Sirkka Heinonen and Juho Ruotsalainen

ENERGY FUTURES 2030

Toward the Neo-Growth paradigm of the Sixth-Wave Era

FINLAND FUTURES RESEARCH CENTRE
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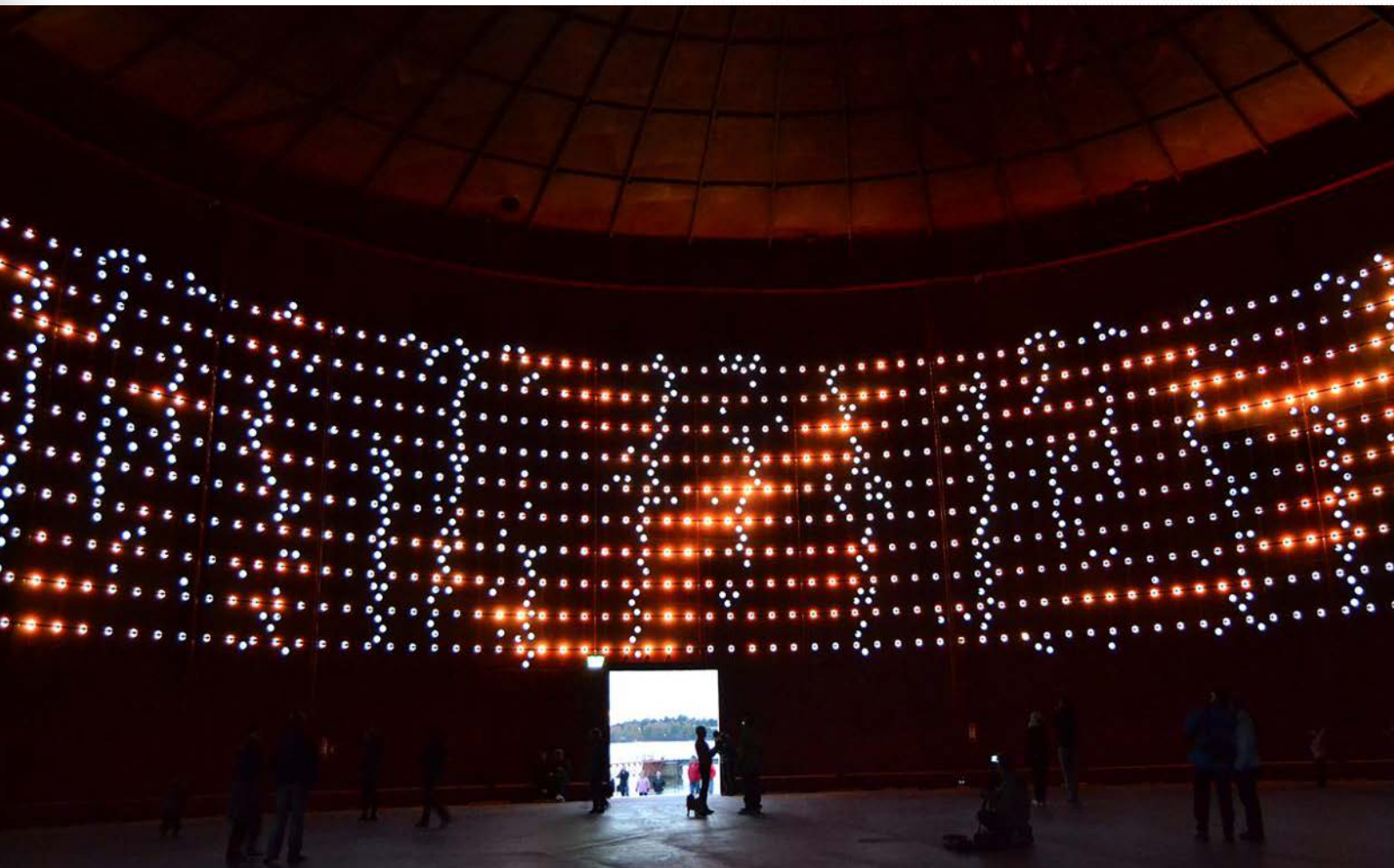

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Cover picture from Kruunuvuorenranta, Helsinki, "Old oil tank converted to environmental art and communal meeting place" © Sirkka Heinonen

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"Energy is eternal delight"

William Blake

PREFACE

As a part of the preparations for the next energy research programme of the Academy of Finland, an anticipatory workshop "Futures Clinique" was commissioned by and held at the Academy on the 3rd of December 2012. The Futures Clinique was planned and conducted by Professor Sirkka Heinonen and Project Researcher Juho Ruotsalainen from the Finland Futures Research Centre (FFRC), University of Turku. The participants included various stakeholders from the current energy research programme of the Academy of Finland and other energy experts as well. The small group sessions were moderated by eight project researchers and advanced students from the Master's Degree Programme in Futures Studies at University of Turku.

This report presents all the results of the Futures Clinique on Energy Futures 2030. They are also intended for the use of all those interested in future developments and prospects of the energy sector in the wider context of societal developments.

The Academy of Finland would like to thank everyone who participated in planning and implementation of the Futures Clinique. Special thanks are owed to the participants who actively attended the workshop process and sessions and contributed to the outcome with their respective expertise.

Helsinki, January 7th, 2013

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ABSTRACT

This report presents the results of the Futures Clinique on *Energy Futures 2030*, conducted in December 2012 to assist in preparations for the new sustainable energy research programme for the Academy of Finland. The aim of the Futures Clinique was to envision the energy system for future Finland. The working reached towards 2030, and was framed by the four generic scenarios as proposed by Jim Dator – Continued Growth, Collapse, Disciplined Society, and Transformation. The concepts of Neo-Growth, Kondratieff's Sixth Wave, and The Third Industrial Revolution, were applied to describe the broad societal change.

The results of the Futures Clinique envisioned a society of distributed energy of diverse energy solutions, local production and consumption, local and responsible lifestyles, bottom-up power relations and systems-sensitive pervasive sustainability.

TIIVISTELMÄ

Tässä raportissa esitellään joulukuussa 2012 järjestetyn "Energy Futures 2030" -Tulevaisuusklinikan tulokset. Tulevaisuusklinikan tarkoituksena oli avustaa Suomen Akatemiaa uuden kestävän energian tutkimusohjelman valmistelussa. Tulevaisuusklinikassa visioitiin ja suunniteltiin tulevaisuuden Suomen energiajärjestelmää. Työskentelyn aikatähtäin asetettiin vuoteen 2030, ja työskentelyä kehystivät Jim Datorin teorian mukaiset "yleiset skenaariot" – Jatkuva Kasvu, Romahdus, Säädelty Yhteiskunta ja Transformatiivinen Yhteiskunta. Työskentelyssä hyödynnettiin lisäksi kokonaisyhteiskunnallista muutosta kuvaavaa kolmea käsitettä: Uuskasvu, Kondratieffin kuudes aalto sekä Kolmas teollinen vallankumous.

Tulevaisuusklinikan tulokset kuvaavat yhteiskuntaa, joka rakentuu hajautetulle, monipuoliselle energiatuotannolle, paikalliselle tuotannolle ja kulutukselle, paikallisille ja vastuullisille elämäntyyleille, alhaalta ylös rakentuville valtasuhteille sekä kaiken läpäisevälle, systeemisestä näkemyksestä ammentavalle kestävyydelle.

1. INTRODUCTION

The need to cut emissions and decrease the ecological footprint of humans is urgent if we are to minimise the would-be catastrophe caused by climate change. We need radical energy innovations – technological, economic, social, cultural, and political – instead of incremental ones, since the time is running out. August 22, 2012 was Earth Overshoot Day, marking the date when humanity exhausted nature's budget for the year. We are now operating in overdraft. For the rest of the year, we grew our ecological deficit by drawing down local resource stocks and accumulating carbon dioxide in the atmosphere. Energy plays a crucial role in the human quest for sustainable futures. (Randers 2012.)

Energy is everything – it is in fact a life enabler. Without energy there would not be life. Energy is deeply linked to the whole of society, as on the most fundamental level society is based on its energy systems. The way we live and arrange our lives affects how we use energy. Today's society is also deeply electronised. The word "electricity" derives from the Gr. ελεκτρον, elektron meaning amber. Already in Ancient Greece electricity was known - electrical effects were produced by rubbing amber. For humans, energy and electricity are now as self-evident as fire used to be. How electronic or how energetic is our future? This is related to the core question: how can humankind in its production and consumption and lifestyles be part of nature – not overspending energy and natural resources but acting as a responsible producer and consumer? (Heinonen & Ruotsalainen 2012).

The Energy Futures 2030 workshop, executed as a Futures Clinique, was framed around three concepts of the dynamics of social change – ***Neo-Growth***, ***Sixth-Wave*** and the ***Third Industrial Revolution*** – which depict the possible near-future development of societies on a very broad and holistic scale. These three concepts have much in common, but they concentrate on different aspects of the future society. Neo-Growth, quite literally, seeks new forms, new definitions and new meanings for growth. Sixth-Wave illustrates the dynamics of economic and societal transformations based on emerging breakthrough technologies. The concept of the Third Industrial Revolution illuminates the connections between energy systems, production patterns and societal structure.

Neo-Growth, Sixth Wave and Third Industrial Revolution have so much in common that at least some of their common features can be assumed to be realised in the future. They all rely on increasing role of immaterial growth. They all point to a future of abundance instead of scarcity. Most importantly, all of them see the future as a distributed and deeply networked one. However, the rise and outcomes of any of these three concepts are by no means predetermined, and they each are highly debatable and include several potentials and alternatives.

We invited the participants of the Energy Futures Clinique to explore energy futures through the options embedded in these new concepts, generate and test emerging ideas and possible innovations. The aim was to create different energy scenarios in the Four Generic Futures framework proposed by Professor Jim Dator (2012), Hawaii Futures Research Centre. These four general scenarios − Continued Growth, Collapse, Disci-

plined Society and Collapse – were to aid in sketching different possible outcomes of the above mentioned societal frameworks and subsequent energy landscapes.

Energy is abundant on Earth. It just needs to be harnessed efficiently and evenly. As an illuminating example, the total sum of solar energy the Earth faces in five days equals all the energy in fossil fuels ever formed (Gelobter 2009). Shell estimates that the global energy demand will be three-folded by 2050 if the current trends of energy consumption continue as they are (http://www.condenast.co.uk/promotions/shell/?page=fe-vid1). This means that either supply needs to be increased accordingly to rising demand, or demand needs to be forced down, or some mix of both. Either supply being arisen or demand being suppressed, both require technological and socio-cultural changes, and make things possible or legitimate that previously were not.

Figure 1. The Futures Clinique began with ideation in small groups, and the groups' results were presented at the end of the day.

2. POSSIBLE SOCIETAL SETTINGS FOR THE UPCOMING YEARS

This chapter presents the three concepts – Neo-Growth, Kondratieff's Sixth Wave, and the Third Industrial Revolution – that frame the whole of future's society, drawing connections between different parts of society and its energy system. They are by no means automations, but argumented projections of future trajectories of societal development as proposed in futures-orientated literature.

2.1 Neo-Growth

Neo-Growth is a concept tentatively sketched and coined by Professor Pentti Malaska (2010). It is a kind of a "positive" version of de-growth as it retains the positive connotations and meanings of growth, but defines growth anew. Neo-growth means economic growth with a dual face: without increasing environmental stress and without decreasing wellbeing in society.

Neo-Growth is a holistic and systems-orientated concept. It encourages finding new sources for growth, synthesising economic and human growth and merging growth with sustainability. It is not yet clearly defined, but at least the following attributes characterise it.

- Growth should have a deeper meaning than mere economic growth. How could economic growth enhance human growth and development, and vice versa?
- All growth should be ecologically sustainable: more has to be produced out of less, and of higher quality.
- Economic growth should be based mainly on immaterial production or on emission-free material production. A Neo-Growth economy is a highly developed service economy.
- Work, sources for growth and the mode of production should be defined anew. This could mean for example prosumerism (the merging of producers and consumers).
- Its lifestyles will be based on the merging of ecological values, individualism and indocollectivism (individual + collective)
- The division between work and leisure will become increasingly or even totally blurred; in principle everything people do, everything they learn, every skill and all knowledge they have can be turned into a productive power.

A neo-growth society can be seen as a "matured" phase or enhanced level of the information society, in which the potentials of information technologies would be thoroughly utilised. The transition is analogical to previous phases of societal development. As Malaska (2010) has noted, in the initial phase of the industrial society, new technologies were used to make the processes and production of agricultural society more efficient. It took a while before the industrial society matured and was able to stand on its own. The same applies

to the information society. From the 1970's to early 2000, information technologies were used to enhance the efficiency and flexibility of industrial processes and production. Now something new is starting to emerge as information and communication technologies are penetrating deep into every sphere of society, especially into immaterial production and social relations. We are entering into a real service economy. Equally crucial is the utilisation of information technologies in other technological fields, such as biotechnology. The convergence of technologies (NBIC – nano, bio, info, cogno) (Roco & Bainbridge 2003) would have radical effects on practically everything, especially on energy systems.

> How would you define neo-growth, and what kind of neo-growth would you prefer?

2.2 Sixth Wave

The Sixth Wave refers to the theory of long-term economic cycles of modern societies, each lasting for 40-60 years. Since the dawn of industrialisation (the end of 18th century) there have been five Kondratieff waves, and the sixth is expected to be rising at the moment. A cycle or wave begins with some major technological innovation spurring economic growth and supplying the central demands, needs and values of the era. The cycle fades off as the growth potential of that technology is used, and as society has changed so that new technologies are required to answer new kinds of needs.

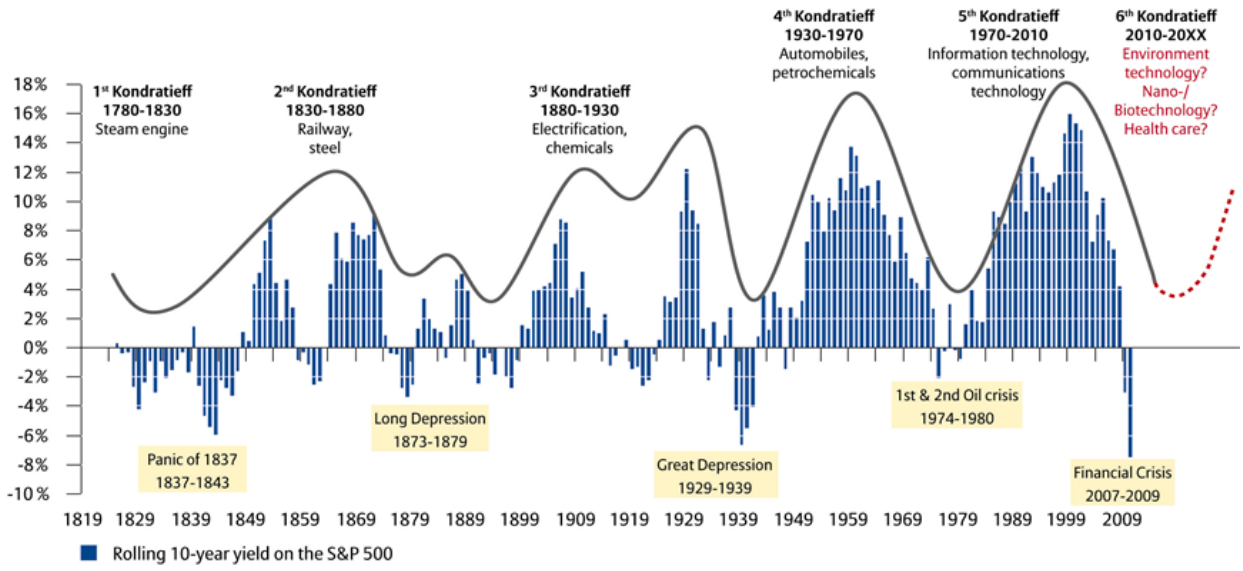


Figure 2. Six Kondratieff Waves and their decisive technologies (Allianz 2009).

The fifth wave (~1975–~2010) was ignited by the construction of basic information technology infrastructure and its initial utilization: the microchip, personal computer, internet/www, mobile phone etc. They were especially used to manage the liberated economy. Now, the sixth wave is anticipated to emerge from **a)** the urgency

for ecological sustainability and **b)** immaterial values of self-expression and identity building. New environmental technologies and the ubiquitous ICT, especially the internet, are to become the core technologies supplying these demands.

Equally important as emerging wave's effects on economy are its effects on culture and values – the whole functioning of society is based on the fundamental values of each era. The economic leaders – nations, corporations, individuals – have always significantly shaped the values of each era by making them legitimate. Thus as the economic potentials of green/clean technologies are being actualized, simultaneously the rise of, or the legitimization of, ecological values can be anticipated.

The sixth wave will, however, bring along other significant changes in values as well. The waves prior to the fifth wave were part of the industrial era, and embodied values of material growth, nationalism, rationalism, efficiency, bureaucratic hierarchy and monoculture. The information society, or the fifth wave, retained some of these values, abolished others and brought along new ones. Nationalism and monoculture paved way to globalism and multiculturalism, rationalism was partially replaced by artistic and creative pursues, and immaterial values began to gain ground.

During the sixth-wave, aside ecological values, immaterial values are presumed to gain more ground. The internet with its huge supply of contents, immaterial products and networked communities offers a firm backbone for hyper-individualised lifestyles seeking for personal meanings of life. However, the internet does not only enforce individuality, but aids forming communities and networks, and thus opens ground for a new kind of social structure based equally on a mix of individualism and collectivism (so called indo-collectivism) (Dator 2012b). This development can lead to the restructuring of power relations in society: the society and its functions will be increasingly structured from the bottom-up.

What kind of potentials does the Sixth Wave hold for Finland?

2.3 The Distributed Society and the Third Industrial Revolution

According to Global Trends think tank, the most crucial trend in the coming years will be the ever deepening networks: **we are moving towards a distributed world** (The Global Trends Report 2013, 2012). Production, consumption and decision-making are becoming increasingly distributed as producers, consumers, companies, politicians, citizens etc. co-create solutions and experiences. Disperse networks are becoming the key organising mechanism for innovation, production and consumption. In a distributed world, relationships and partnering become critical for societies, organisations and citizens: delivering on rising and complex demands and addressing complex issues and vicious problems is more than one actor can do alone. Power is being distributed as well as individuals become increasingly networked, tapping into the wisdom of friends and digital & physical communities – shifting relationships from one-to-one to many-to-many. (Ibid.)

Furthermore, new energy technologies have a fundamental role in the shaping of the new societal structure, reaching beyond mere economic and environmental gains. New energy technologies are contributing to the distributed society as significantly as the information technologies. Jeremy Rifkin (2011) claims that all great

societal and economic revolutions occur **when new communications technologies converge with new energy systems**; neither of them alone is enough. Energy systems provide the basic cogwheels of society and economy, and information technologies are used to manage and coordinate that system.

We may now be facing the third industrial revolution after the phase led by oil and the mass media. To put it simple, the oil-led phase (the second industrial revolution) was a centralized and hierarchical one. Energy production was concentrated in the hands of a few, and the system was coordinated by the mass media (one-to-many) of newspapers, radio and television, and "individual" media such as the telephone (one-to-one). Both production and consumption were equipped with the prefix "mass". Centralized forms of communication were used to manage the economy of centralised energy and centralised businesses.

Post-Carbon paradigm is now emerging. The corresponding Post-Carbon Strategy is concerned with providing information and analysis, as well as innovative solutions for dealing with climate change, energy scarcity, overconsumption, and other issues related to sustainability and long term social resilience. The EU has currently a research call for proposals on Post-Carbon Cities. All over the globe several countries and cities have Post-Carbon Programmes. Previously the related discourse was mainly on Low-Carbon, Carbon-Neutral, Eco or Green Societies or cities. The concept of Post-Carbon makes the demands considerably higher.[1]

As opposite to oil, renewable energy resources are abundantly everywhere. Analogously, the internet is a networked, ubiquitous many-to-many media. The synergy of renewable energy and the internet may be leading us to a **distributed and collaborative society and green economy**. According to Rifkin, in the coming post-oil era, people will produce their own green energy in their homes, offices, and factories and share it with each other on an **"energy internet"**, just like we now create and share information online. Instead of economic activity being driven by "elite" energy, such as oil and gas, only found in a few places and being expensive to recover and distribute, we will have access to "democratic" energy. As ordinary citizens gain access to cheap and abundant energy, their power will presumably increase in an unprecedented way.

In the age of enhanced individualism and fertile grass-roots, it is pivotal to take the civil society seriously in all functions of society, from the energy system to production to decision making. Digital technologies together with abundant renewable energy are making difficult and expensive tasks easy and cheap. We are only just begun to see the rise of so called *generative technologies*, such as a PC, a blog or a 3D printer, which are enabling ordinary people to do things that earlier were possible only for large organisations.

> What does the third industrial revolution and the distributed society mean for energy systems, and in what ways could the trend of "distributed innovations" be utilised for energy innovations?

[1] A Low-Carbon Economy (LCE), Low-Fossil-Fuel Economy or Decarbonised Economy is an economy that has a minimal output of greenhouse gas (GHG) emissions into the environment biosphere, but specifically refers to the greenhouse gas carbon dioxide.

3. FOUR GENERIC IMAGES OF THE FUTURE BY JIM DATOR

Despite the emphasis on environmental issues of the concepts of neo-growth, sixth-wave, and the third industrial revolution, the outcome of any of these societies is not predetermined – if they are to become reality at all. A crucial question is: how will the values of the future society relate to sustainability? Immaterial values, such as the search for an individually meaningful life, are linked to the (mega)trend of individualisation, which in turn emphasises the rights and liberties of an individual, which often are in contradiction with ecological sustainability. Sustainability presumably requires sacrifices from individual needs.

Furthermore, it is often neglected that "immaterial" economy itself consumes plenty of energy and resources as well, and generates hazardous electronic waste (Heinonen et al. 2001). Digital processing and digital technologies are becoming abundant and ubiquitous, but their effects on the energy and resources consumption are not yet thoroughly inspected. According to a research by the New York Times, data centers, the very backbones of the emerging society, consume vast amounts of energy (Glanz 2012). The Moore's Law, which means that the amount of transistor in one microchip is doubled every 18 months, is downgrading the basic technologies and gadgets we use obsolete at an unprecedented rate – and producing massive amounts of waste. We also face the dilemma of "obsolete planning" where products are intentionally designed for a short lifecycle.

The new Post-Carbon distributed era of "sustainable development", "immaterial" consumption and deeply networked societies incorporates numerous potentials possibly to be actualised. It is a crucial task to inspect these potentials more closely, and map the possible futures that can become reality. Therefore, in the Energy Futures 2030 workshop, energy futures and future societal settings were scrutinised through Four Generic Futures by Professor Jim Dator (2012). The purpose was that in this way the positive and negative aspects, and also different possibilities of "sustainable development" and "green society" would be handled openly and systemically. Radical innovations and trajectories for energy use and systems for 2030 were also explored within these generic frameworks.

Dator (ibid.) states that all future images or scenarios – of citizens', corporations', politicians', found in media etc – can be fitted into the framework of these four generic scenarios, based on his large empirical study of the existing future descriptions. The Four Generic Futures by Jim Dator are:

1) Continued Growth,
2) Collapse,
3) Disciplined Society, and
4) Transformation.

Continued Growth Scenario

The Continued Growth scenario refers to a continuation of today's cherished trends and values. It is a Business-as-usual scenario, and emphasises economic growth. It is the official view of the future everywhere, by far the most dominant of the future images.

The Continued Growth group in this Energy Futures Clinique concentrated on **finding ways to combine Continued Growth with sustainability.**

Collapse Scenario

The Collapse scenario means a total ecological, economic, social, cultural and political collapse of society. Collapse can also refer to a collapse of some specific sphere of society. An ecological collapse would cause collapses in other spheres of the society, too.

The Collapsed Society group in this Energy Futures Clinique concentrated on **finding solutions that would steer society back on the sustainable path after a global collapse of societies**.

Disciplined Society Scenario

Disciplined Society almost equals sustainable development, but is more comprehensive: the whole ethos of society is based on "pragmatic" ecological values. It is a kind of mix of Continuous Growth and Transformation: the society is highly regulated to ensure sustainability, but without deep transformations. The economy is based on green growth.

The Disciplined Society group in this Energy Futures Clinique concentrated on **regulatory systems and on lifestyles based on ecological values.**

Transformation Scenario

A transformational future is one which has gone through deep structural and systemic changes which have transformed all the spheres of society reaching from economics and politics to values and lifestyles. Thinking of transformations requires constant criticism, radical mindset and stepping out of conventional concepts and notions.

The Transformed Society group in this Energy Futures Clinique concentrated on **deep structural changes in society.**

1. ANSWERS TO THE PRE-ASSIGNMENT

Prior to the workshop, two preliminary questions were posed and sent to the participants. The first question was about radical sustainable energy solutions, and the other was about how to combine sustainability with rising standards of living. The idea of addressing the participants already prior to the workshop is part of the specially structured Futures Clinique process (Heinonen & Ruotsalainen 2013). This procedure is aimed at on one hand engaging the participants in building the contents of the workshop and on the other hand orientating them to thinking proactively about the issue to be tackled during the workshop. The questions and the answers thus received are presented below.

4.1 Radical sustainable energy solutions

The second pre-assignment question that was posed to the participants registered for the Energy Futures 2030 workshop and the replies received before the actual workshop were the following.

Can you mention some radical sustainable energy solutions that are not possible or acknowledged yet, but could/should be?

Answer no. 1

The production of food, its availability, and the health benefits/disbenefits related to it are spread unevenly globally.

In affluent western countries there's too much energy stored in humans, as in poorer countries people are starving and there is a shortage on energy. Both the lack and excess of food causes diseases and other unwelcomed consequences.

According to an internet analogy, the excess energy people eat could be harnessed e.g. with smart clothing and fed into a shared energy network. In the future donating energy could be compared to donating blood.

This would bring a lot of health and economic benefits besides providing dispersed energy.

Answer no. 2

I think that biosolar energy is one of the most promising ways to produce truly green energy and I hope that it will became efficient enough to be viable option http://web.mit.edu/newsoffice/2012/biosolar-0203.html.

I think one radical solution could be "a limited energy right" which defines the amount every citizen can use energy yearly, so the energy use would be measured all the time and if the limit is exceeded there are remarkable penalties

Answer no. 3

Using human as the source of energy. This can be done in different ways. For example, the energy can be produced from a person's movements like walking or exercising.

Answer no. 4

From supplying energy to providing energy services. Key points:

- end-users' direct access to the spot price based energy market
- aim at a system where end users are charged by the "quality" of their
- connection to the energy system rather than their energy consumption.

The global challenges of the 21st century marked a turning point in the energy market, stressing the limits of an energy system infrastructure largely thought to meet the needs of a highly centralized, primarily carbon based, energy network. A crucial element for the achievement of a sustainable energy strategy, especially in the North, will have to be based on the development of instruments and analytical tools for the efficient utilization of decentralized energy solutions based on locally available renewable energy resources; a set of technologies we today generically refer to as smart energy grids.

A smart energy grid can be briefly described as an energy production, transmission and distribution based on a two ways communication between energy supplier and consumers, now better described as energy providers and users.

In a system where single – or small groups of – end users constitute individual micro-grids, with direct access to an energy market defined by spot, the role of the energy providers is likely to (even expected to) shift from the supply of energy to the supply of energy services. The energy providers role will then be to understand and monitor the development of the smart energy network in order to guarantee energy security, maintain power quality, provide technical support (at the energy infrastructure and information level), adapt their energy policies to the long term effects on the overall energy consumptions profile, etc.

It is my personal believe that the main challenges for the deployment of these system is cultural in nature rather than technical or technological.

Answer no. 5

Any project in every company, no matter which industry, service or manufacturing, is forced to have the "sustainable" justification and implementation. Voluntary work and organizations with power to influence. Stop of production and usage of cars, flights, and other vehicle which use fossil fuels.

Answer no. 6

Moving to hydrogen society by 2050:

Today we rely mainly on electricity as the energy carrier. Storing of electricity is a problem and no good technological solutions are available. Hydrogen, as an alternative energy carrier is easily storable. Hydrogen can be used as fuel for transport, heating, CHP or production of electricity, without any pollution. Use of hydrogen

could be the best solution for storing and regulating energy from solar and wind power units, to help stabilizing the electric network.

Answer no. 7

- Harnessing and utilizing the energy of lightnings
- Harnessing energy from e.g. sports devices and peoples' movements (roads, stairs etc.)
- Harnessing tectonic warmth from very deep

Answer no. 8

This is a combined answer to both questions.

In the background paper it is mentioned that the organisational paradigm of society is changing from bureaucratic hierarchies and unidirectional communication patterns with easily distinguishable power centers to something that could be described almost as a form of anarchy. This shift by itself releases a lot of energy, that was used to keep the hierarchical systems going. Though the industrial mind might boast of being highly efficient, it actually produces huge amount of waste on every step. First step towards balancing the economic expectations of civilization with the environmental sustainability is reinventing efficiency of all processes, including energy production, distribution and consumption.

The largest challenge here is not the efficiency itself, but a fast and "bloodless" demolition of the obsolete and highly inefficient energy production/distribution companies and their networks. They say that a problem cannot be solved within a mindset that has created it - this is a screaming case for this saying. Most of large corporations know that there is no place for them in the lean thinking, highly networked and efficient world of tomorrow's prosumers. That is exactly why it takes so long to make the transition - the ones in power now are prolonging the present hoping that tomorrow never comes. Which obviously is a question of politics.

Also – the portable ICT devices that are now used mainly for launching birds onto pigs can be likewise used for e.g. remote energy efficiency control of households – who needs hot water or warm radiators while he is on a weekend trip to country or even at work for 8 hours per day?

Answer no. 9

Space Solar Power. This avoids to large extent the intermittent nature of solar power.

Answer no. 10

First a comment: Whatever will be done here with 5.3 million people effects globally only as a good example, nothing else. It is most important that such countries as China, USA and India will also make reasonable energy solutions. Finland cannot allow its economy to suffer by making more expensive energy solutions than the countries operating in the same markets.

Much can be done globally for example with traffic: fast shift from traditional cars to plug-in hybrid technology. Small economic diesel engines are used in long distance driving and electricity in city area ing. Then maximum allowed speed should be about 120 km/h globally in highways. In addition, all the buses

at the city area should be operated with landfill gas (which is regarded as renewable energy). The strongly decreased gasoline consumption in traffic may then enable to use biodiesel in small cars at large portion to replace mineral-oil-based gasoline and diesel. Unfortunately this will increase electricity consumption forcing to increase electricity production. As for the CO2 free sources of electricity, biomass, wind and solar electricity cannot cover the whole gap. In addition, it may be necessary to increase also nuclear power capacity.

I am combustion specialist. In that area all solutions which decrease CO2 production are welcomed. Closest to my work is the better utilisation of waste and agro biomass in energy production. This needs research because such fuels can damage the power plant constructions if there is lack of information how to produce energy from such biomass.

Answer no. 11

- Large scale wave energy.
- Heating based on biowaste decomposers.

Answer no. 12

- Producing energy by solar power e.g. in Sahara or somewhere else on the equator, and distributed across Africa, Europe and Asia. This is however a difficult matter politically (security, power, costs etc)
- Producing energy from hydrogen. Hydrogen is abundant almost everywhere. The problems are related to security and technology.

Answer no. 13

Satellites that beam solar power to receivers on land; wind machines that hover in the atmosphere and generating electricity.

4.2 The paradox between sustainable development and rising standards of living

The first pre-assignment question that was posed to the participants registered for the Energy Futures 2030 workshop and the replies received before the actual workshop, were the following.

Can you name one or a few ways to solve the paradox between ecological sustainability and rising standards of living?

Answer no. 1

The paradox between sustainable development and the rising standards of living can be solved by a change in culture (which would be slow). The change affecting culture and peoples' values and conduct could be aided in many ways. Cutting the ecological footprint should also be made economically profitable.

Although the efficiency in producing and consuming energy would increase significantly in the future, this would not be enough in solving the problem. If consuming and "green consuming" keep on growing in the future, the result can be an even larger "green" footprint. That's why solutions decreasing consumption should be utilized as a broad palette, and the criteria for "green" perhaps tightened.

A few examples on how to cut consumption:

- Utilizing similar means and campaigns as in fighting smoking. Non-smoking has become a norm in campuses, workplaces, cafes, restaurants, balconies etc. This development is largely due to the changes in values and attitudes. Few of the young smokes anymore. A cultural change is possible.
- Using deposits in recycling as is now done in bottle recycling.
- A service which lets the consumer rent of borrow almost anything!
- Second hand markets and services could be developed further.
- Regional logistical solutions could save a lot of peoples' time and energy.
- Enterprises could be obligated to e.g. prolong the life cycles of their products.
- Creating attracting images and affecting peoples' identity and consumer behavior through marketing, taxation, pricing, propaganda, laws and restrictions/punishments.

Answer no. 2

I think this can be used as an answer to the first question as well. It is crucial to challenge the idea that rise of the standard of living equals with growth. In other words I believe it is possible to reduce ecological footprint and at the same time raise the standard of living. Examples include gardening as a hobby instead of traveling and buying factory farm's products, doing social activities with friends and family members regularly instead of more material and energy consuming entertaining activities, spending more time in the nature instead of sticking to the computers, TVs and all electrical devices, listening to live music played by friends and family members instead of from speakers, cycling instead of using cars or buses.

It is possible to make all these happen easily. For example by adding the cost of ecological footprint to the price of everything and introducing the substitutes people will change their behaviour.

Answer no. 3

The problem of relationships between economic growth and environmental harm is not easy one. Economic growth is usually associated with the GDP. But well-being of the society is not only about money and the GDP growth. As it is shown by Tim Jackson, some non-wealthy countries could be even happier than much richer countries, mainly because GDP cannot be an indicator of well-being of society. Therefore, if we want to live in a strong and healthy society within environmental limits, values of society should be changed. And in network society the promotion of such issues as sustainability, resource scarcity, respect for future generation as well as what is happiness and well-being should be widely discussed. Internet forums, universities' and schools' programs, TV-programs should focus on environmental issues and values. (I just remembered that one Russian politician told lately during the conference that most media companies in Russia are owned by Energy companies). Also, I believe that legislation should promote the sustainability as well, so it is embedded in the real business (sustainable accounting, environmentally friendly investments). The problem is that every country is different and they need their own ways to move towards sustainability. But the more actions are taken and issues are discussed, the more attention it will take. Developed countries should give examples to others to encourage them.

Tim Jackson shows in his book that it is possible to envision the sustainable world with high level of well-being, but without increasing GDP. Also societies are striving now to obsolete decoupling of CO2 emissions from economic growth, but current economic system and consumerism do not let it so far. As it is said "The human animal is a beast that dies and if he's got money he buys and buys and buys". I like the idea of meaningful life and focus on essentials. The world which Tim Jackson describes includes: investments in "public good" (sport facilities, libraries, parks); Investments are vital, but the aim of the investments is ecological transformation; "shared" and participatory work; manufacturing will need to pay more attention to durability and reparability and so on.

I will agree with Jackson in the sense that I do not believe that sustainable investments or new technologies will save the world. People's values should be developed or changed towards sustainable values and meaningful life.

Answer no. 4

I have no answer as I do not understand the concept of immaterial economy. To my best understanding all kinds of material is absolutely necessary for all our basic needs; we cannot live in social media and internet.

Answer no. 5

- Change in values so that a good standard of living doesn't mean excessive material competition
- Changes in laws so that households and communities would be forced towards a completely eco-friendly consumption

Answer no. 6

In my view the solution is control of population growth. On the other hand the nationalisation (case Venezuela) of natural resources results in material efficiency to increase.

Answer no. 7

- Selective growth in particular sectors that are less harmful to the environment (=less energy intensive).
- The vicious circle from luxury products to mass production could be broken. Let's keep luxury luxurious: only to be used in special occasions, not on daily basis.

Answer no. 8

I'm sceptic if there are any solutions to achieve real "sustainable development" at all. I would, however, like to believe that resource-efficiency, recycling and bio economy could offer some solutions. These should be realized through changes in economy, technology and culture.

Answer no. 9

1) Better global governance is the key to managing both globalization and the global environment. Globalization thus helps to sustain the illusion among the rich and powerful that the limits to material growth have been permanently abolished and eliminates any reason to question the prevailing expansionist myth.
2) Managing institutional fragmentation
3) Establishing sustainable development as a common goal
4) Finding new and meaningful ways to engage non-state actors from business and civil society.
5) We can highlight the dangers in this situation through international comparison.

2. WORKSHOP RESULTS

The results of the workshop are presented in chronological order in this chapter: the Futures Wheel, PESTEC table and Scenario Narrative of each group. The participants were divided into eight small groups. Each generic scenario in Dator's (2012) framework was addressed by two groups. The working was divided into three sessions (see a detailed description of the sessions in the following sub-chapters). In Session I the groups filled the Futures Wheel. In Session II the ideas gathered on the Futures Wheel were elaborated on a PESTEC table. In the Session III the groups finalised and summarised their ideation as a Scenario Narrative. After the sessions each group presented its Scenario Narrative to the other groups.

The whole workshop was organised as a Futures Clinique, as developed at Finland Futures Research Centre (FFRC). A Futures Clinique is a participatory and exploratory futures workshop and a collective futures research method to tackle uncertainties, identify disruptions and generate innovations. The Futures Clinique aims at a) promoting futures thinking, futures preparedness and provocative futures dialogue, and at b) harnessing collaborative creativity for insights, innovative ideas and practical solutions to the selected futures topics. (Heinonen & Ruotsalainen 2013.)

The Futures Wheel is a foresight method developed by Jerome Glenn of the Millennium Project. The method of Futures Wheel is used to give the ideation and discussion a structure. A Futures Wheel consists basically of an inner and outer circle (= wheel) drawn to a large sheet of paper (approx. 2 metres x 1 metre). Ideas evolved in the initial discussion dealing with general issues on the topic are written down to post it pads and placed on the inner wheel. This phase usually lasts for an hour. The outer circle can be used to elaborate and develop the ideas gathered on the inner circle, and especially to ideate practical solutions and innovation. The Futures Wheel method is however a very versatile one. For example, in this Futures Clinique to the center of the wheel were gathered ideas on the ideal society, and technological solutions already on the inner wheel.

The Futures Table is a matrix tackling the issue under study from different dimensions and as multiple variants. The Futures Table applied here was PESTEC Table, analysing the topic from political (=P), economic (=E), social (=S), ecological (=E), as well as cultural, citizen and customer (=C) dimensions.

5.1 Continued Growth Scenario

Scenario Summary

The following array of the input from small group sessions summarises the results of Groups' 1 and 2 workings in a form of a scenario sketch. The joint task for Groups 1 and 2 was to find ways to combine Continued Growth ("business-as-usual" scenario) with sustainability.

- In the world of continued growth, **long-term perspectives and foresight** are needed, so that better plans can be composed and implemented. The situation of continued growth is a very **volatile** one, so it is especially crucial to look further forward than a few months or a few years.

- **Zero-carbon society, resource efficiency** and associated clean technologies have provided **a prosperous export industry** for Finland.
- Especially the **abundant bio-mass resources** of Finland are used and managed intelligently to produce consumer goods, chemicals, energy products such as liquid biofuels and hydrogen, and bio-materials to replace plastics.
- Companies – including e.g. oil and car industries – have kept on **maximizing their profits** by all means possible, which means lobbying has increased significantly compared to first decade of the millennium. Highly developed **transparency** is however applied to regulate corporate interests and mitigate their negative effects on society and the environment.
- **To foster both growth and sustainability**, stress has been put on **research and innovation policy and investments in R&D**. CleanTech has become a Finnish export success story.
- **Traditional institutions and actors have remained in power** -> but **traditional policy instruments** (such as legislation and subsidies) are implemented **efficiently and innovatively**.
- Alongside "official" and traditional means, the **importance of civil society and NGOs is however recognised, and people are empowered** through different means to produce their own energy and innovate. So the solutions to manage the society are a mix of centralised and distributed approaches.
- **Global agreements are needed to cut CO2 emissions**; nations have recognised that because they will be striving for more growth, they must come together for firm solutions to constrain their "urges".
- The same applies on the **individual level**: people's almost inherent desire for increasing well-being is recognised, so resources are allocated to **environmental education** starting from kindergartens.
- **Solutions are to a large extent technological**, so ubiquitous and smart technologies are highly developed. Ubiquitous ICT enables to **maximise the efficiency of every function**.
- **Old technologies are being replaced, but gradually** so that costs are minimised.
- **Values** are based on **freedom and individual choices**, so a special emphasis has been put to minimise and regulate their negative effects
- As **material production still reigns**, **recycling** is developed as extremely efficient (zero-waste)
- Different energy forms are accepted, including **nuclear energy**. Nuclear energy is in its **renaissance**, as it provides massive amounts of energy without CO2 emissions.
- **Work and production provide for the meaning of life**, but in a different way than in the beginning of the century: work requires constant learning, and the concept of **life-long learning has transformed into developing oneself holistically as a human being**, not only as a worker.
- **Transformations** have also occurred: living, production and consumption have become increasingly local, energy production is increasingly distributed, alongside centralised solutions such as nuclear energy, work is done increasingly at home thus decreasing traffic, houses have become zero-energy houses producing their own energy from various sources, social life has become increasingly virtualised.

5.1.1 Continued Growth Scenario by Group 1

Participants : Marianna Mäki-Teeri/University of Turku (moderator), Mia Aarnio/Finnish Meteorological Institute, Pedro Fardim/Åbo Akademi University, Arja Kallio/Academy of Finland, Jaana Roos/Academy of Finland, Kari Törrönen/EnergyWave Ltd.

Futures Wheel by Group 1

This section presents the Futures Wheel of Group 1 as documented from the paper version, elaborated during the group session. The Futures Wheel working phase began by the group discussing from each participant's own point of view what the ideal sustainable society would be like. The ideas gathered in the discussion are presented right after the Futures Wheel. After discussing the ideal society, the group started to fill elements onto the **inner circle**. The group discussed and ideated **technologies/practices** that are **promising and interesting** in terms of sustainable energy production. After the inner circle the group moved on to the **outer circle**. On the outer circle the group discussed and ideated **ways of how to combine Continued Growth ("business-as-usual" scenario) with sustainability**.

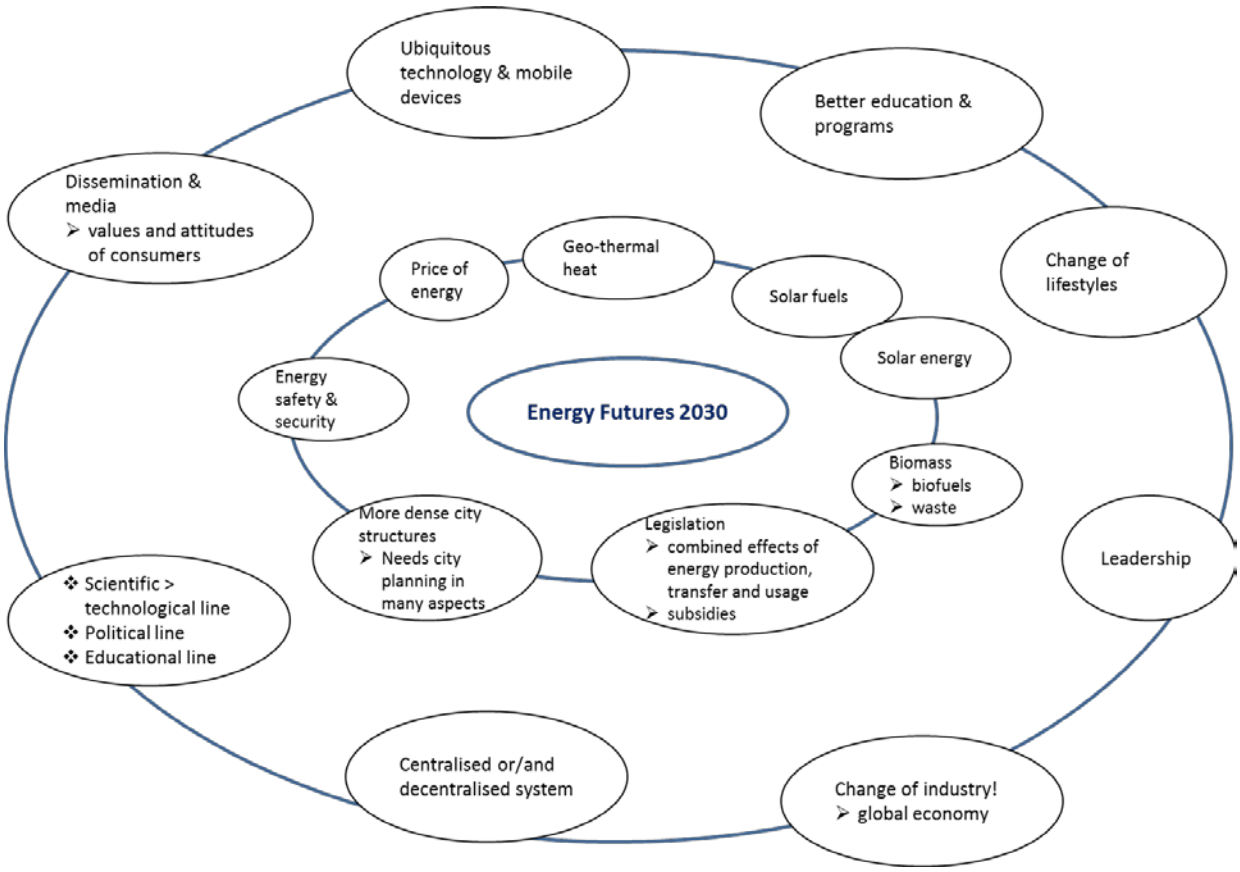


Figure 3. The Futures Wheel elaborated by Group 1.

Ideas on the ideal society of sustainable growth and well-being

The following ideas on the ideal society of sustainable growth and well-being were selected to the centre of the wheel:

- No growth or negative growth? > Well-being without economic growth
- Recycling and re-use & solutions made with low resources
- Values and attitudes
    - Equality
    - Green values
    - Value of nature
    - Democracy?
    - Producing sustainable products (not disposables)!
    - From short term focus to long-term focus in development and design
    - Health and climate aspects of changes in tech
- Bio economy & hydrogen society
- Better education > knowledge/skills –based society

Drivers by Group 1

In the beginning of Session 1, each group voted for 6 drivers from a drivers list (see Appendix 2) that they found important and interesting in relation to the formation of futures societies. Below are presented the six most voted drivers by Group 1.

Megatrends

1. Climate change
2. Prospering global population, rise of middle-class (especially in China)

Trends

1. Claims for heightened productivity
2. Abundant flows of information, related fast pace of changes and possible short-sightedness

Weak signals

1. Neo-communality (people are communicating and forming communities increasingly, but still retaining their individuality
2. Biomimics (mimicking the models, processes and structures found in nature)

PESTEC table by Group 1

In Session 2 the groups worked on their PESTEC table. The groups first discussed and defined their preferred future within the framework of their generic scenario based on the ideas generated in Session 1. After reaching consensus on the "definition of the preferred future", the groups gave it an illuminating name.

The groups then began to fill in the PESTEC table: defined the most important measures, steps and pre-conditions on all dimensions of PESTEC to achieve the preferred future within their scenario framework. The groups could use the ideas already gathered during the previous ideation session and come up with new ones.

Table 1. PESTEC Table constructed by Group 1.

PESTEC	MULTI-SOURCE ENERGY & KNOWLEDGE BASED SOCIETY 2030				
Political	Change of values and attitudes	Long-term perspectives needed	Lobbying ➢ oil/car industry ➢ transparency needed!	EU-directives vs. national legislation (Finnish views!)	Research & innovation policy ➢ R&D&I funding
Economic	Security &safety ➢ e.g. H2 cars & gas buses > transport ➢ industry &households > price, availability, reliability	Policy instruments ➢ legislation ➢ subsidies ➢ price of energy	Health effects ➢ diseases ➢ mortality > transport, combustion techniques	Clean-tech one of the Finnish export areas	European energy market ➢ integration ➢ price ➢ local/regional solutions
Social	Focused and quality of education	Skills & learning in information society			
Technological	Ubiquitous intelligent design/ products	Communication technologies ➢ remote meetings ➢ distance working	Management systems of decentralised energy (net production)	Solar and H2-technologies=key technologies	Biofuels & nuclear power= transition sources of power
Environmental	Life cycle analysis & ecological footprint	Emissions & health effects			
Cultural/ Customer/ citizen	Values and attitude change	Emissions & health effects	Non-governmental movements (and organisations) ➢ "food from waste"	Prosumerism ➢ city cars	

Scenario Narrative by Group 1

In Session 3 the groups composed a scenario narrative, which would vividly describe the societal setting and energy landscape of 2030 framed by and built on the group's given generic scenario, the group's preferred future, the most voted drivers and the ideas generated for the futures wheel and the PESTEC table (Sessions 1 & 2). In addition the concepts of Neo-Growth, Sixth-Wave and the Third Industrial Revolution could also be used in the ideation process if the group so wanted. The scenario narrative by Group 1 is presented below.

Scenario narrative:

Multi-source energy & knowledge-based society 2030

As seen through the eyes of the Clean-Tech Guy

- Wakes up in the morning
- Breakfast=local food/ food from waste
- Distance work > no need for traffic
- Zero energy house
  - Multi-source energy house
    - Geo-thermal energy
    - Solar energy > income from surplus energy
    - Wood (Note! Combustion technology/habits
- Ubiquitous technology > energy consumption measurement & smart management
- Cultivation of the food > vertical farming
- Lives in s smart city > use of city/ H_2 cars and public transportation
- Work life has changed / his job clean-tech guy
  - Lifelong learning: new skills and education
  - Video meetings
  - Biomimics > structures and processes
  - Productivity of work has increased (measurement of productivity)
  - Multi-national company
- Social life
  - Virtual communities
  - Public/private spaces: joint saunas
  - Public complexity? How about the poor/unskilled people? Conflicts?
  - Values: Sustainable growth, individual choices, freedom

Hot Topics for Further Research Suggested by Group 1:

- Technical solutions: H_2 and solar energy
- Energy systems > management of de-centralized energy system
- Energy efficiency + transfer + storage
- Material recycling
- Safety of e.g. nuclear & geo-thermal energy
- Acceptance of different energy forms

5.1.2 Continued Growth Scenario by Group 2

Participants: Mohammad Mehr (moderator)/University of Turku, Päivi Aarnio/Helsinki Region Environmental Services Authority, Pertti Kauranen/VTT, Yury Nikulin/University of Turku.

Futures Wheel by Group 2

This section presents the Futures Wheel of Group 2 as documented from the paper version, elaborated during the group session. The Futures Wheel working phase began by the group discussing from each participant's own point of view what **the ideal sustainable society would be like**. The ideas gathered in the discussion are presented right after the Futures Wheel. After discussing the ideal society, the group started to fill elements onto the **inner circle**. The group discussed and ideated **technologies/practices** that are **promising and interesting** in terms of sustainable energy production. After the inner circle was done, the group moved on to the **outer circle**. On the outer circle the group discussed and ideated **ways of how to combine Continued Growth ("business-as-usual" scenario) with sustainability**.

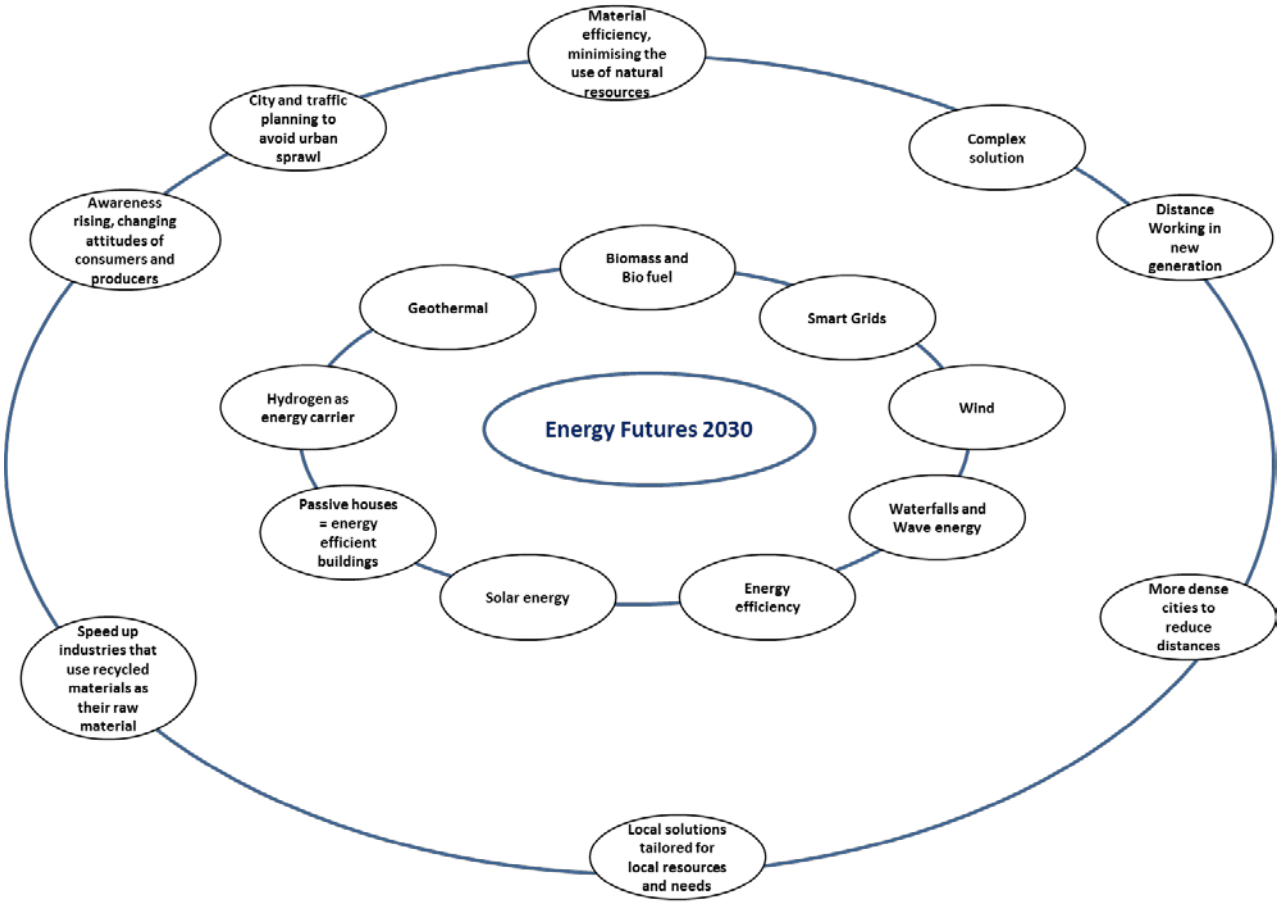


Figure 4. The Futures Wheel elaborated by Group 2.

Ideas on the ideal society of sustainable growth and well-being

The following ideas on the ideal society of sustainable growth and well-being were selected to the centre of the wheel:

- Energy efficiency
- Material efficiency
- Self-motivation and social benefit
- Recycling – No waste
- Forerunner in cleantech exports
- Happy people with sufficient money for primary needs
- Renewable energy sources

Drivers by Group 2

In the beginning of Session 1, each group voted for 6 drivers from a drivers list (see AQppendix 2) that they found important and interesting in relation to the formation of futures societies. The six most voted drivers by Group 2 are presented below.

Megatrends

1) Climate change
2) Population growth

Trends

1) Clean tech
2) Rise of BRICS countries

Weak signals

1) Self-sufficiency
2) Biomimics

PESTEC Table by Group 2

In Session 2 the groups worked on their PESTEC table. The groups first discussed and defined their preferred future within the framework of their generic scenario based on the ideas generated in Session 1. After reaching consensus on the "definition of the preferred future", the groups gave it an illuminating name.

The groups then began to fill in the PESTEC Table: defined the most important measures, steps and pre-conditions on all dimensions of PESTEC to achieve the preferred future within their scenario framework. The groups could use the ideas already gathered in the previous ideation session and come up with new ones.

Table 2. PESTEC table constructed by Group 2.

PESTEC	Smart energy system combining central power stations and decentralized generation			
Political	- Promotion of distributed generation. - International agreements on Power/energy distribution	- Tax Credits - Nuclear Power	Feed in Tariffs	International agreements on cutting CO2
Economic	- Energy companies become system operators - Gradual replacement of old technologies	- Optimisation of market conditions - New jobs e.g. Economics of scale	- Emission trading	- Privatization or share based ownership
Social	- Empowering people with own production	- Shared ownership of Local Production	- Energy awareness by ICT	
Technological	- Transmission and distribution from local sources	- Solar houses	- Wind farms - Biogas plants	- Energy storage - Sophisticated control systems
Environmental	- Reduced GHG Emissions - Higher standards in plant's networking e.g. environmental and social	- Changes in Landscape	- Optimal use of biomass	- Changes in architecture and city planning
Cultural/ Customer/ citizen	- Pro-consumers	- Energy awareness	- Education e.g. available technologies, Environmental impacts	

Scenario Narrative by Group 2

In Session 3 the groups composed a scenario narrative, which would vividly describe the societal setting and energy landscape of 2030 framed by and built on the group's given generic scenario, the group's preferred future, the most voted drivers and the ideas generated for the futures wheel and the PESTEC table (Sessions 1 & 2). In addition the concepts of Neo-Growth, Sixth-Wave and the Third Industrial Revolution could also be used. The scenario narrative by Group 2 is presented below.

Smart energy system combining central power stations and decentralized generation

Once upon the time there was a small country in Scandinavia which decided to build a zero carbon society by 2030 and make good business out of that. The government recognised that the change in the infrastructure is costly and has to be taken gradually. Moreover, it recognised that there is no single solution available and that different renewable energy technologies and energy efficiency measured should be promoted. The solutions deployed should also be applicable for solving global environmental problems and to renew the export industry of the country.

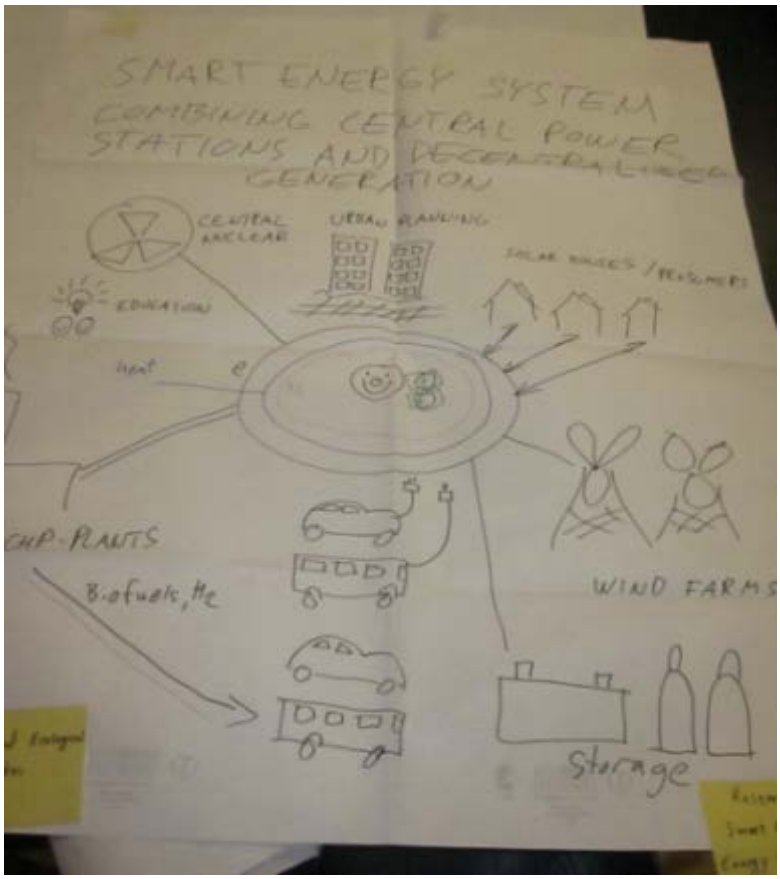
The government realised that the investment in renewing the energy production and distribution systems would raise energy prices and public support for the changes would be paramount. Therefore, education about energy and environment was introduced to all levels of education from day care centres to higher university

degrees. Moreover, local energy production in solar houses, biogas plants at farms and locally owned wind farms was promoted by investment subsidies and/or feed in tariffs. New building standards were gradually introduced for the new houses to become zero energy or plus energy without sacrificing indoor air quality and technologies were developed to renovate the existing building block. As a result, the energy awareness of the population increased drastically and they became prosumers producing a great deal of their own energy need.

The utilities continued economic utilisation of their power plants until the technoeconomic limit. The utilities became operators of smart energy networks combining the central power production at bio-CHP and nuclear plants and the distributed generation by the prosumers. Energy storages were introduced to the systems in order to balance the timely differences between renewable production and consumption. Surplus electricity was used to charge electric cars and to produce synthetic fuels, e.g. hydrogen, for zero emission vehicles.

City planning was improved and public transportation was promoted in urban areas. Hydrogen fuel cell vehicles and biofuels were used for long distance transportation.

The promotion of renewable sources decreased fuel imports and improved the trade balance as well as energy security of the country. Although some of the technologies, e.g. solar cells and zero emission cars, were imported, new technologies for energy efficiency, biomass conversion, wind power and electric grids and control ICT were developed and successfully exported all over the world and thousands of new jobs created. Especially, the biomass resources of the country were intelligently managed to produce consumer goods, chemicals and energy products, e.g. liquid biofuels or hydrogen. Also in other industrial sectors, industrial ecosystems were built in order to make the best of the scarce raw material resources.



The building and maintenance of the distributed system provided additional jobs at local level. Especially, the biomass production chain was of great importance for the countryside. Tourists from all over the world came to enjoy the natural beauty and the clean air of the low carbon society.

And the people lived happily in their low carbon society.

Figure 5. Ad hoc visualisation of the scenario narrative of smart energy system combining central power stations and decentralised generation.

Hot Topics for Further Research Suggested by Group 2:

- Smart grids
- Hydrogen energy and energy storage for grid balancing

5.2 Collapse Scenario

Scenario Summary

The following array of input from small group sessions summarises the results of Groups' 3 and 4 workings in a form of a scenario sketch. The task for Groups 3 and 4 was to find ways to steer the world back towards sustainability after a Collapse.

- Managing a collapsed society requires **firm political institutions with no corruption**.
- After the collapse, **traditional institutions and big players have lost their dominant stance**. The catastrophe has led to a **renaissance of self-organising, cooperation and collectivism, a kind of a detour to the pre-industrial era**.
- One of the tools developed for this is **electronic direct democracy.** In a world of absolute scarcity, **every asset is being used as efficiently as possible**, **including knowledge and skills.**
- Production is **downscaled** and **local production prioritized**.
- The economy and society is based on **individuals and local communities**, which have led to a **new growth in entrepreneurship** – small and medium sized companies employ the most. Especially **community-scale social enterprises** thrive.
- **Nations have become obsolete**. Borders are redefined on need; **society has become a network of networks**. On the other hand, **circles of trust are narrowing** to approximately **200 people** thus enforcing **(networked) localism**.
- **Trade and material flows are increasingly local**, and based on need. Local production and recycling loops are established.
- Energy production is **decentralized and diversified**.
- Polluted or otherwise damaged areas are **supported globally** (in terms of healthcare, food security, finance etc.).
- **Population growth** is strictly **controlled**.
- The consumption of **meat** has decreased due to education programs about the environmental stress caused by meat production and consumption.
- The collapse has **increased awareness on personal responsibility** towards society and the environment. Ethical issues are embraced.

5.2.1 Collapse Scenario by Group 3

Participants: Sara Moqaddamerad (moderator)/Turku School of Economics, Enrique Acha/Tampere University of Technology, Raimo Salonen/National Institute for Health and Welfare (THL), Pasi Vainikka/VTT, Kristian Spilling/Finnish Environment Institute

Futures Wheel by Group 3

This section presents the Futures Wheel of Group 3 as documented from the paper version, elaborated during the group session. The Futures Wheel working phase began by the group discussing from each participant's own point of view what **the ideal sustainable society would be like**. The ideas gathered in the discussion are presented right after the Futures Wheel. After discussing the ideal society, the group started to fill elements onto the **inner circle**. The group discussed and ideated **technologies/practices** that are **promising and interesting** in terms of sustainable energy production. After the inner circle the group moved on to the **outer circle**. On the outer circle the group discussed and ideated **solutions that would steer society back on the sustainable path after a global collapse of societies**.

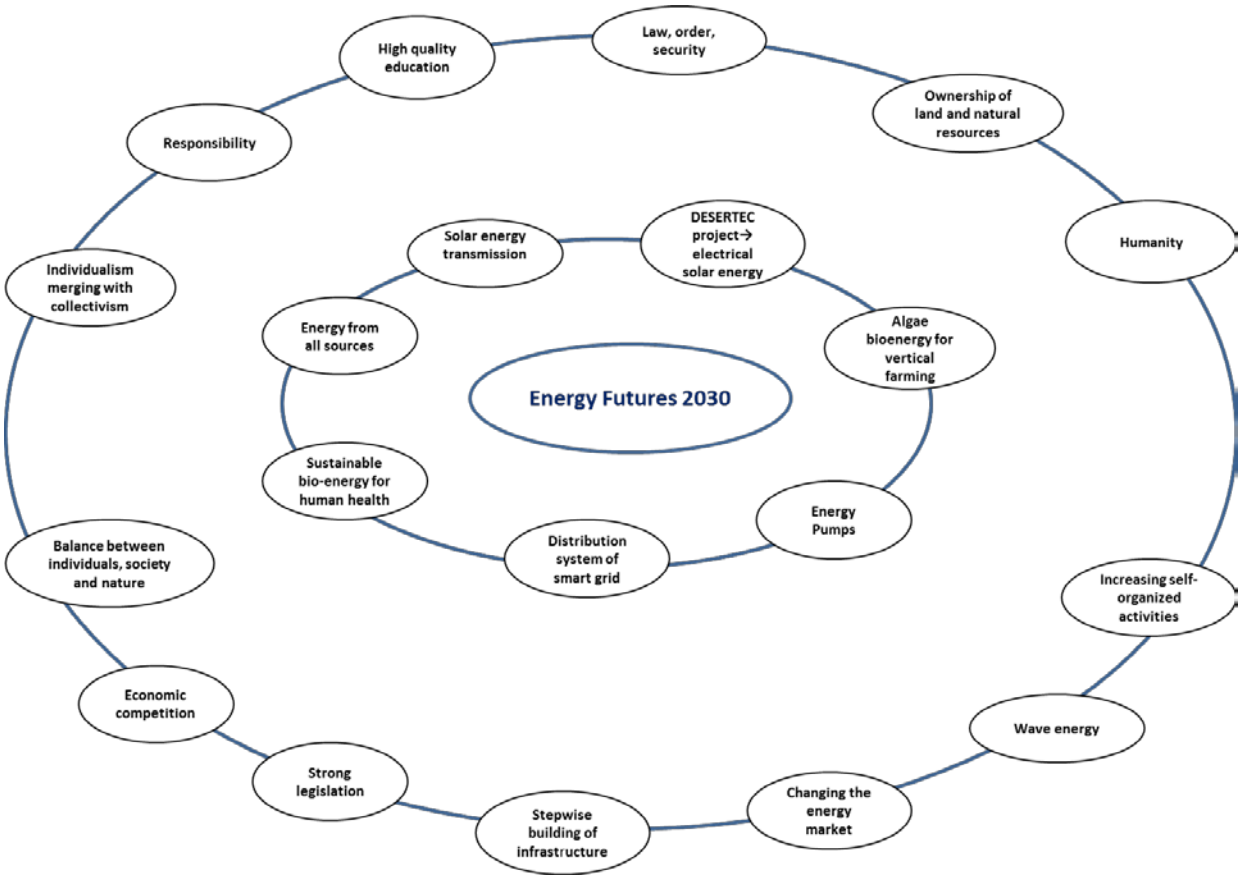


Figure 6. Futures Wheel elaborated by Group 3.

Ideas on the ideal society of sustainable growth and well-being

The following ideas on the ideal society of sustainable growth and well-being were selected to the centre of the wheel:

- Living based on harmony and happiness
- Sustainable growth meaning that to meet your needs without damaging the environment. For example: no waste and everything is recyclable
- Energy long-term visioning
- Individual fulfilment and empowerment
- Centralised and decentralised energy system in different sizes of communities

Drivers by Group 3

In the beginning of Session 1, each group voted for 6 drivers from a drivers list (see Appendix 2) that they found important and interesting in relation to the formation of futures societies. Below are presented the six most voted drivers by Group 3.

Megatrends:

1. Deepening globalisation & global economy
2. Population growth

Trends:

1. Abundant flows of information, related fast pace of change and possible short-sightedness
2. The rise of BRICS countries

Weak signals:

1. Prosumerism in its different forms
2. Vertical farming

PESTEC Table by Group 3

In Session 2 the groups worked on their PESTEC table. The groups first discussed and defined their preferred future within the framework of their generic scenario based on the ideas generated in Session 1. After reaching consensus on the "definition of the preferred future", the groups gave it an illuminating name.

The groups then began to fill in the PESTEC Table: defined the most important measures, steps and pre-conditions on all dimensions of PESTEC to achieve the preferred future within their scenario framework. The groups could use the ideas already gathered and come up with new ones.

Table 3. PESTEC Table constructed by Group 3.

PESTEC	From Colonial Resourcing to Individualized, Diversified and Multi-Agent Society in 2030			
Political	Firm political institutions with NO corruption	Anti- colonialism: dismantle the neo-colonialism to get the price of raw material fair	Geo-politic: the value of products should match the real cost. Non-for-profit products	
Economic	Individual-based economy No tax bartering	New growth in entrepreneurship	SMEs employ the most	
Social	Increasing personal responsibility towards the society	Raising humanity and ethical issues towards the happiness of the society	Increasing self-organizing activities, collectivism and security when a catastrophe happens	
Technological	Decentralised and diversified technology	Find supply for triple energy consumption, shale, gas hydrocarbon		
Environmental	Finding the ways for measuring ecological damages due to malpractice	Providing more sustainable driving forces for building clean-tech machines	Global health solution for the polluted areas	Considering the side-effects of climate change and efficient factory farming for the growing population
Cultural/ Customer/ citizen	Reducing individualism and changing the concept of consumption	Controlling population rate in third-world countries	Increasing the awareness about side-effects of meat consumption	Increasing the level of education and providing more information on the label of products about the process of production

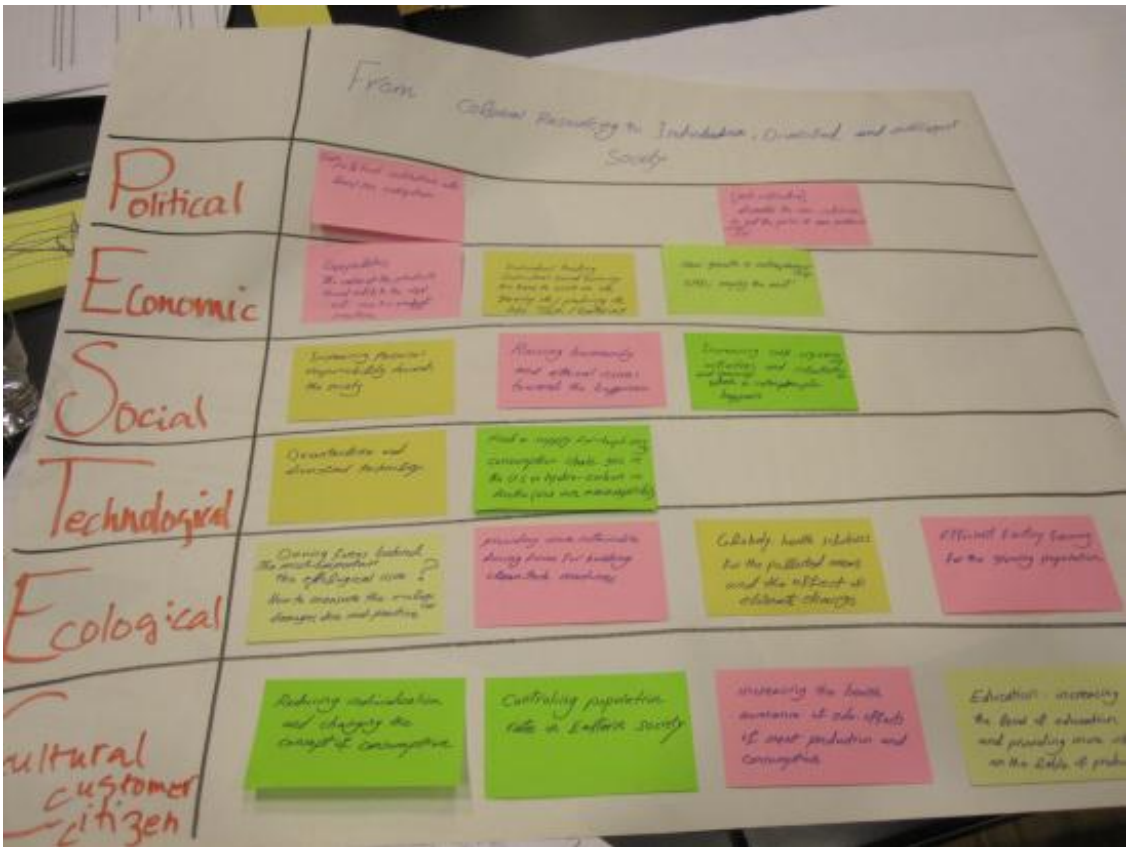


Figure 7. PESTEC Table being processed in the group.

Scenario narrative by Group 3

In Session 3 the groups composed a scenario narrative, which would vividly describe the societal setting and energy landscape of 2030 framed by and built on the group's given generic scenario, the group's preferred future, the most voted drivers and the ideas generated for the futures wheel and the PESTEC table (Sessions 1 & 2). In addition the concepts of Neo-Growth, Sixth-Wave and the Third Industrial Revolution could also be used. The scenario narrative by Group 3 is presented below.

From Colonial Resourcing to Individualized, Diversified and Multi-Agent Society in 2030

Mr. Jonson is a parliament member and today he is going to bring up some of the most challenging problems ofsociety at the time to the politicians and authorities in the parliament and he proposes some solutions to the problems as well. He starts his speech with:

Today we are facing so many chronic problems; population rate is increasing and as a result we need more energy to consume but the supply of energy is not adequate for everybody use it equally. The number of nuclear power plants is increasing but are they producing clean energy? We need to combine many energy sources that we have to use our resources efficiently. We need to have windmills in each local area to centralised energy production. The system that we have today is not flexible enough to produce sustainable energy. Therefore, The House of Representatives should pass a new energy-control bill in which it bans the building of new power generation machines based on wood combustion and also reduce the number of nuclear plants in the country but the key question is that how we can use these power plants to balance the intermittent production of solar and wind energy which are not cost effective at the moment for mass production due to the deficit that the government is facing currently. The other solution can be the production of battery storage insulations. The production of power grid is more sustainable and ensures the security of supply of energy. One important proposal is starting an extensive research on electrical energy system storage. Integration of bio-mass in power stations with use of solar energy and battery system can be used for the storage of wind energy. Due to the abundant flows of information we need to make our society more efficient, aware and resilient. Moreover one state-of the- art solution is the key concept of MICROGRIDS, which when combined with ICTs and information technology brings about the concept of Smart Grids. These are small-scale version of what we have today as company-owned and operated large-scale power grids. A micro-grid can be as simple as the electrical installations of a house with its own means of electricity generation such as photo-voltaic panels or, in the future, a fuel cell or a micro-turbine. The individual micro-grid can operate on their own or in a cooperative manner with neighboring micro-grids. Because of much improved energy efficiencies, future micro-grids will operate on Direct Current (DC) as opposed to the customary Alternating Current (AC). There are still many technical and economic issues to be resolved for the successful large-scale integration of distributed energy systems (smart grids or smart micro-grids) but all the "fingers" point at that direction as a way of fulfilling a strong wish for individualism, social responsibility and taking ownership of energy resources away from the corporative world.

Hot Topics for Further Research Suggested by Group 3:

- DC Smart Grids
- Battery Energy Storage Systems
- Sustainable biofuels
- Research on developing heating/cooling technology more efficient, and using more renewables regarding heating/cooling
- Regulating electricity production in order to enable intermittent electricity generation (namely wind & solar)
- An analysis and identification of the role of biomass as a "storable renewable" i.e. as an enabling energy carrier facilitating the penetration of other renewables: to generate regulating energy for wind and solar. At the moment we have no understanding how all these technologies should work together.
- Cross-disciplinary R&D project on the analysis of societal impacts of solar power on global level. Solar is very democratic means of energy. Does this change the geopolitics of energy?

5.2.2 Collapse Scenario by Group 4

Participants: Reinis Plavins (moderator)/Turku School of Economics, Martti Aho/VTT, Antonio Caló/NorTech Oulu/Thule Institute/University of Oulu, Markku Hurme/Aalto University, Kari Koskinen/Aalto University School of Electrical Engineering, Markus Olin/VTT, Petri Salminen/No Emission Monday

Futures Wheel by Group 4

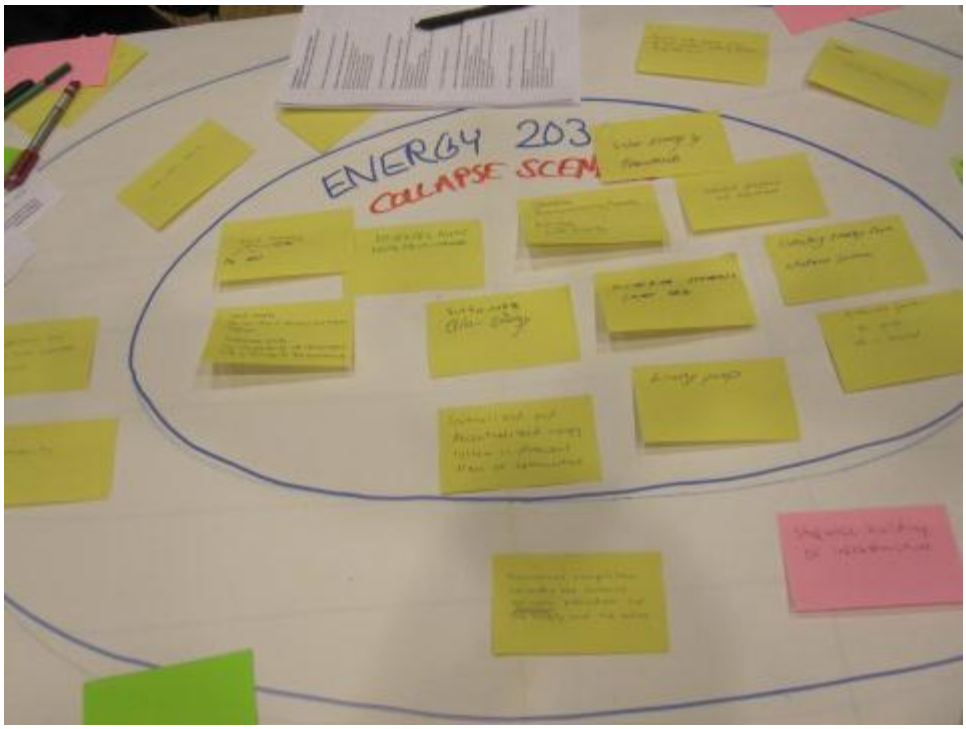


Figure 8. Futures Wheel during the stage of processing ideas.

This section presents the Futures Wheel of Group 4 as documented from the paper version, elaborated during the group session. The Futures Wheel working phase began by the group discussing from each own point of view what **the ideal sustainable society would be like**. The ideas gathered in the discussion are presented right after the Futures Wheel. After discussing the ideal society, the group started to fill elements onto the **inner circle**. The group discussed and ideated **technologies/practices** that are **promising and interesting** in terms of sustainable energy production. After the inner circle the group moved on to the **outer circle**. On the outer circle the group discussed and ideated **solutions that would steer society back on the sustainable path after a global collapse of societies**

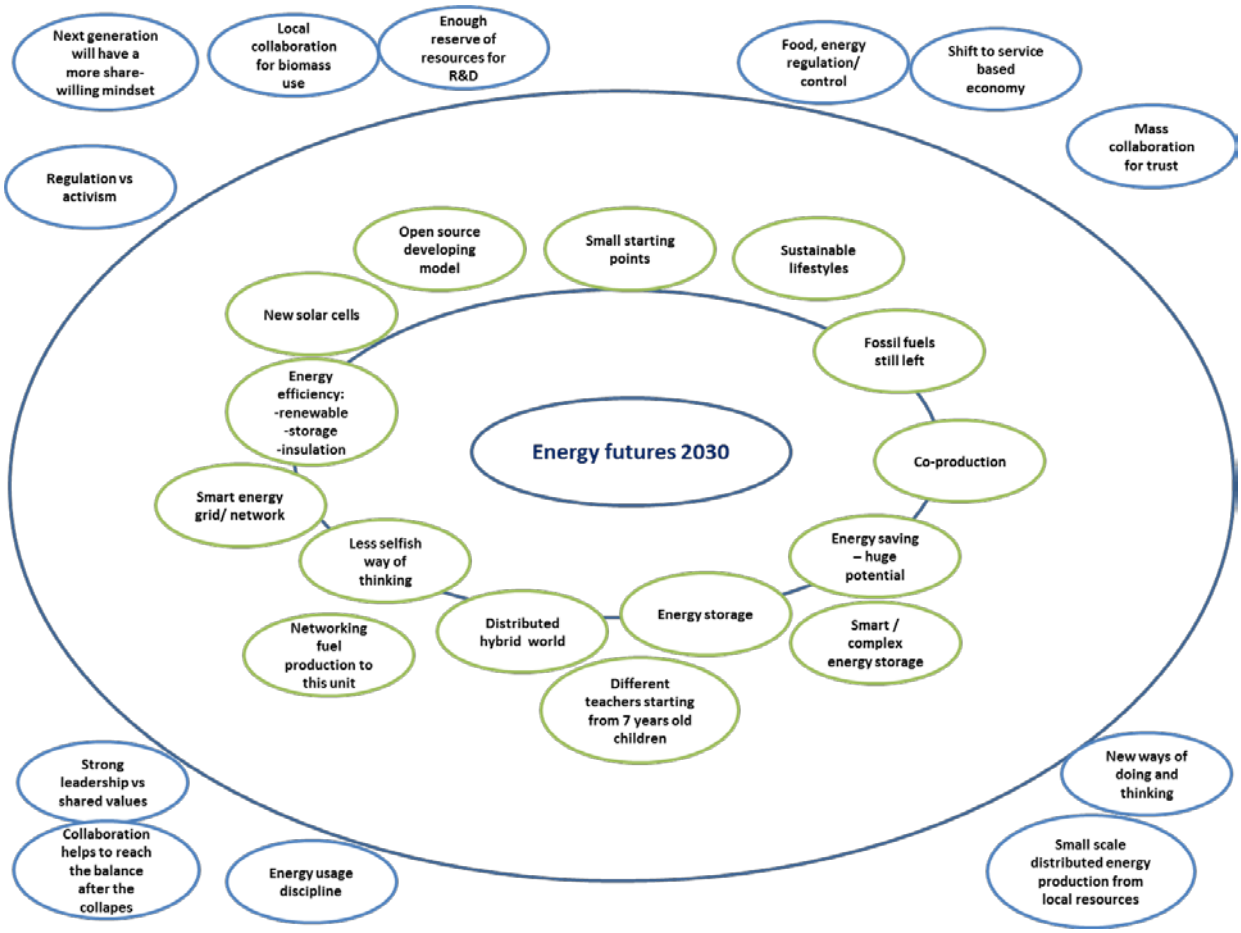


Figure 9. Futures Wheel elaborated by Group 4.

Ideas on the ideal society of sustainable growth and well-being

The following ideas on the ideal society of sustainable growth and well-being were selected to the centre of the wheel:

- Entrepreneurs who apply sustainable business practices will be accepted by the consumers
- Redefinition of values
- Market based to sharing based community
- Fully closed material flow cycles
- Developing world does not follow USA growth model
- Long-term thinking
- Only renewable energy

Drivers by Group 4

In the beginning of session 1, each group voted for 6 drivers from a drivers list (see Appendix 2) that they found important and interesting in relation to the formation of futures societies. Below are presented the six most voted drivers by Group 4.

Megatrends

1) Climate change
2) Deepening and spreading networks

Trends

1) Open information/ big data
2) The rise of the BRICS countries

Weak signals

1) The third industrial revolution
2) Neo-communality

PESTEC table by Group 4

In Session 2 the groups worked on their PESTEC table. The groups first discussed and defined their preferred future within the framework of their generic scenario based on the ideas generated in Session 1. After reaching consensus on the "definition of the preferred future", the groups gave it an illuminating name.

The groups then began to fill in the PESTEC Table: defined the most important measures, steps and pre-conditions on all dimensions of PESTEC to achieve the preferred future within their scenario framework. The groups could use the ideas already gathered and come up with new ones.

Table 4. PESTEC table constructed by Group 4.

PESTEC	Local Loops – Networked Micro-communities			
Political	• Creating community scale social enterprises • Stricter immigration policies	• Decentralisation of power. • Centralised power become administrative in nature.	• End of nations. Borders redefined on need. • Network of networks • Consensus vs privileges of a certain group	• Better organised decision making systems. • Electronic direct democracy
Economic	• Towards zero waste economy • Trades & material flows based on need	• Self sustainig practices • More focus on industries that maintain people alive and their working ability.	• Downscaling of production • Prioritising local production	• New models of operation and production
Social	• Much better co-operation and combination of different skills than today	• Population redistribution • Cooperation & sharing	• Narrowing circle of trust => localism	• Equal rights guaranteed by government
Technological	• Merging of energy and ICT networks • Wind and biomass	• High consumer energy efficiency	• Initially lower energy production efficiency • Practical technology CHP	• Decentralisation of energy market • Local networks
Environmental	• Start from most critical environmental issues	• Understanding and use of environmental services	• At first keeping people alive dominate over environmental issues	• Local recycling loops
Cultural/ Customer/ citizen	• From supplier-consumer to provider-user	• Relatives keep more contact. Generally all needs to co-operate increases	• Culture giving visions and hope	• The SHARE generation and beyond

Scenario Narrative by Group 4

In Session 3 the groups composed a scenario narrative, which would vividly describe the societal setting and energy landscape of 2030 framed by and built on the group's given generic scenario, the group's preferred future, the most voted drivers and the ideas generated for the futures wheel and the PESTEC table (Sessions 1 & 2). In addition the concepts of Neo-Growth, Sixth-Wave and the Third Industrial Revolution could also be used. The scenario narrative by Group 4 is presented below.

Local Loops – Networked Micro-Communities

- In the post-collapse world sustainable = reliable
- Small scale hybrid energy production
- Downscaled models of production for closed loop economy
- Reliability, maintainance and efficiency are the key factors
- Self-organising direct democracy based micro communities
- Survival induced sustainable lifestyle practices

Hot Topics for Further Research Suggested by Group 4:

- Energy saving and energy efficiency
- Energy storage
- Smart grids
- Small-scale distributed energy produced from local resources
- Open source developing models
- Networked Micro-Communities as self-sustainable units
- Closed material cycles

5.3 Disciplined Society Scenario

Scenario Summary

The following array of input from small group sessions summarises the results of Groups' 5 and 6 workings in a form of a scenario sketch. The task for Groups 5 and 6 was to concentrate on possible regulatory systems and on lifestyles based on ecological values.

- **Germany reached a vanguard position in early 2000** and acted as a model for Finland with its renewable energy policy model. **Wise incentives**, such as feed-in-tariff, were widely applied.
- **The main goal of regulatory measures** was to create **a distributed energy system managed by smart grid technologies**. Renewable energy (solar, wind, tidal, waste to energy solutions etc.) is produced by prosumers and their cooperatives. There is also an increasing appreciation for **social energy enterprises that are non-market-based** and subsidised.
- **Increased environmental awareness and ecological values of citizens** eased the transition to a more regulated system
- In a distributed world of networked small enterprises **people work increasingly from their homes.**
- **Industrial production** is fossils free, and is based on closed loops**.**
- **The Finnish culture of non-hierarchical social structures and low threshold of new technologies** has given Finland a forerunner position in the distributed and smart hi-tech world.
- **Long-term commitment** was needed to claim ambitious emissions caps, strict regulations and also incentives. Radical measures were not avoided: **huge taxes were put on fossils**, **per capita limitations of energy consumption, and in general polluting and detrimental technologies have been made economically unviable**.
- The transition from the existing system of the early 2000 to the current, ecologically disciplined one required **system based understanding**, and taking a holistic approach to environmental politics. **Smart grid technologies and a multitude of ICT solutions** are widely used to **efficiently manage** different parts of the whole. For instance **high-end metering/monitoring systems** were applied for consumption – meaning e.g. taxation of car driving according to kilometres driven.
- As opposed to the traditional Finnish cautious attitude towards change, **the importance of trend-setting first movers** and forerunners has been acknowledged.
- Alongside strict regulations, **do-it-yourself mentality** is acknowledged, and value given for active **prosumerism**. Customers are in general treated as a part of creating the solutions. Consumers and citizens are **empowered to act, make proposals, innovate and participate in decision-making.**
- Bottom-up society requires **equality and distributed wealth**
- Information on the material flows and ecological footprint of production are **transparent**, so that customers are able to make wise decisions.
- **In the transition phase** towards clear energy, **clean coal technologies and safe nuclear** power plants were widely used.

5.3.1 Disciplined Society by Group 5

Participants: Mira Käkönen/Finland Futures Research Centre FFRC (moderator), Paavo-Petri Ahonen/Academy of Finland, Risto Hillamo/Finnish Meteorological Institute, Jarmo Partanen/Lappeenranta University of Technology, Saila Seppo/Academy of Finland, Jukka Reivinen/Academy of Finland

Futures Wheel by Group 5

This section presents the Futures Wheel of Group 5 as documented from the paper version, elaborated during the group session. The Futures Wheel working phase began by the group discussing from each participant's own point of view what **the ideal sustainable society would be like**. The ideas gathered in the discussion are presented right after the Futures Wheel. After discussing the ideal society, the group started to fill elements onto the **inner circle**. The group discussed and ideated **technologies/practices** that are **promising and interesting** in terms of sustainable energy production. After the inner circle the group moved on to the **outer circle**. On the outer circle the group **concentrated on regulatory systems and on lifestyles based on ecological values**.

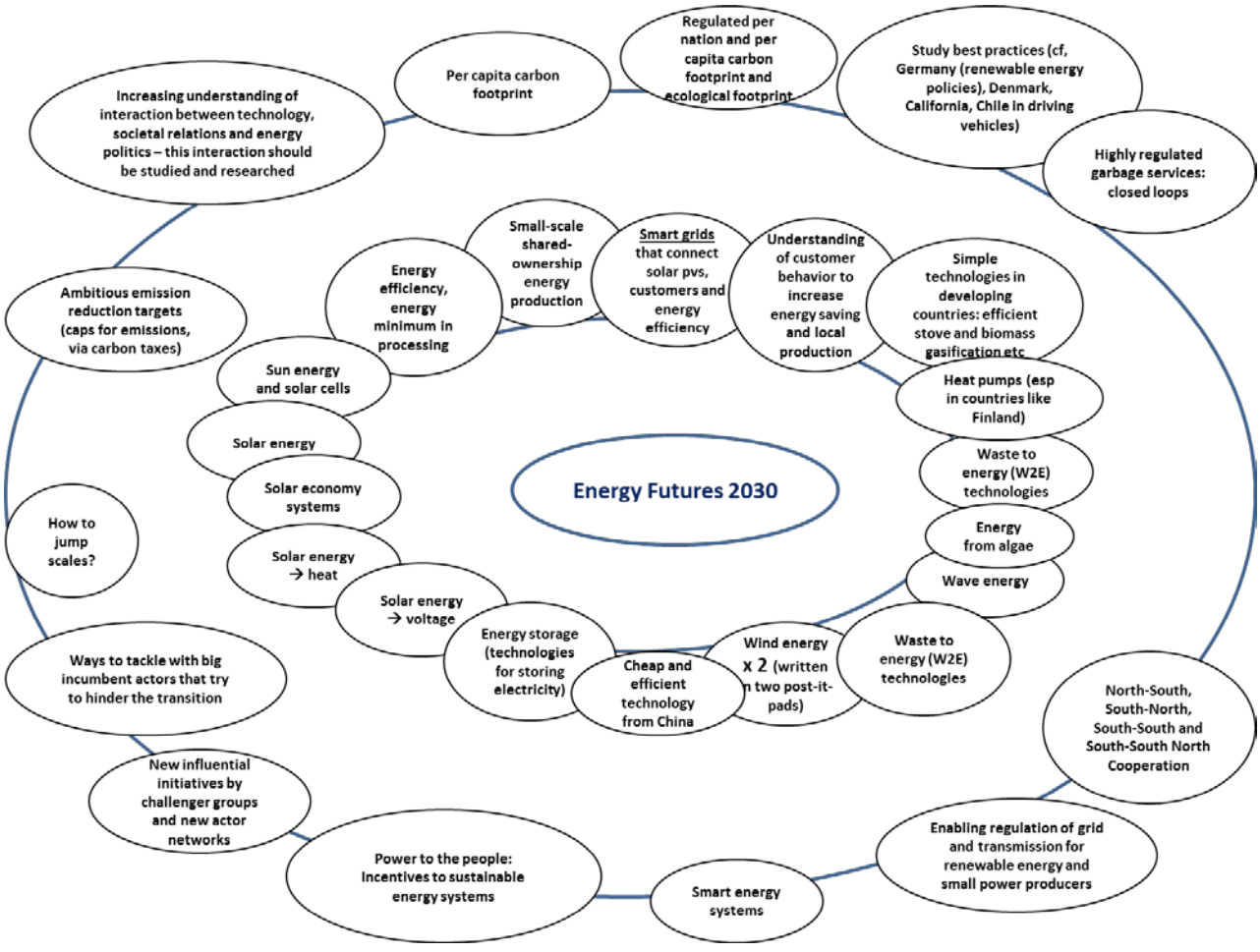


Figure 10. Futures Wheel elaborated by Group 5.

Ideas on the ideal society of sustainable growth and well-being

The following ideas on the ideal society of sustainable growth and well-being were selected to the centre of the wheel:

- Reduced consumption
- Sustainable energy production (reduced GHG emissions, enhanced air quality)
- Global equality in energy consumption
- Understanding of global politics
- Convergence of global emissions and ecological footprint between global North and global South = global equity, this requires down shifting in global North
- Developing countries go directly to sustainable energy system without extra costs (leap frogging)
- Balance reached between 1) climate change, 2) equal well-being globally, 3) global competition
- Recycling 100% in all societies
- Efficient environmental and energy regulation
- Fast transition to efficient use of energy
- From centralised production and ownership to distributed ownership and production (DIY)
- Green society
- Good and equal flow of information and knowledge
- Attitudes are changed into moral idea of well-being, in household and society level

Drivers by Group 5

In the beginning of Session 1, each group voted for 6 drivers from a drivers list (see Appendix 2) that they found important and interesting in relation to the formation of futures societies. The six most voted drivers by Group 5 are presented below.

Megatrends

1. Climate change
2. Prospering global population -rise of the middle-class (especially in China)

Trends

1. The rise of environmental industries,
2. Heightened awareness on environmental issues

Weak signals

1. The third industrial revolution
2. Social enterprises (non-market-based, subsidized)

PESTEC Table by Group 5

In Session 2 the groups worked on their PESTEC Table. The groups first discussed and defined their preferred future within the framework of their generic scenario based on the ideas generated in Session 1. After reaching consensus on the "definition of the preferred future", the groups gave it an illuminating name.

The groups then began to fill in the PESTEC Table: defined the most important measures, steps and preconditions on all dimensions of PESTEC to achieve the preferred future within their scenario framework. The groups could use the ideas already gathered and come up with new ones.

Table 5. PESTEC table constructed by Group 5.

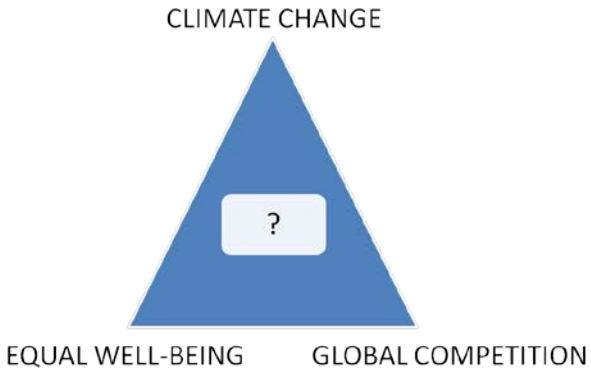
PESTEC	Towards distributed, multifuel and efficient smart energy system powered by prosumers and cooperatives			
Political	- Lessons learnt from German renewable energy policy model - Wise incentives, esp. feed-in-tariff	- Long term commitment: in global, national and local level, measures include ambitious emissions caps and strict regulation as well as incentives	- Huge taxes put on fossils - Per capita limitations/caps of energy consumption - Metering systems for consumption – e.g. taxation in driving according to km	- How to deal with power struggles, power imbalances, conflicting interests, esp. how to deal with big incumbent actors that are not willing to make changes in their behaviour
Economic	- Making polluting and detrimental technologies and fuels economically unviable	- Eventually only sustainable biofuels accepted	- System based understanding of transition from existing to future system	
Social	- Important role of first movers – setting trends and fashion	- New 'celebrities' who are heroes of sustainable living & energy consumption and production	- Do it yourself mentality - Value given for prosuming	- Values: green & equality
Technological	- Self-organised and self-healing SMART GRID - ICT solutions that enable smart grid	- Solar power and heat - Wind power - Tidal power (waves) - Waste to energy solutions - Sustainable biorefinery and bioenergy	- In transition phase solutions include also: clean coal and safe nuclear	- Efficient use of energy - Energy storages: electricity as a commodity "that can be bought as commodities in supermarket"
Environmental	- Biofuels should not threaten the 'lungs of the earth', cf. problems caused by palm oil in Indonesian peatland forests and rainforests	- Everything should be based on nature and green thinking	- 'Green washing' increasingly a problem	- Emerging problems of renewables: materials & minerals needed for PV, biomass, biofuels, wind, ICT etc. - Need to maintain renewables as green solutions
Cultural/ Customer/ citizen	- Understanding of customer behaviour	- Customers are kings	- Customers are part of creating the solutions and not perceived as trouble makers	- Empowered consumers and citizens - Precondition for wise customers is transparency in material flows and ecological footprint of different energy solutions

Scenario Narrative by Group 5

In Session 3 the groups composed a scenario narrative, which would vividly describe the societal setting and energy landscape of 2030 framed by and built on the group's given generic scenario, the group's preferred future, the most voted drivers and the ideas generated for the futures wheel and the PESTEC Table (Sessions 1 & 2). In addition the concepts of Neo-Growth, Sixth-Wave and the Third Industrial Revolution could also be used. The scenario narrative by Group 5 is presented below.

Towards distributed, multifuel and efficient smart energy system powered by prosumers and cooperatives

Finland's energy politics have been driven until 2012 by large industrial needs and actors. BUT in 2030 Finland has become a front-runner and example of sustainable and smart distributed energy system. Important elements of this system include a smart grid powered by renewable energy (solar, wind, tidal, waste to energy –solutions etc.) produced by small power producers i.e. prosumers and co-operatives. This transition towards sustainable and distributed energy systems has been enabled and fostered by a mix of regulatory measures similar to those in Denmark and Germany. One of the main drivers for this transition has been the climate change accelerated by global rise of middle class and consumption of fossil fuels. Positive drivers have included the increased environmental awareness and ecological values of citizens, consumers and decision-makers and as response the rise of environmental industries. Third industrial revolution is going on and it has included a shift towards networks of small energy enterprises. There is also increasing appreciation for cooperatives and social energy enterprises that are non-market-based and subsidised. In this transition it has been important that Finland has become a key actor in cleantech markets globally. This in turn was enabled by creation and strengthening of domestic cleantech markets. **As Finland moves towards more distributed system it needs to recognise its strengths such as the culture of non-hierarchical social structures and low threshold of new technologies.**



Transitions in different sectors:

In housing zero energy target has nearly been reached and the technologies in place enable non-interruptible in all houses. In transportation pendeling has been significantly reduced, public transportation especially in rails has remarkably increased and electric vehicles are becoming more common. **People have started to increasingly work at home. Industrial production is energy efficient. It has become fossils free and it is based on closed loops**. Co-generation can serve as midterm solution but eventually it becomes irrelevant.

Sustainable lifestyles are attractive because the energy system is reliable and it works in all circumstances. Sustainable does not mean that life becomes more difficult. First movers have been showing the way for all the

rest. **Customers are increasingly actually prosumers and are not blamed as trouble-makers but are seen as solution-makers**.

Importantly these shifts towards more sustainable energy systems have been enabled by research. Energy research programme should be multi-, inter-, and transdisciplinary. Studies in technologies are not enough.

Hot Topics for Further Research Suggested by Group 5:

- Energy politics, policies and markets. Also including studies on the best practices applicable in Finland
- Technologies and systems of sustainable energy
- Social sciences that look at energy in society, economy, legislation, and behaviour of customers
- Natural sciences including modelling & validation and ecology.
- The energy solutions need to be compatible with the climate science.

5.3.2 Disciplined Society Scenario by Group 6

Participants: Petri Tapio/Finland Futures Research Centre, University of Turku (Moderator), Timo Hyppänen/Lappeenranta University of Technology, Sirkka-Liisa Jämsä-Jounela/Aalto University, Mikko Savolahti/SYKE

Futures Wheel by Group 6

This section presents the Futures Wheel of Group 6 as documented from the paper version, elaborated during the group session. The Futures Wheel working phase began by the group discussing from each own point of view what **the ideal sustainable society would be like**. The ideas gathered in the discussion are presented right after the Futures Wheel. After discussing the ideal society, the group started to fill elements onto the **inner circle**. The group discussed and ideated **technologies/practices** that are **promising and interesting** in terms of sustainable energy production. After the inner circle the group moved on to the **outer circle**. On the outer circle the group **concentrated on regulatory systems and on lifestyles based on ecological values**.

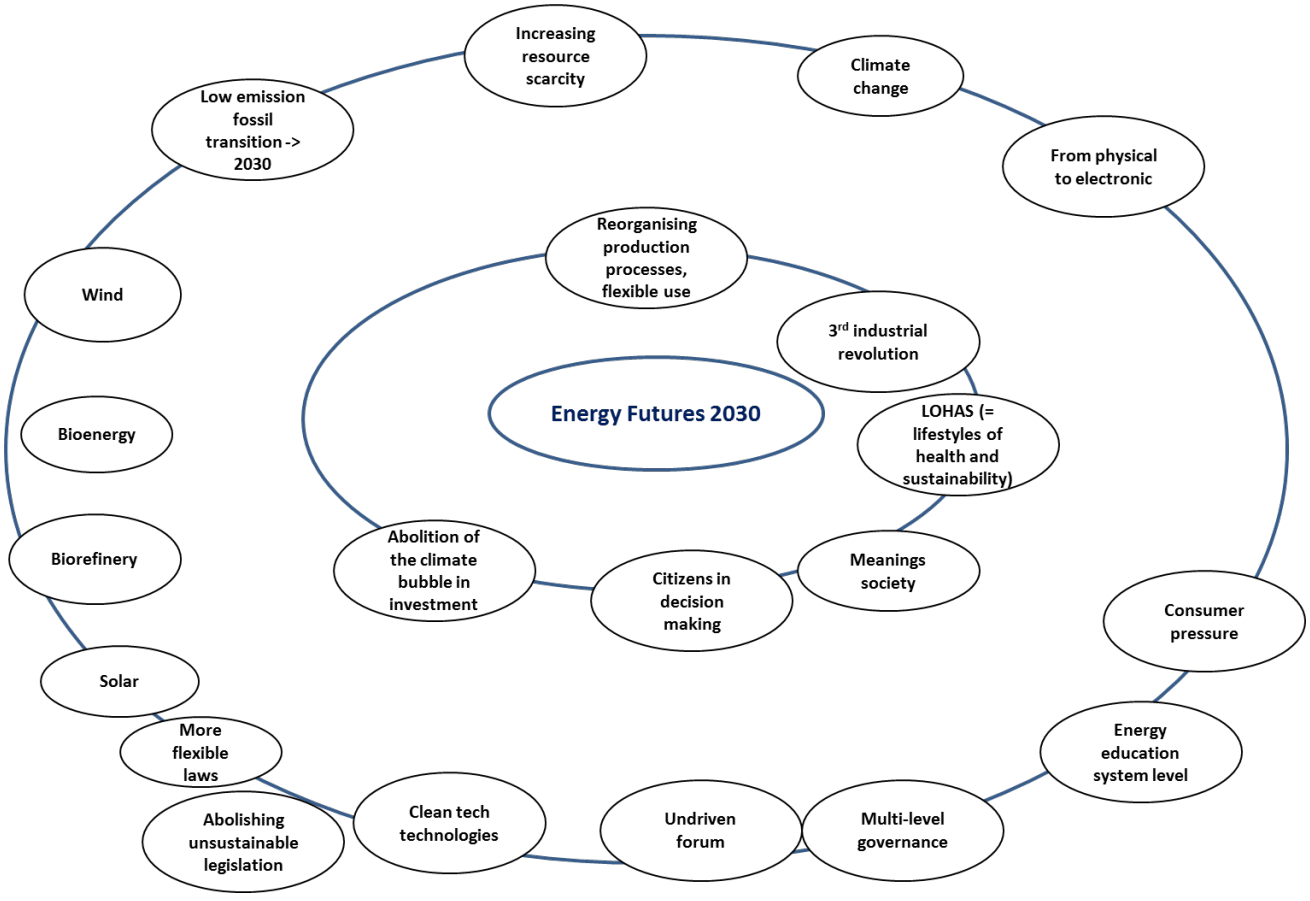


Figure 11. Futures Wheel elaborated by Group 6.

Ideas on the ideal society of sustainable growth and well-being

The following ideas on the ideal society of sustainable growth and well-being were selected to the centre of the wheel:

- Flexible
- Distributed
- Energy efficient
- Human needs first
- Happiness
- Smart
- Less combustion
- Renewable energy
- Multiple measures
- More with less
- Global agreements

Drivers by Group 6

In the beginning of Session 1, each group voted for 6 drivers from a drivers list (see Appendix 2) that they found important and interesting in relation to the formation of futures societies. The six most voted drivers by Group 6 are presented below.

Megatrends

1. Climate change
2. Increased resource scarcity

Trends

1. Lohas
2. Meanings society

Weak signals

1. 3rd industrial revolution
2. Citizen participation

PESTEC Table by Group 6

In Session 2 the groups worked on their PESTEC Table. The groups first discussed and defined their preferred future within the framework of their generic scenario based on the ideas generated in Session 1. After reaching consensus on the "definition of the preferred future", the groups gave it an illuminating name.

The groups then began to fill in the PESTEC Table: defined the most important measures, steps and preconditions on all dimensions of PESTEC to achieve the preferred future within their scenario framework. The groups could use the ideas already gathered and come up with new ones.

Table 6. PESTEC Table constructed by Group 6.

PESTEC	BALANCED SUSTAINABLE LIFE			
Political	- Flexible laws for small scale energy	- Distributed wealth	- Multi-level governance: global, national, local	- Controlled transition from fossil fuels
Economic	- Reorganising production processes, flexible use, industrial ecosystems	- 3rd industrial revolution	- Demand for sustainable products	- Rising energy & resource prices
Social	- System level energy education	- Population growth reduction	- Decreased materialism	
Technological	- Smart grid: distributed energy, wind, solar, bioenergy	- Energy efficiency in life cycle		
Environmental	Saving energy in water management	- Integrating air pollution control and climate policy	- Climate change perception in daily life	
Cultural/ Customer/ citizen	- Redefining happiness	- Citizen empowerment	- Ubiquitous technology for optimal energy use	- Lohas

Scenario Narrative by Group 6

In Session 3 the groups composed a scenario narrative, which would vividly describe the societal setting and energy landscape of 2030 framed by and built on the group's given generic scenario, the group's preferred future, the most voted drivers and the ideas generated for the futures wheel and the PESTEC Table (Sessions 1 & 2). In addition the concepts of Neo-Growth, Sixth-Wave and the Third Industrial Revolution could also be used. The scenario narrative by Group 6 is presented below.

Balanced Sustainable Life

Key feature: Balanced interplay between societal & individual decision-making to reduce energy use

Key measures: Smart grid, distributed energy production, systemic energy education, campaigns & marketing, lohas, controlled transition away from fossil fuels

Bottlenecks: 3rd world poverty, willingness to change

Figure 12. Ad hoc visualisation of the scenario narrative of balanced sustainable life.

Hot Topics for Further Research Suggested by Group 6:

- Smart grids for distributed energy production, use & storage
- New business models
- Systemic energy education
- Flexible bio refineries
- Management of renewable energy impacts
- Minimizing fossil fuel harm in transition phase
- Increasing lifecycle energy efficiency (production & consumption)
- Combining analyses of technical and institutional change

5.4 Transformational Society Scenario

Scenario Summary

The following array of the input from small group sessions summarises the results of Groups' 7 and 8 workings in a form of a scenario sketch. The task for Groups 7 and 8 was to concentrate on deep structural changes in society.

- In establishing a transformed society, **long-term planning** was needed so that society could be orderly steered into **plausible and novel directions**.
- **Shift to ecological values has been thorough**, but initially the shift was **forced politically and economically.**
- Deep ecological transformation is reflected even in **architecture**, as **buildings mimic natural forms**.
- The society has transformed so that it is **thoroughly organised from the bottom-up**; society is based on **local and hyper-local decision-making and initiatives**.
- **Individualism** has been **mitigated by more collective approaches** without compromising individual liberties.
- As society is organised at the local level, **resources are gathered and used locally**, and **energy is produced from local resources → production circles are closed**.
- However, **all CO2 free technologies are in use, including nuclear power**.
- The abundance of clean energy has led to a situation where **energy is almost free of cost** enabling e.g. **more free time.**
- Local lifestyles are supported by **highly developed, ubiquitous ICT**.
- Local, tight communities have become very **resilient** ensuring **economic, ecological and social stability**.
- Grass-roots initiatives are supported by **taxation benefits**.
- **People now in power, well-being and happiness are set as the highest values**, and striving towards them is a self-evident part of the whole culture.
- One of the founding ideas behind the transformation was **the realisation that sustainability and happiness/well-being are not contradictory**, but support each other. Time is valued high, and **free time is associated with happiness**.
- The economy has been transformed by **clean-tech/environmental industries** and **prosumeristic, pro-amateur production**.
- **Openness for new possibilities and perspectives** is pervasive throughout the whole culture
- As a consequence of all of the above, Finland attracts a lot of **green tourism.**

5.4.1 Transformational Society Scenario by Group 7

Participants: Maryna Sasunkevich/Turku School of Economics (moderator), Ulla Ehrnstén/VTT, Risto Soukka/Lappeenranta University of Technology, Risto Vilkko/Academy of Finland, Kai Zenger/Aalto University School of Electrical Engineering

Futures Wheel by Group 7

This section presents the Futures Wheel of Group 7 as documented from the paper version, elaborated during the group session. The Futures Wheel working phase began by the group discussing from each own point of view what **the ideal sustainable society would be like**. The ideas gathered in the discussion are presented right after the Futures Wheel. After discussing the ideal society, the group started to fill elements onto the **inner circle**. The group discussed and ideated **technologies/practices** that are **promising and interesting** in terms of sustainable energy production. After the inner circle the group moved on to the **outer circle**. On the outer circle the group concentrated **on deep structural changes in society**.

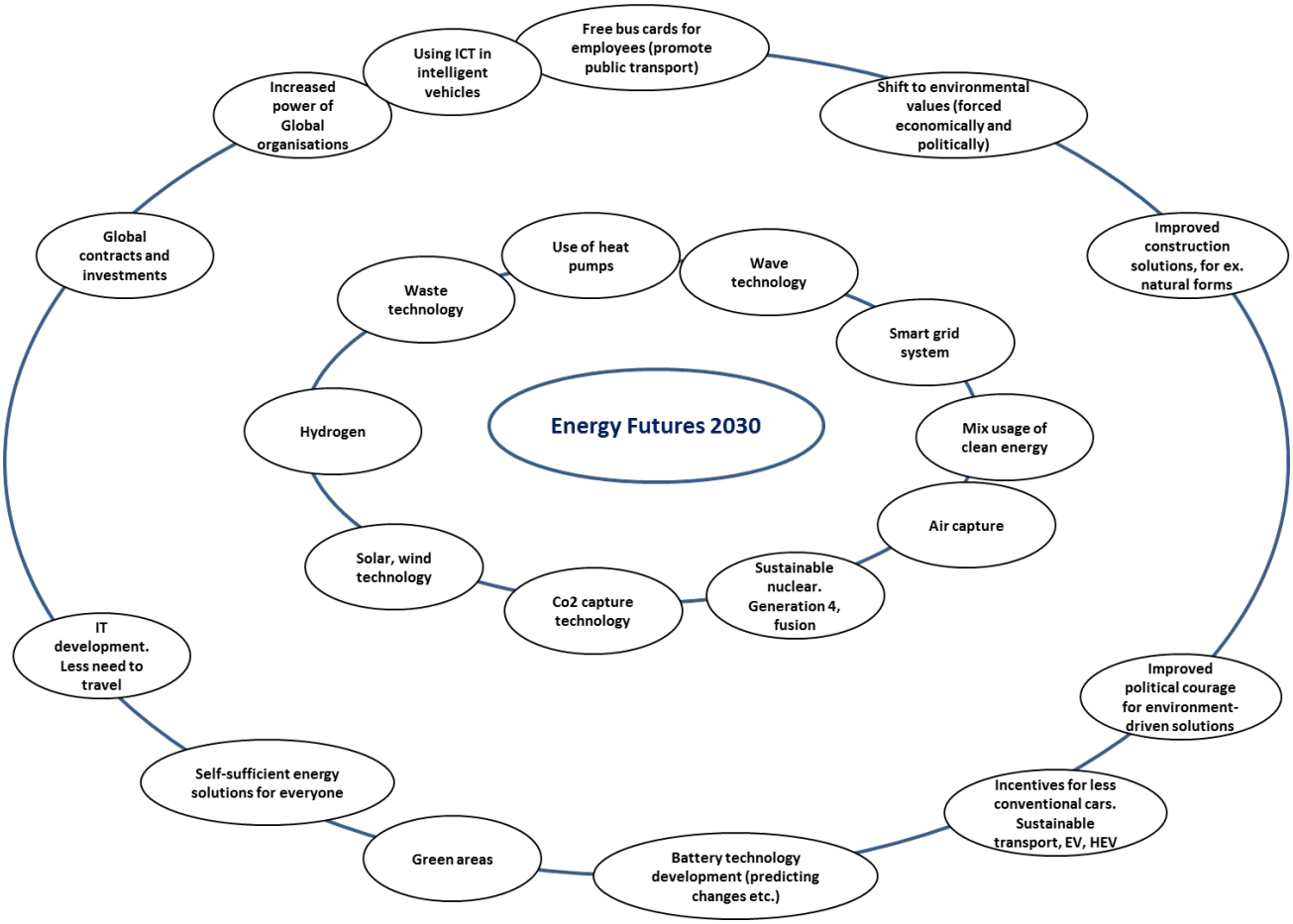


Figure 13. Futures Wheel elaborated by Group 7.

Ideas on the ideal society of sustainable growth and well-being

The following ideas on the ideal society of sustainable growth and well-being were selected to the centre of the wheel:

- Happiness is increased when people have more time for their friends and family and are not stressed about productivity at work
- Economic and social equality
- Technology and innovations
- Society is stable and peaceful
- ”Clean” food and water
- Enough renewables, efficiency and recycling

Drivers by Group 7

In the beginning of Session 1, each group voted for 6 drivers from a drivers list (see Appendix 2) that they found important and interesting in relation to the formation of futures societies. The six most voted drivers by Group 7 are presented below.

Megatrends

1. Climate change
2. Population growth

Trends

1. Ubiquitous technology
2. Heightened awareness on environmental issues

Weak signals

1. Vertical farming
2. Increase appreciation of local services

PESTEC Table by Group 7

In Session 2 the groups worked on their PESTEC Table. The groups first discussed and defined their preferred future within the framework of their generic scenario based on the ideas generated in Session 1. After reaching consensus on the “definition of the preferred future”, the groups gave it an illuminating name.

The groups then began to fill in the PESTEC Table: defined the most important measures, steps and preconditions on all dimensions of PESTEC to achieve the preferred future within their scenario framework. The groups could use the ideas already gathered and come up with new ones.

Table 7. PESTEC table constructed by Group 7.

PESTEC	Happiness through sustainability			
Political	- Political courage - Political stability - Public transportation development (based on technology advances)	Global contracts: - Double bottom ships for oil transportation - Optimisation of ship driving - Less coal - Non-pollutive cars - Etc.	Development of legislation	Share of resources (scientific, academic, etc.)
Economic	Suitable economic mechanism: taxes, certificates	Society needs production sectors for employments and stability	Production utilising sustainability as a competitive advantage	Low unemployment incentives
Social	Equal health care through technological innovations	Face to face, not "Facebook" relationships	Good education: more emphasis on sustainability and thinking	Reduction of price on electricity, ultimately free for everyone
Technological	Utilising ICT technology to provide sustainability (EV, monitors at home for safety)	-Energy monitoring technology -Smart transport and traffic system	-The products must be designed to be recyclable -Technology to separate different waste fractions	-self-driven cars
Environmental	More efficient use of renewables (waste energy)	Advanced energy systems (hybrid system)	Waste used must be utilised	Life-cycles of solar and wind energy should be increased
Cultural/ Customer/ citizen	Change of values. Deduction of individualistic thinking	Local services are valued by citizens	More time and peace of mind instead of extreme productivity	Promotion of remote work by utilising ICT

Scenario Narrative by Group 7

In Session 3 the groups composed a scenario narrative, which would vividly describe the societal setting and energy landscape of 2030 framed by and built on the group's given generic scenario, the group's preferred future, the most voted drivers and the ideas generated for the futures wheel and the PESTEC table (Sessions 1 & 2). In addition the concepts of Neo-Growth, Sixth-Wave and the Third Industrial Revolution could also be used. The scenario narrative by Group 7 is presented below.

Happiness through sustainability in 2030

The happy person wakes up in 2030 in a house heated by solar collectors connected to central heating system that also collects energy from a waste-water treatment plant by using heat-pumps. She eats a breakfast which consists of locally produced food as well as fruits and vegetables from her own (vertical) garden. She can chose a remote working day or take the electrical public transportation to a green zone. Green zones are supported by the governmental supporting mechanism. Vehicles are manufactured using recyclable materials developed by international cooperation. Entering the green zone the vehicle uses batteries and monitoring energy use with possible re-routing. She enters her office and the vehicle is recharged by a recharged action, or goes to take care of others duties. She works for a company which designs smart ships with double bottoms. She uses the GCT multi-touch system to discuss and interact with colleagues around the world. She

takes contact with her mother and checks simultaneously monitoring information about her health. After the working day she does her grocery shopping with her friends at a local shops and then after goes to the gym. She has a plenty of time for her family, friends and hobbies.

Hot Topics for Further Research Suggested by Group 7:

- Smart cars
- Efficient use of time
- Material development
- Hydrogen society
- Battery technology
- Monitoring technology

Attractiveness Factors:

- Global contracts
- Economic incentives, efficient use of resources
- Improved quality of life
- Happiness=sustainability

5.4.2 Transformational Society Scenario by Group 8

Participants: Elizaveta Shabanova-Danielyan (moderator)/University of Turku, Tiina Jokela/Academy of Finland, Henrik Saxén/Åbo Akademi, Ron Zevenhoven/Åbo Akademi, Värme- och strömningsteknik.

Futures Wheel by Group 8

Here is presented the Futures Wheel of Group 8 as documented from the paper version. The Futures Wheel working phase began by the group discussing from each own point of view what the ideal sustainable society would be like. The ideas gathered in the discussion are presented as a list below the Futures Wheel. After discussing the ideal society, the group started to fill elements onto the **inner circle**. The group discussed and ideated **technologies/practices** that are **promising and interesting** in terms of sustainable energy production. After the inner circle the group moved on to the **outer circle**. On the outer circle the group concentrated **on deep structural changes in society**.

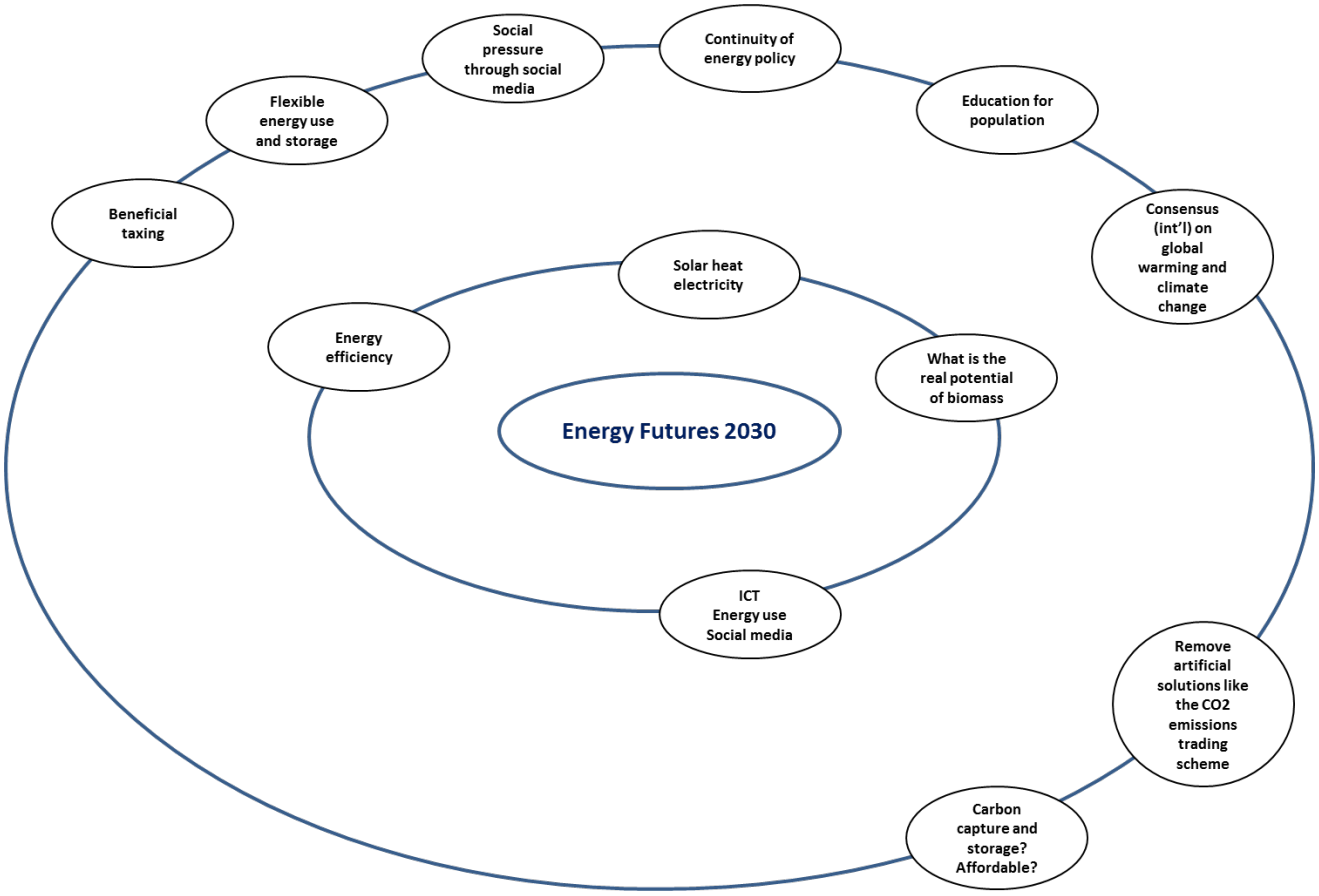


Figure 14. Futures Wheel elaborated by Group 8.

Ideas on the ideal society of sustainable growth and well-being

The following ideas on the ideal society of sustainable growth and well-being were selected to the centre of the wheel:

- Energy independence
- Zero emission electricity & transport
- How fast can we phase-out our old technology? Not by building it. 1/3 - nuclear fuel, 2/3 – waste heat
- Energy is cheap. Should it stay like that?
- How to come to agreement across borders & regions? "Same thing" can mean something different elsewhere
- Decentralised energy transfer – no grids

Drivers by Group 8

In the beginning of session 1, each group voted for 6 drivers from a drivers list (see appendix 2), that they found important and interesting in relation to the formation of futures societies. Below are presented the six most voted drivers by group 8.

Megatrends

1. Climate change
2. Raising energy prices

Trends

1. Rising energy costs
2. Decreased importance of mobility

Weak signals

1. Increasing application of local services
2. Slow life

PESTEC Table by Group 8

In Session 2 the groups worked on their PESTEC Table. The groups first discussed and defined their preferred future within the framework of their generic scenario based on the ideas generated in Session 1. After reaching consensus on the "definition of the preferred future", the groups gave it an illuminating name.

The groups then began to fill in the PESTEC Table: defined the most important measures, steps and preconditions on all dimensions of PESTEC to achieve the preferred future within their scenario framework. The groups could use the ideas already gathered and come up with new ones.

Table 8. PESTEC Table constructed by Group 8.

PESTEC	Less imported energy			
Political	- Long-term planning	- More local decision-making	- More "in-line" with Sweden and Norway	
Economic	- Taxation benefits and penalties	- New employment opportunities	- Export new technologies	
Social	- "Hyvää kotimaista energiaa"	- Keep your mind open for new possibilities	- Well-being of people	
Technological	- Make use of local resources	- Export products/markets	- Replacing technology by more energy-efficient	
Environmental	- Closed production circles	- Green tourism, eco-tourism	- More local control & awareness (YIMBY)	
Cultural/ Customer/ citizen	- A way of life will become a part of culture	- Smaller footprints		

Scenario Narrative by Group 8

In Session 3 the groups composed a scenario narrative, which would vividly describe the societal setting and energy landscape of 2030 framed by and built on the group's given generic scenario, the group's preferred future, the most voted drivers and the ideas generated for the futures wheel and the PESTEC Table (Sessions 1 & 2). In addition the concepts of Neo-Growth, Sixth-Wave and the Third Industrial Revolution could also be used. The scenario narrative by Group 8 is presented below.

Less Imported Energy

In 2012, climate change and raising fuel prices created pressure from local communities for more self-sustaining energy policy. A few political parties won the elections by playing into this. Long-term planning involved the minimization of imported energy. Taxation favours the use of local energy sources.

A first result was energy policy similar (more similar) to the other Nordic countries, improved (cooperation with Nordic countries), new employment options created, improved well-being and raised consciousness on local environmental issues and economics.

In 2030, public and private transport runs on electricity (solar in summer) or biodiesel (in winter). Replacing old vehicles by new ones has been completed. Zero-energy houses and buildings can distribute heat and electricity to local industry. Solar energy, heat pumps and small wind parks generate the necessary heat and power. Forests and other local resources use is optimized. Energy-related developments in Finland attract international attention and trigger eco-tourism.

The population of Finland has less to worry about compared to the year 2012. Legislation secures that excess heat and electricity can be put on the local grid or other distribution system. The so-called "smart grids" should indeed be realised.

Research on solar energy (thermal, electricity) gives better and better technology.

Hot Topics for Further Research Suggested by Group 8:

- More research in the field of renewable energy
- Research especially on solar: solar thermal (including solar cooling), solar photovoltaic energy. Note: electricity needs for cooling during summer are larger than for heating needs during winter. Also in Finland.
- Energy storage (heat and power)
    - Improved efficiency of large and medium scale electricity production (for example: new Olkiluoto 4200 MW fuel energy in, 1600 MW electricity out, 2600 MW to the fish as cooling water: this means 38% efficiency. This is a very bad number for 21st century technology. At the same time, efficiency of energy use by consumers is a hot topic: when will electricity producers be forced to be more efficient too?! While the consumers by energy saving lamps....)
- How does Finland go from 30% to 38% renewable energy when taking into use more nuclear power in the (near) future?

6. CONCLUSIONS AND RECOMMENDATIONS

This concluding chapter presents some of the main common features of the Groups' results and the fields of research suggested by the groups for the new energy programme. The summaries of each general scenario, as well as their detailed session outputs, can be found in Chapter 5.

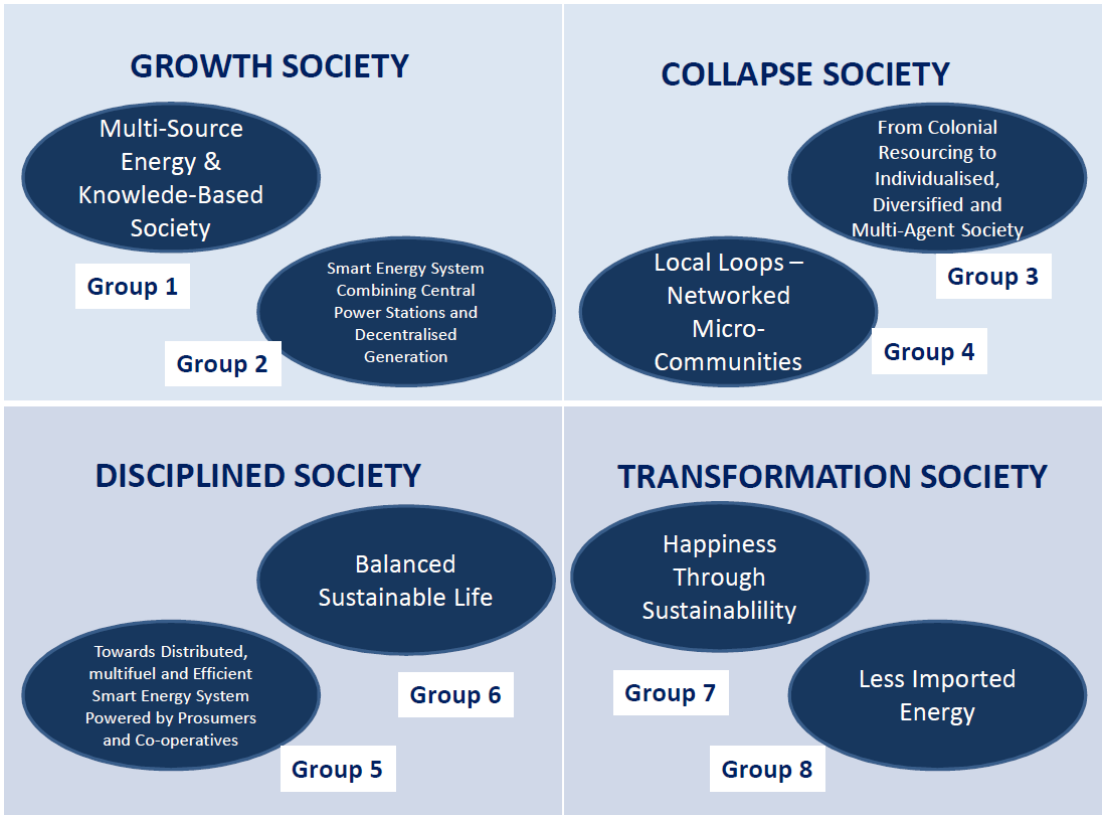


Figure 15. The eight scenario sketches elaborated in this Futures Clinique within Dator's framework of four generic futures.

By far the most common idea in the groups' work was that of dispersed, decentralised, local and diverse energy production – all groups based much of their workings on locally produced, distributed clean energy. Regardless the scenario, the society would be fossil-free or producing very little fossil emissions. The palette of distributed energy consists of such technologies as geothermal heat, solar energy, wind energy, wave energy, biofuels (such as algae), and technologies of energy efficiency. In a local world, city infrastructures would be much denser than today. In establishing a sustainable society long-term, futures oriented perspectives are needed to anticipate required measures and to open up new possibilities. International agreements on cutting CO_2 emissions are also crucial, as are economic incentives.

Another common feature and statement in many groups was the realisation that we need multiple solutions and also multiple energy forms. Combinations of various energy sources and ways of production should abound. In fact, this could be one line of research themes for the new energy programme.

The combination of social, economic, ecological, technological and cultural was analysis was another finding of crucial importance from the sessions. Every group acknowledged that the path towards a sustainable society is not paved only by technology and policy planning, but changes in values, attitudes and lifestyles are required as well. Every group described the whole society functioning increasingly from the bottom-up, and lifestyles being based on local, communal cultures and green values. Individualistic thinking and materialism have been restrained. The rise of the civil society means people taking personal responsibility on environment instead of relying on official institutions. Not only lifestyles and energy production, but all production and consumption would be mainly local. Digital manufacturing could enable local production, as for example 3D printing allows production not depended on a certain place. Raw materials and resources could also be produced locally, if the knowledge on bio-materials was advanced enough. Local peer-to-peer approaches and do-it-yourself mentality also mean that innovations rise increasingly from the grass-roots as small and medium sized companies thrive.

Highly developed ICT would ensure that no community or individual be isolated from the national and global community. Virtual communities in general thrive, and teleworking is cherished. However, the world of localism and scarcity can lead to narrowing circles of trust. Notwithstanding the society being increasingly self-organised by citizens, the idea that society should also be regulated on a national and also global level was widely supported. For example, pervasive environmental education is needed to raise eco-savvy citizens. However, imperative for sustainable society is, according to the groups, that citizens find sustainability meaningful and really worth striving for. Thus we need to find ways to combine sustainability with wellbeing, happiness and individual fulfilment – the baseline for ecological sustainability is a socially and economically sustainable society.

As for energy technologies, smart grids form the basic infrastructure on which the distributed energy system relies on. Opposed to the paradigm of distributed energy a few groups mentioned nuclear power as a central part of the energy system, at least during the transition phase to renewable energy, and as the fourth generation energy form – fusion. Suggested for further research were solar energy, hydrogen, technologies for energy efficiency, efficient recycling technologies and practices (cradle-to-cradle), battery technology, material development and smart cars. Efficient regulatory means and energy politics should also be studied, and examining the energy system as a part of the whole from the point of view of social sciences, consisting e.g. of economy and customer behaviour. This also means, for instance, developing efficient methods for environmental education. It is of paramount importance to find out new business models, such as utilising social enterprises and developing a functional sharing economy.

Tunnel vision, short-sightedness as well as a lack of holistic systems thinking, awareness and political will were perceived in many of the group discussions as bottlenecks hindering a rapid introduction of sustainable energy systems. Interestingly enough, many groups expressed the need for re-defining several key concepts – that of growth, consumption and happiness. One of the goals of this Futures Clinique was to find radical energy solutions and innovations. Some technological ones, such as self-driven cars and harnessing kinetic power, were suggested. However, perhaps the most radical ideas were related precisely to the idea of holistic changes – that energy solutions should be dispersed, and that besides changes in energy systems we need thorough changes in lifestyles, behaviour and values as well.

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APPENDIX 1. PROGRAM

FUTURES WORKSHOP: ENERGY 2030

TOWARD THE NEO-GROWTH ENERGY PARADIGM OF THE SIXTH WAVE ERA

Monday 3rd December 2012 at 08.30–16:30

Place: Academy of Finland, Seminar Room "Monitoimitila" (1st floor),
Hakaniemenranta 6, 00531 Helsinki

PROGRAM

08:30–09:00	Sign up & coffee
09:00–09:10	Opening words Director Arja Kallio, The Academy of Finland
09:10–09:50	Futures Provocation Future as Signals How to probe different futures of energy? Professor Sirkka Heinonen and project researcher Juho Ruotsalainen Finland Futures Research Centre (FFRC), University of Turku
09:50–10:00	Futures Window Visualizing weak signals as food for imagining energy futures
10:00–11:30	SESSION 1: Futures Wheel
11:30–12:30	Lunch
12:30–14:00	SESSION 2: Futures Table (PESTEC)
14:00–15:30	SESSION 3: Four Energy Futures Scenario Narrative
15:30–16:30	Conclusions Presentations of results & discussion

APPENDIX 2. DRIVERS FOR CHANGE

Sirkka Heinonen & Juho Ruotsalainen
29th November 2012

Drivers catalysing change

In futures studies a major aim is to look at the futures landscape and the futures horizon in order to foresee driving factors and emerging issues, as well as discontinuities and tipping points. Such anticipation of change through horizon scanning can be done on four levels: megatrends, trends, weak signals and black swans. Black swans (sudden, rare and unexpected events with radical and widespread impacts) are not included in this drivers list and futures workshop.

I Megatrends

Megatrend is a global, very strong phenomenon affecting practically everything. Megatrends cannot be changed at least on a short period of time.

- Climate change
- Increasing resource scarcity
- Urgent need for renewed energy systems
- Deepening globalization & global economy
- Prospering global population, rise of the middle-class (especially in China)
- Urbanization
- Ageing of the population
- Population growth
- Increased mobility
- Digitalization/spread of the internet
- The exponentially developing technology/technological convergence
- Deepening & spreading networks
- Individualization
- Experience economy

II Trends

Trend is a medium-strength phenomenon and it indicates a relatively stable development path.

- Individualism merging with collectivism → indocollectivism (flexible and loose communities organised around shared values, tastes, interests, etc.)
- Changes in conceptions of privacy – our private life being increasingly public
- LOHAS – Lifestyles of Health and Sustainability
- Open innovation processes: cooperative innovation with other organisations and companies, customers, consumers/prosumers, civil society, research institutes etc.
- Open information/big data
- Claims for heightened productivity
- The growth of the service sector/Transformations of the service sector
- The growth and transformation of the creative economy
- The merging of industries
- Abundant flows of information, related fast pace of changes and possible short-sightedness

- Increased appreciation of leisure
- The merging of work & leisure
- Claims for City Green (pocket parks etc.)
- NIMBY (Not In My Backyard) vs. YIMBY (Yes In My BackYard)
- Dense cities
- Decreased importance of physical mobility (e.g. in the US the Generation Y owns much less cars than their parents)
- Mobile devices
- Ubiquitous technology
- Claims for multi-functional urban spaces
- Living alone – the amount of single-person households has risen 88% since 1996
- Smart City (City infrastructure embedded with information technology, the ubiquitous utilization of ICT and digital services)
- Rising energy costs
- The rise of environmental industries
- Heightened awareness on environmental issues
- CleanTech
- The rise of BRICS countries (Brazil, Russia, India, China, South-Africa)
- Health-oriented lifestyles
- Democratization
- Crowdsourcing
- The quest for individualized lifestyles, meaningful experiences and identity building
- The rise of the meanings society (a possible societal phase after the information society; has the same common features as neo-growth, sixth wave and the third industrial revolution)

III Weak Signals

Weak signal is a sign indicating a possibly strengthening emerging phenomenon. The term of weak signal is often used to refer to the phenomenon itself, not only to its indicators. For example, rise of the civil society is a phenomenon to which the increasing number of grass-roots activities (= weak signal) is pointing to.

- Exchange economy
- Rise of the civil society: grass-roots activities and local democracy
- DIY (Do-It-Yourself): enthusiastic amateur production (amator = lover)
- Prosumerism (producers + consumers) & its different forms
- Peer-to-peer production – autonomous, voluntary and peer-organized production or prosumerism
- The third industrial revolution: from mass production to tailored niche-production, 3D-printing, networks of small & micro enterprises, ”garage factories”
- The occupying of public spaces/combinations of private and public spaces: ”public living rooms” or “hybrid spaces”
- The fourth sector – market-based production seeking only for small profits; has other goals than profit-making (social, cultural, environmental etc.)
- Social enterprises (non-market-based, subsidized)
- Neo-communality (people are communicating and forming ”communities” more and more, but still retaining their individuality)
- Rise of suburbs, ”urban villages”
- Increasing appreciation of local services
- Citizens' opinions & knowledge gaining more power in decision making

- Self-sufficiency economy
- Biomimics (mimicking the models, processes and structures found in nature)
- Vertical farming
- Slow life

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APPENDIX 3. EXAMPLES OF ENERGY INNOVATIONS

Examples of some promising energy innovations, in work or realised, are presented below in order to stimulate open futures thinking.

- **Artificial Leaf**: Massachusetts Institute of Technology has created an artificial leaf mimicking nature's photosynthesis process – only ten times more efficient. The "leaf" is made from stable, widely available and inexpensive materials like silicon, electronics and chemical catalysts. With less than 4 litres of water the "leaf" could produce enough electricity to power a house in a developing country for an entire day. (Brown 2011.)

- Another technology for a faux photosynthesis is being developed by a multi-institution project at the Joint Center for Artificial Photosynthesis. The technology would produce storable and transportable fuels from non-organic photosynthesis. This method could increase the efficiency of photosynthesis even a hundredfold. (Diamandis & Kotler 2012, 167 – 169.)

- **Harvesting noise vibrations and other "junk" energy:** Researchers at Georgia Tech are developing techniques for converting ambient microwave energy into DC power. University of Buffalo physicist Surajit Sen is studying ways to use vibrations produced on roads and airport runways as energy resources. (Futurist 2012; Pauli 2010, 218 - 219.)

- **Hyper-Dense Smart Cities:** Hyper-urbanisation refers to cities as extremely dense and ecologically sustainable communities with open and shared public spaces instead of closed and private ones. Cities are increasingly being developed as smart cities with ICT and sensors embedded in every part of the infrastructure and every function of the city. ICT is used to collect vast amounts of (open) data and enhancing the functions of the city ecologically. Smart cities utilize a variety of digital services e.g. to leverage the civil society and providing information on ecological solutions. A smart energy grid would for example enable citizens to sell the surplus energy they have produced.

- **Biofuel from Algae**: According to US Department of Energy, algae can produce thirty times more energy per acre than conventional biofuels. Moreover, algae are being tested at several power plants as a carbon dioxide absorber. (Diamandis & Kotler 2012, 161–164.)

- **Quantum Solar Cells**: Today's solar cells convert only 10–15% of the light they receive into current. Semiconductor crystals, or quantum dots, being research could rise the percentage to 60. (Minkel 2011.)

- **The Holy Grail of Storage**: Hydrocarbons are easy to storage, but wind and solar power work only when the sun shines and wind blows. For grid-level storage today's lithium-ion batteries are woefully inadequate with low storage capacity and lithium being rare and toxic. Aquion Energy builds batteries similar in design to lithium-ion batteries, but using sodium and water instead. The batteries can hold a kilowatt-hour for one cent. Primus Power builds rechargeable "flow" batteries, in which electrolytes flow through an electrochemical cell that converts chemical energy directly to electricity; these are already used to store wind energy in a 75-megawatt-hour energy storage system in Modesto, California. ARPA-E has developed a Liquid Metal Battery with currents ten times higher than present day high-end batteries and with cheap design. (Diamandis & Kotler 2012, 164–166.)

- **Collaborative Consumption**: renting, lending and even sharing goods instead of buying and owning them. Besides meaning producing and consuming less stuff, collaborative consumption and peer-to-peer sharing "involves the re-emergence of community," according to Rachel Botsman, co-author of What's Mine Is Yours: The Rise of Collaborative Consumption. (Walsh 2011.)

- **Food That Lasts Forever**: US Army and NASA, among other research institutions, are developing new methods to preserve food and keeping them fresh for a very long time. Instead of chemicals, heat, salt etc. new preserving methods rely for example on high-pressure processing (HPP), which greatly improves taste and freshness of the preserved food. US Army's goal is to create meals that can last up to 10 years tasting so fresh people wouldn't notice it's preserved. In the future we may have to go to the grocery store only once a month and will rarely, if ever, need to throw out food because it has gone bad. Frozen- and chilled-food sections might also become obsolete. (Blum 2012.)

- **Fourth Generation Nuclear Energy and Fusion-Triggered Fission**: The urgency to cut emissions may lead into a renaissance of nuclear power. Some environmental activists, such as Stewart Brand and George Monbiot have turned pro-nuclear energy in the face of climate change. It has even been argued that on a relatively short time-scale (~10-20 years), the emission cuts needed are not possible without building more nuclear power plants. Generation IV reactors burn at higher temperatures which gives them the ability to turn nuclear waste an surplus, low grade uranium/plutonium into electricity. Some generation IV reactors can burn thorium, which is four times more plentiful than uranium, and doesn't create any long-lived waste. The reactors can't melt down as they are able to shut themselves down without human intervention. Generation IV reactors can even be turned into self-contained, small scale modular "backyard" reactors. They are sealed completely and designed to run for decades without maintenance. The reactor vessel serves as the unit's burial cask. (Diamandis & Kotler 2012, 167–169.)

- The National Ignition Facility in Livermore, California, has come up with a new method of using fusion to drive fission. The method would multiply the reactor's power output by a factor of four or more. The process could lead to prototype plants in 20 years. The process eliminates the need to sustain a chain reaction, which requires plutonium or uranium. The hybrid fusion-fission plant would broaden the menu of possible fuels (including nuclear waste) and enhance the burnup thus requiring perhaps only a 20th as much fuel as typical fission reactor. (Collins 2011.)

- **Heat Engines**: Up to 60% of the energy generated in the U.S. is wasted – much of it lost as heat. General Motors is researching exotic materials called shape-memory alloys, which can convert heat into mechanical energy that in turn generates electricity. The applications are endless: cars, trains, factory boilers, refrigerators, chimneys etc. can be turned into sources of electricity. (Trivedi 2011.)

- **Shock-Wave Auto Engine**: Michigan State University is developing a wave-disk engine or shock-wave engine that would eliminate pistons from engines. If the project is to succeed, future hybrids could go five times farther on a liter of gasoline. (Ashley 2011.)

- **Integration of wind turbines along the motorways**: Wind turbines could be sited along motorways thus minimizing the noise harm. Turbines integrated along motorways would also be easier to maintain. They could even be turned into environmental art! (Helsingin Sanomat, Mielipide, 30.8.2012)

- **The Solar Airplane**: The single-seat Solar Impulse airplane weighing as little as a family car is powered by 11 600 solar cells and can fly continuously for more than 24 hours; the second model will be able to fly around the world (Time 2011).

- **3D Printing as an Ecological Alternative**: 3D printing of objects or "additive manufacturing" is much more efficient and produces much less waste than the traditional substractive manufacturing methods requiring as little as one-tenth of the amount of material. It allows the creation of parts in shapes that conventional techniques cannot achieve – and suiting especially well for biomimicry products – resulting in new, much more efficient designs in e.g. aircraft wings or heat exchangers. Production by 3D printing could be very local thus eliminating the need for heavy logistics. (http://www.economist.com/node/18114327)

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