry as we saw in Chapter 2, the private sector in the Kingdom is still developing and as one index of the maturity of the sector we look at Gross Fixed Capital Formation. Between 2001 and 2009 the Gross Fixed Capital Formation—the value of acquisitions of new or existing fixed assets—has considerably decreased for the private sector, see Figure 57 (Sfakianakis, Merzaban, & Al Hugail, 2011).

Further, we previously argued that the development of the "Alternative Energy Industry" will need considerable capital investments. Studies reveal that "the cost of electricity, generation, transmission and distribution systems is particularly high. Total investments needed to meet the demand may exceed $90 billion by 2023" (Al-Ajlan, Al-Ibrahim, Abdulkhaleq, & Alghamdi, 2006). Additionally, when we consider the effect of the "cost curve for changing of energy efficiency performance" (see Figure 7) such estimates could potentially be higher. Furthermore, the above study argues "no financial institutions invest in energy efficiency projects—this could be attributed to the high risk associated with investing in new technologies" (Al-Ajlan et al., 2006). Other studies argue "the requirements for a successful market implementation of CSP [Concentrated Solar Power, a renewable energy alternative for the Kingdom] become clear: the associated large long-term investments require equivalent long- term, secure revenues. An investor cannot take the risk of investing in a huge stock of fuel for 40 years of operation in the form of a solar collector field, if s/he is unsure of the stability of a project's revenue streams. Projects with costs that are fixed but revenues that are not will have a difficult time attracting the desired financing at the required cost" (Trieb, Muller-Steinhagen, & Kern, 2011).

The Banque Saudi Fransi, a major investment entity in the Kingdom that was referenced in Chapter 2 recognizing the potential for renewable energy in the Kingdom, acknowledges the lack of strength of the private sector to sustain major developments: "A number of mega-projects in the country have suffered

from a lack of investor appetite. When the King Abdullah Economic City mega-project was unveiled in 2005, it was considered to be the single-largest private sector investment. One of five economic cities planned to speed up job creation, the city, located along the Red Sea north of Jeddah, includes plans for an industrial zone, a seaport and residential community. The dearth of private sector interest has stalled this project's development compared with its initially stated goals" (Sfakianakis et al., 2011).

Furthermore, on March 28, 2011, Saudi Arabia's King Abdullah announced a $93 billion economic stimulus program (Emerging Markets Monitor: Middle East, 2011). The program includes the creation of 60,000 jobs within the interior of Ministry, mosque renovations, and additional investment in Commission for the Promotion of Virtue and Prevention of Vice—an organization in charge of the preservation and cultivation of Islam. There was no highlight of investment or regulation toward boosting the private sector. Rather, the King's speech signaled the government's growing concern with social unrest in the Kingdom and the use of short to medium term investments to prevent such unrest.

Therefore, our recommendation for the Kingdom is to provide economic incentives to the "Alternative Energy Industry" and "Utilities Companies" that make them competitive with the cost and price of electricity produced by fossil fuels. Nevertheless, as we discussed in Chapter 1, the economic incentives for the whole energy industry must eventually be considerably reduced. This measure will allow the growth of a strong private industry and will allow rational utilization of energy. That said, the author of this thesis understands the reluctance of the government of Saudi Arabia to delay the reduction of economic incentives. People will not tolerate calmly the lack of the most basic services. We just have to look to the unrest in India for a clear and recent example of this (The Economist, 2012). Additionally, it will take the Kingdom a long period, perhaps more than 10 years, to slowly reduce the incentives and augment the price of electricity. Therefore, that the citizens of the Kingdom must learn to live through and with this change.

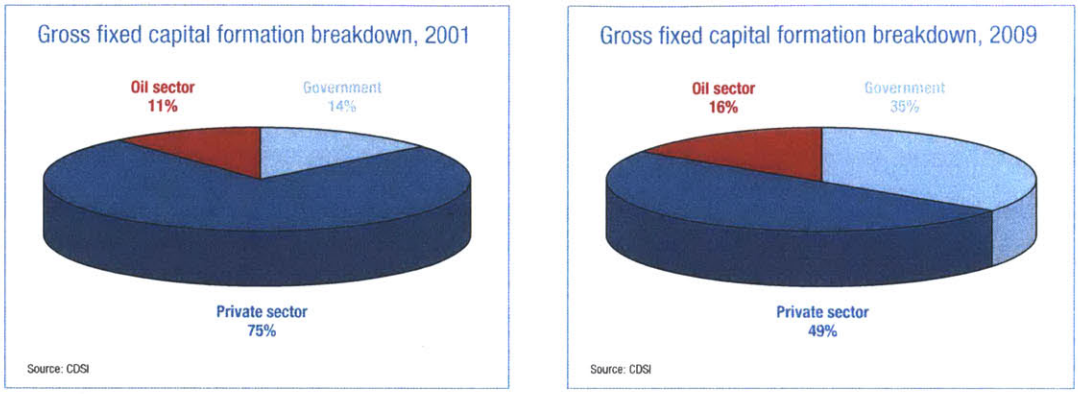

Figure 57 - Comparison, gross fixed capital formation in Saudi Arabia (Sfakianakis et al., 2011)

5.3. Investment in Education and Knowledge Creation

As we look at Figure 54, we see that the most important inputs for the most important stakeholder "Universities and Research Centers," are **policy direction** and **reports on economic activity and energy demand forecasts**. Both of these are instrumental to improving the quality of Saudi education programs and research development efforts. Accordingly, Figure 55 shows that **reports on economic activity and energy demand forecasts** for the "Universities and Research Centers" are instrumental in the industry to deliver **scientific knowledge** and **technology systems** for the "Alternative Energy Industry." The tradeoff is whether to reform the educational national system or support the Saudi youth to receive a quality education abroad.

As an example of the relationship between policy making and information-sharing between government, industry and the educational system, we found that of The Free State in South Africa. The Organization for Economic Co-Operation and Development (OECD) produces "Reviews of Higher Education and in Regional and City Development," these are "are the OECD"s vehicle to mobilize

higher education for economic, social and cultural development of cities and regions" (OECD, 2012). South Africa has similarities with the Kingdom of Saudi Arabia. South Africa's economy has been dependent on the exploitation of its natural resources through mining. Additionally, although it benefits from constant growth, it fails to provide adequate job creation, as the Kingdom does. OECD found in their study that a major recommendation for promoting human capital development is to "make every effort to establish a co-operative culture among the post-school educational institutions, the governments and other public and private stakeholders in the region" (OECD, 2012). In other words, data information between the stakeholders involved in the economy and the central government is key in the development of human capital.

Coming back to the case of Saudi Arabia, in the last chapter we argued that the presence of **scientific knowledge** and **technology systems** as the most important value cycles in the network is a signal of the lack of maturity and the considerable research and development of technology that needs to be done before "Alternative Energy Industry" can take its intended role in the Kingdom. Such a signal is confirmed by the data presented in Chapter 1: 0% of electricity produced by alternative sources by 2011 (ECRA, 2011). Further, the Gulf Research Center also argues about this lack of maturity and highlights the micro level studies that are been performed in the Kingdom to evaluate the adoption and feasibility of this technology, and also highlights the surprisingly lack of research in some of the alternative modes of energy (Bachellerie, 2012). For example, they point out the lack of an economic study estimating the cost of electricity for Concentrated Solar Power (Bachellerie, 2012).

Further, the Saudi Arabian General Investment Authority (SAGIA) who, among several responsibilities, is in charge of creating the Economic Cities of Saudi Arabia, explains the need to improve the quality and quantity of national human capital in the Kingdom. SAGIA states that recently, Saudi Arabia has become the 8th highest education spender in the world and that it has "initiated a complete overhaul of its educational system at a cost of US$3.1 billion" (SAGIA, n.d.-b). Further, SAGIA states that in Saudi Arabia "some 80% of engineers,

doctors and scientists are foreigners" (SAGIA, n.d.-b). This is clearly a drawback when it comes to the challenge of changing the energy supply mix for the production of electricity. The Kingdom will find, at the very least, that it is not sustainable to mature and expand the "Alternative Energy Industry" with such a huge lack of national human capital. Furthermore, SAGIA explains how more and better Saudi human capital will allow the Kingdom to become a "knowledge based economy," as the United States is, and that such economies "increase productivity, drive economic growth and advance the prosperity of a nation" (SAGIA, 2009)

Further, such major ambitions for the national human capital in Saudi Arabia cannot be achieved by relying on international education institutions. That is, not only does Saudi Arabia want to improve the quality of human capital in terms of economic production as described above. Also, as The Ministry of Education points out, "education is not merely a group of skills, knowledge and values that the learner acquires only to repeat exams. Nor is it a series of lab experiments only. Education transcends all of these to the goal of preparing the Muslem personality to effectively interact fully with the world" (Ministry of Education, 2004). Additionally, it is common knowledge that the universities that will pay the most attention to the issues of a country are the national ones (Selvaratnam, 1985). Thus, for Saudi Arabia to achieve human capital improvement in terms of both economic output and cultural development, such an educational improvement must come from within the Kingdom.

Accordingly, as we saw above, the Kingdom has just initiated a heavy investment in education for the country. However, it will take at least a generation for them to experience the impact of such an investment. Ten to twenty years from now, if the Kingdom is serious about this strategy, they will be able to become a "knowledge based economy," as stated by SAGIA (SAGIA, 2009). When that happens, the Kingdom will be in the proper position to shift the "Alternative Energy Industry" to be mostly private working under proper regulation, like the electric grid of the U.S. currently (MIT, 2011).

Therefore, our third recommendation for the Kingdom is to maintain, and possibly increase, the level of investment of education. Also, the Kingdom should keep providing funds for the "Universities and Research Centers" so that they can continue their research and development efforts towards the maturity of alternative sources of energy in the Kingdom.

5.4. Data Accessibility in the Kingdom

The final major mechanism for "Government" to take the Kingdom in the desired energy direction, as shown by the results in Figure 54 and Figure 55, is an improvement in data collection and distribution in the Kingdom. Figure 54 shows that four of the most important inputs for "Government" are **reports on economic activity and energy demand forecasts** from the most important stakeholders in the network. Additionally, Figure 55 shows that these inputs for "Government" are part of the most important value cycles.

From our perspective, there are two views of the quality of data collection and distribution in the Kingdom. During our interview with stakeholders, described in the last chapter, government representatives seemed to have the necessary data to fulfill their objectives. After all, "Government" has successfully developed the Kingdom through the "National Development Plans," (for a brief history of these see Chapter 1). From this point of view, "Government" is simply stressing the importance that such inflow of data has for their central role.

Nevertheless, from a second viewpoint, there is a lack of data collection and accessibility. As described in Chapter 1, this research effort is part of a long term collaboration between MIT in the United States and KACST in Saudi Arabia: the Center for Complex and Engineering Systems. Researchers on both sides of the Center are facing data accessibility issues because data is not always well publicized. Data has been accessed through project and research collaboration with individual stakeholders but not to the extent that researchers are used to have in developed countries, and countries with a different type of government.

In other words, Saudi Arabia's centralization of government has interest in keeping information and data close to its arms. To reinforce this argument, we invite the reader to review again Figure 48. We see that news and noteworthy information from "Government" to "Media" is ranked third, above many other important value flows for the energy challenge we are addressing.

Our recommendation for the Kingdom, based on our results, is to increase—or maintain if "Government" entities do have the data they need—the data collection investment and to invest in increasing the accessibility for the general public. Indeed, some countries are pursuing open data initiatives like the United States (The White House, 2009). Other countries in Europe have demonstrated that openness leads, among many other things, to a larger and healthier private industry. Studies found that open Public Sector Information (PSI) leads to "more companies in the value chain, at various points and with more diversified products, all things that lead to increased tax revenues" (Dekkers, Polman, te Velde, & de Vries, 2006; Fioretti, 2011). Nevertheless, we acknowledge that such a change might take time.

5.5. Recommendations

In this last chapter we fulfilled the general objectives of this thesis. We identified potential mechanisms—and their tradeoffs—for the government of Saudi Arabia to propel the Kingdom to shift the energy mix for the production of electricity from only fossil fuels—oil and gas—to a mix that includes alternative sources—atomic and renewable energies.

We conclude that the Kingdom will increase the value delivery to the stakeholder network, and thus increase the sustainability and promptness of such a change, by:

1. Taking the Alternative Energy Industry under its wing and giving the support that other state owned companies in the Kingdom enjoy: the Oil and Gas

Industry and the Manufacturing and Services Industry. As described in this chapter, the Kingdom has no economic or social stability room to treat the alternative energy industry as venture when it is still changing its policy and infrastructure to support a robust private industry

2. Initially, the government must provide economic incentives to the alternative energy industry that make their product attractive to utilities companies. Eventually, the government must considerably reduce the economic incentives to all of the energy industry if it wants to be successful in growing their private industries and improving the rational utilization of energy. Currently, however, the Kingdom is heavily invested in maintaining the social stability while Saudi Arabia's neighbors are suffering from unrest. If the prices of electricity were to increase because of a reduction in economic incentives, a large part of the population would be dissatisfied
3. The government has initiated a heavy investment in education in the Kingdom. They must maintain such a level of commitment during one generation so that the current youngest part of the population is really able to improve its education levels and also its opportunity for quality employment in the Kingdom, versus foreigners. Further, the successful improvement in human capital in the Kingdom is key to the success of changing the mix of energy assets
4. Finally, in the medium term, the government must increase the accessibility to data in the Kingdom. Such accessibility will be instrumental in the development and growth of the private industry. Therefore, it will be instrumental for the reduction of economic incentives that halt progress in the Kingdom. Finally, accessibility of information will conduce to a realization by the population that they are a central component of the key energy change in the Kingdom: a change that will lead them to a sustainable production of electricity, sustainable progress of their economy, and an improved quality of life

Appendix A: Stakeholder Characterization Templates

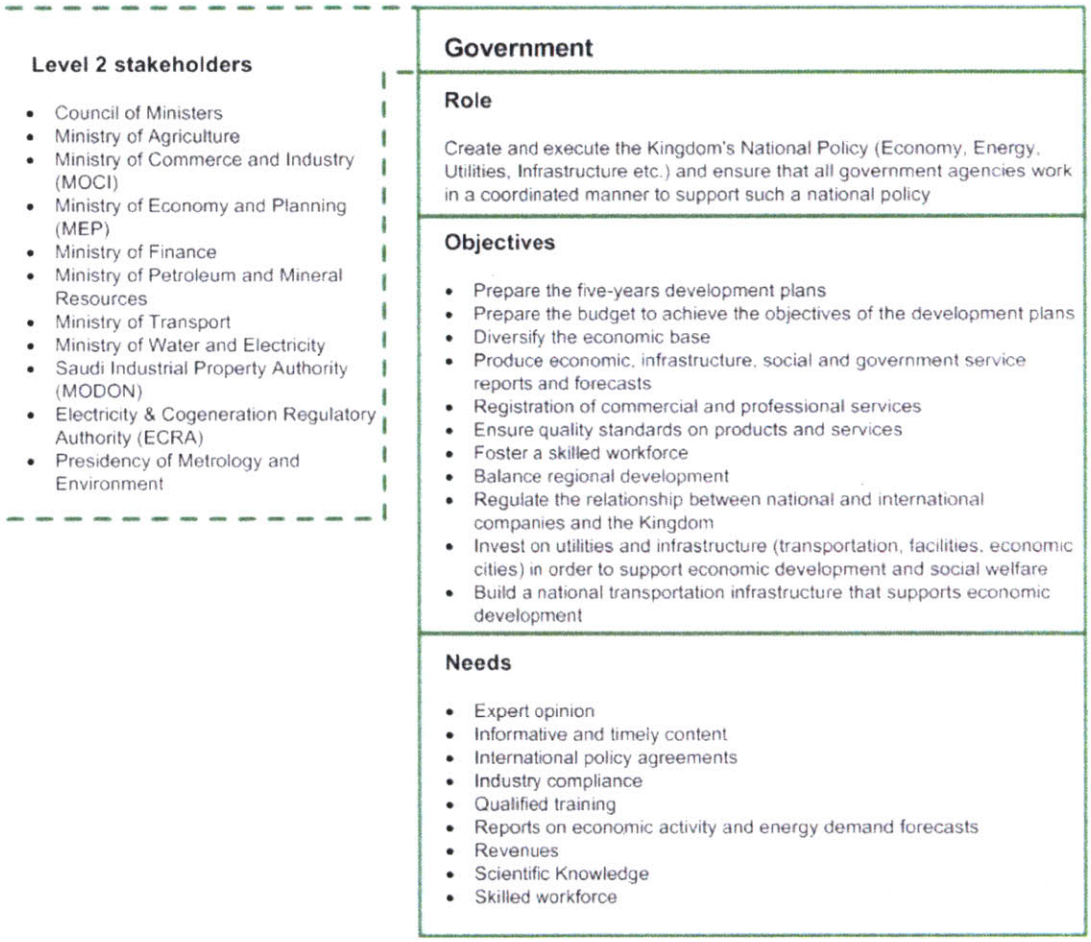

Figure 58 - Characterization Template – Government ("Ministry of Commerce and Industry," 2006, "Ministry of Economy and Planning," n.d., "Ministry of Transport," n.d., "Saudi Geological Survey," 2012, "Saudi Industrial Property Authority," 2012)

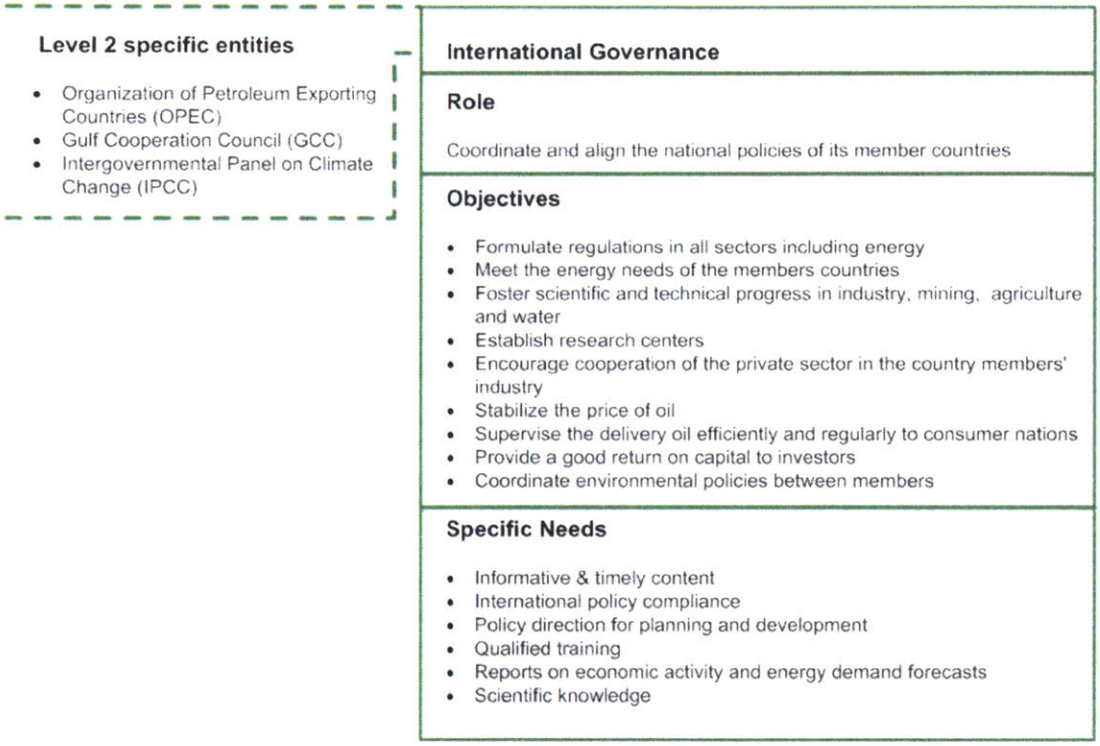

Figure 59 - Characterization Template – International Governance ("IPCC - Intergovernmental Panel on Climate Change," n.d., "OPEC," 2012, "The Cooperation Council For The Arab States of The Gulf - Secretariat General," 2012)

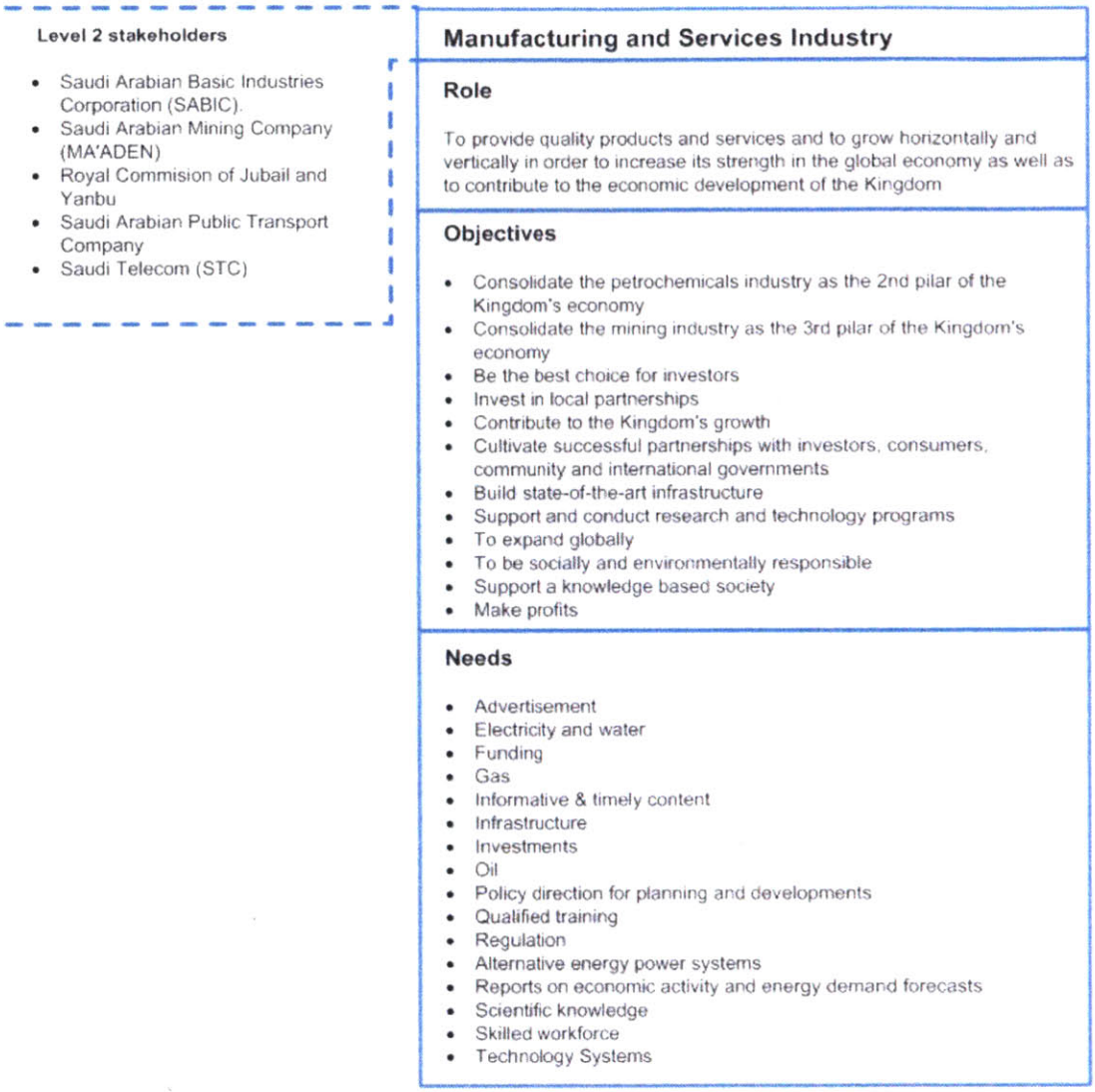

Figure 60 - Characterization Template – Manufacturing and Services Industry ("Maaden | Saudi Aabian Mining Company," 2012, "Royal Commission for Jubail & Yanbu," 2010, "STC," 2012, "Welcome to the SABIC homepage," 2012)

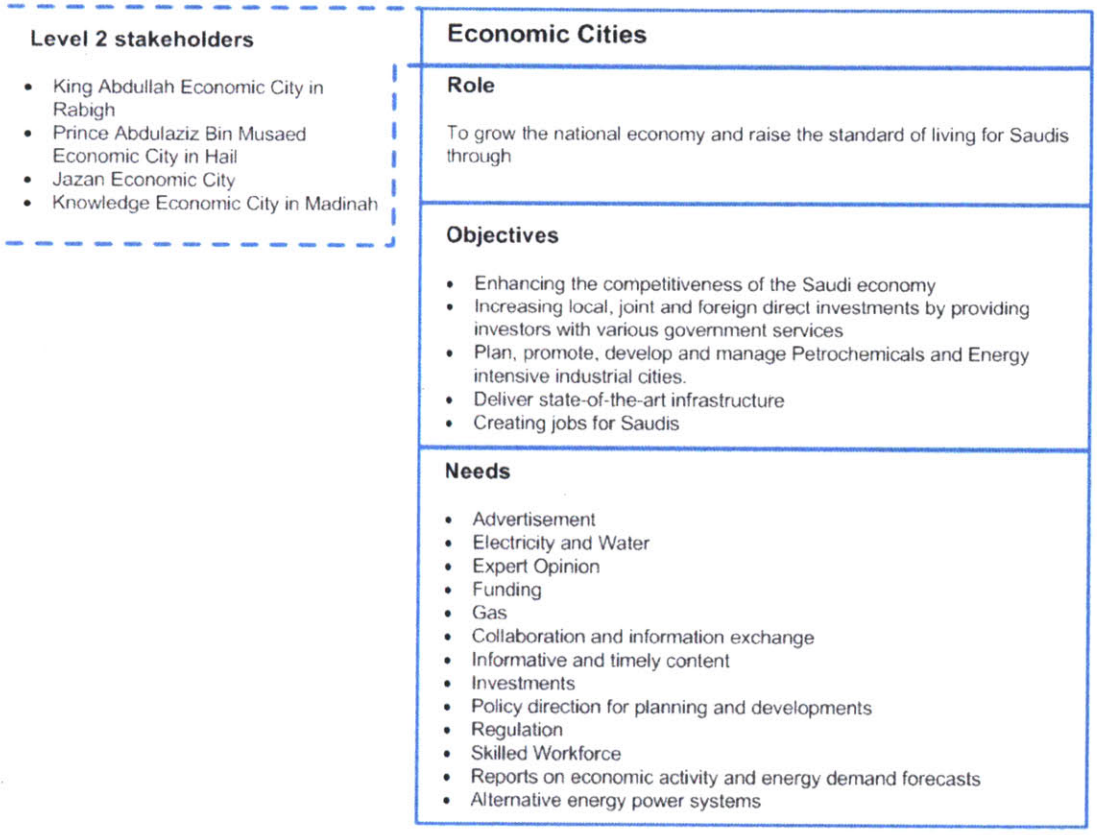

Figure 61 - Characterization Template – Economic Cities ("Jazan Economic City, Saudi Arabia," 2010, "Royal Commission for Jubail & Yanbu," 2010; SAGIA, n.d.-a)

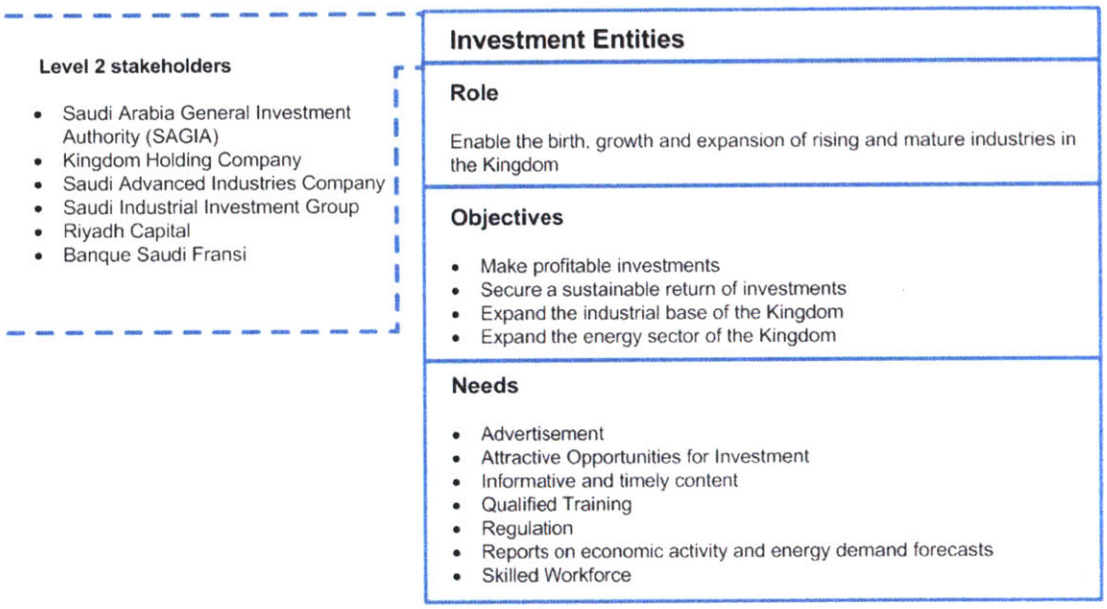

Figure 62 - Characterization Template – Investment Entities

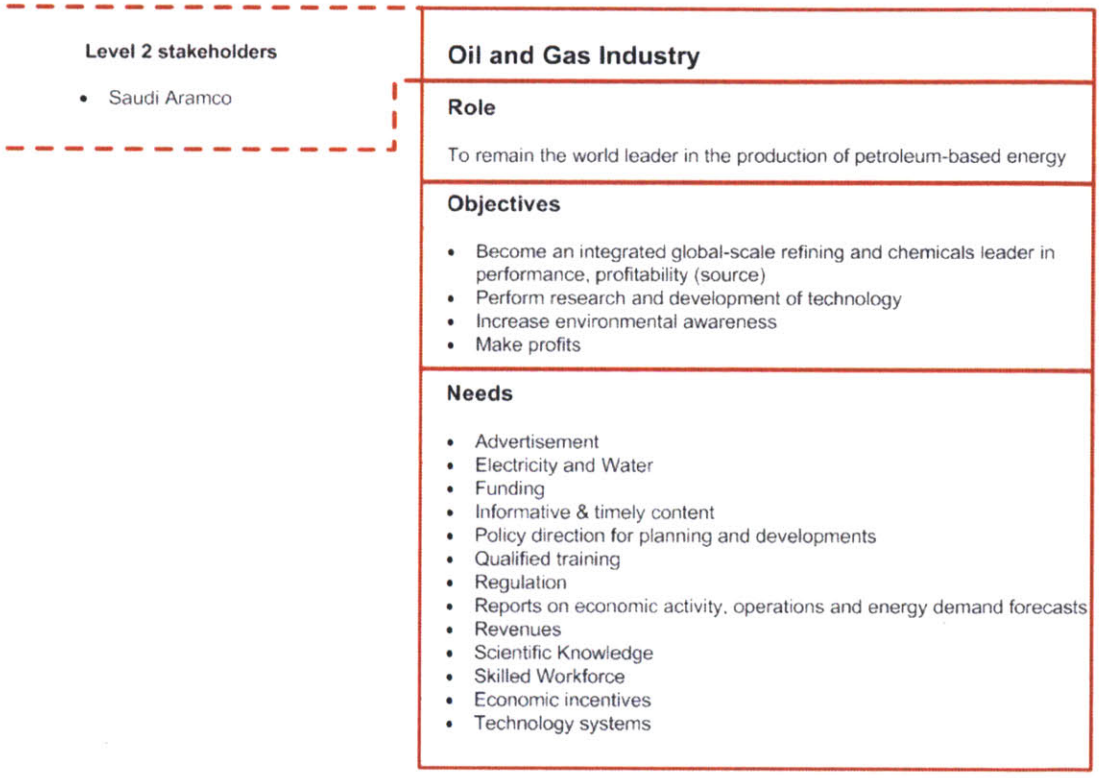

Figure 63 - Characterization Template – Oil and Gas Industry (Aramco, 2012)

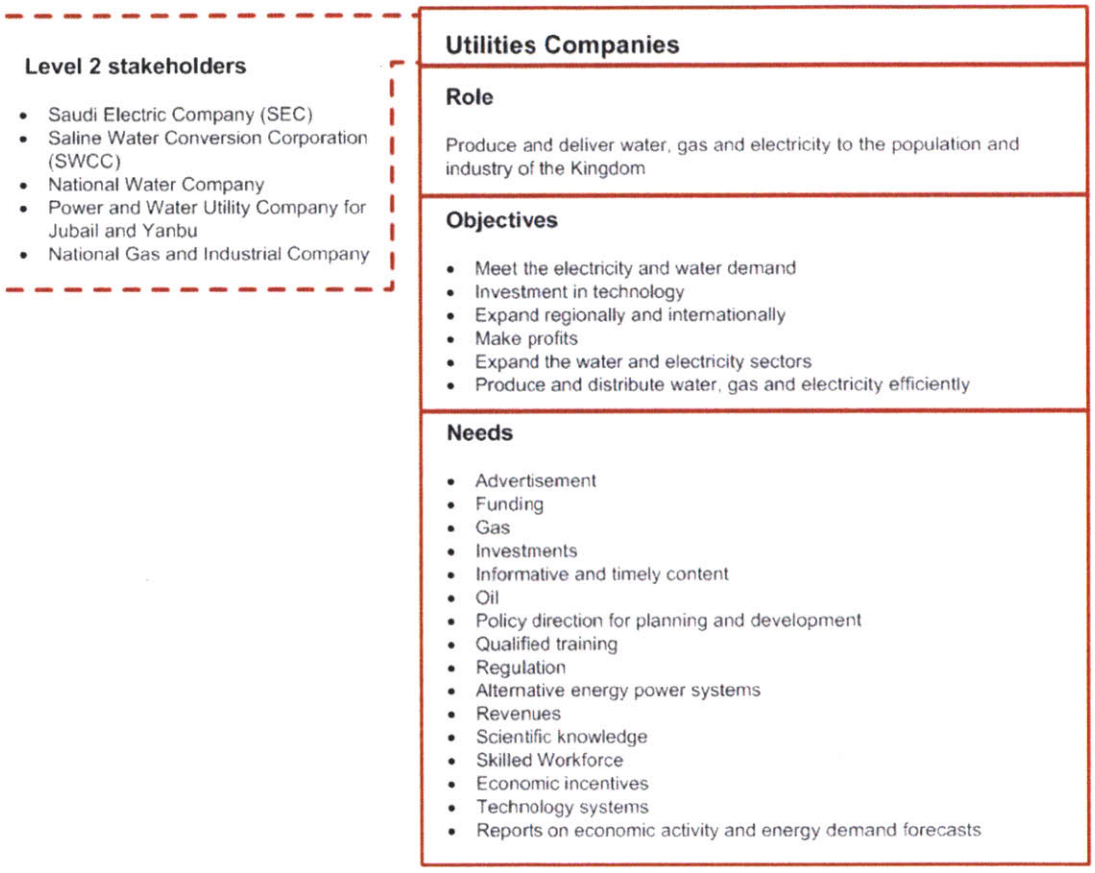

Figure 64 - Characterization Template – Utilities Companies ("National Water Company," 2011, "Saline Water Conversion Corporation," 2012; SEC, 2010)

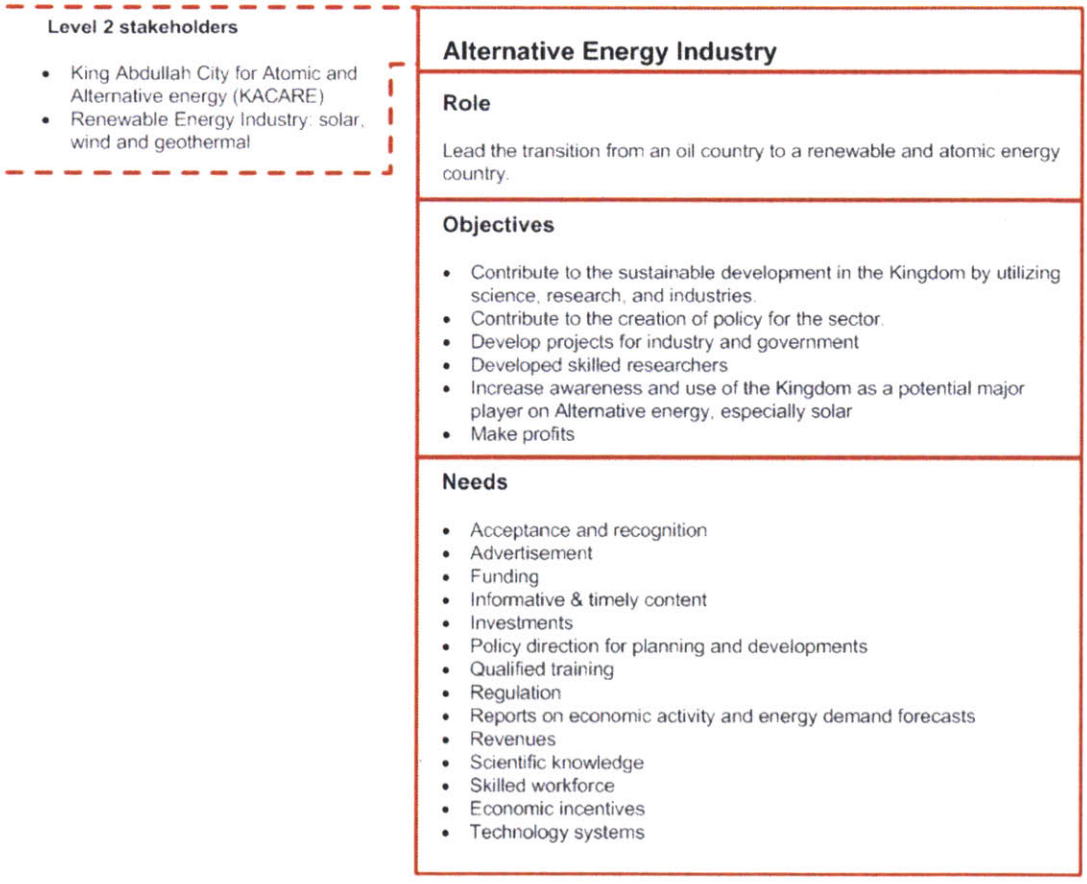

Figure 65 - Characterization Template – Alternative Energy Industry (KACARE, 2010)

People

Role

Become useful members of their society, to love their homeland and take pride in its history

Objectives

- Abide by the Kingdom's laws
- Acquire knowledge and skills
- Contribute towards the nation's unity and welfare
- Cooperate amongst themselves in charity, piety and cohesion

Needs

- Education
- Electricity and Water
- Gas
- Informative & timely content
- Kingdom's achievements
- Protection & Security
- Quality jobs

Figure 66 - Characterization Template – People

Figure 67 - Characterization Template – Universities and Research Centers ("KACST," 2012, "KAPSARC," 2012, "KAUST," 2012, "KFUPM," n.d., "KSU," 2010)

Media

Role

Distribute news, knowledge, information and content

Objectives

- Analyzing and publishing past and present content
- Collecting opinion from the industry and the public
- Make profit

Needs

- News & noteworthy information
- Qualified training
- Regulation
- Skilled workforce

Figure 68 - Characterization Template – Media

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