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Perspectives on Sustainable Energy for the 21st Century

DRAFT

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Perspectives on Sustainable Energy for the 21st Century

Executive Summary

Energy and sustainable development

Affordable access to essential services underpins development. Energy fuels many such services. The 'energy-system' harnesses resource, transforms it to energy carriers that are used in appliances and machinery to provide those services. In order to provide services to current and future generations, the 'energy-system' itself needs to be sustainable. This 'energy system' may impact and interact with the economy, the environment (including other physical resource or commodity systems) and society. The effects of this impact and interaction should also be sustainably managed.

The energy decision maker is thus concerned with: (i) enabling appropriate, affordable and adequate service access; (ii) ensuring the energy-system can do so in a sustainable manner; and (iii) ensure that the broader interactions between systems does not compromise the planet's sustained development.

Polarized and politicized views

Polarized and politicized views typically dominate the energy debate, at national, regional and global levels. This has made it increasingly difficult for energy decision-makers to untangle the evidential basis for developing consistent decision-making frameworks.

Through interviews with energy experts and a literature review, twenty stylized perspectives on energy were identified that are representative of the range of dominant views in the global energy debate. They are summarized in Table 1. It should be noted, however, that the lines of division between these views are not clear-cut, and views of energy experts typically consist of a mix of several of the stylized views presented. These perspectives represent either goals and strategies, means and policies, or contexts and limits, and thus operate on rather different levels. Apparently contradictory conclusions ultimately derive from a range of assumptions made for different time scales which are rarely (if ever) made explicit, including in many academic articles.

Suggestions for the way forward

Based on the experts' feedback and literature review, six suggestions were identified as commonly-agreed 'no regret' commitments for Rio+20. They are generally modest in their ambition, but may be nevertheless considered important steps for energy decision maker to consider, regardless of the negotiated outcome of Rio+20. They are:

A. Scenarios and indicators: Promote tracking the diagnosis, progress and scenarios of national, regional and global energy systems with a common set of 'strategic' SD indicators.

B. Energy assessments: Promote platforms for transparent national and international energy assessments (tracking economic development, fuel flows, physical resource use and environmental impacts in a quantitative manner)

C. Economic efficiency: Assess opportunities to increase the economic efficiency of the energy system, especially (but not limited to) where these promote end-use energy efficiency improvements.

Table 1. Twenty stylized perspectives on energy, identified through interviews of experts.

		Stylized views	Description and rationale
Goals and strategies	Individual	Empower the poor	Lack of access to electricity, safe heating, and cooking causes over a million of deaths a year, yet this has received little attention compared to GHG emissions mitigation.
		Oh behave	Behaviour needs to change, since so-called 'planetary boundaries' will be exceeded, if current economic growth patterns continue. It may even be necessary for the 'de-growth' of rich nations, for equitable access to services.
	National	Security first	Is there enough energy available at the right price to ensure development? It is the priority and right of every government to secure its energy supplies.
		Development first	Lower income countries should be encouraged to undertake sustainable development actions that are compliant with their drive to develop: nationally appropriate mitigation measures are needed.
Means and broad policies	Technology preferences	Biofuel is bad	Using crops for large scale biofuel production will lead to higher food prices for the poor, and our vulnerability to the climate.
		Energy technology revolution	In order to meet global GHG emissions targets, the burning of fossil fuels with no capture and storage must be limited. Urgently, a rapid change is needed in energy system investments, including, inter alia, large scale investments in renewable energy, energy efficiency, nuclear power, and carbon capture and storage.
		Sustainable energy technologies	Investments should be made only in energy efficiency and renewables, since only renewable 'fuel sources' can ultimately be sustained.
		Nuclear renaissance	Nuclear energy should be the preferred option, as it is not intermittent and it is clean. Plants require little land, but produce much power as well as material used for medical, security and other uses.
		Anti-Nuke	Nuclear energy should be phased out, due to unacceptable risks at power plants, dangerous waste that remains radioactive for a very long time and might enable weapons production.
	Market instruments	Free the market	Markets provide the best mechanism to determine what investment and R&D needs to take place in the energy system, therefore subsidies must be removed. By getting everyone to play by transparent rules, access to resources can be secured, as long as the "price is right".
		Leverage learning through subsidies	Markets are entrenched and subsidies need to be provided, especially for renewable energy, to help them compete with conventional fuels and secure necessary R&D.
		The polluter pays	There should be a clear (exonerative or punitive) penalty charged for external costs incurred by damaging the ecosystem and society.
	Various policy measures	The prime movers pay	As damage to the ecosystem (including GHG emissions) were made by (now) rich countries, they should pay to fix the problem.
		Basket case	Put in place standards, feed-in tariffs, measurement and verification, mandatory audits, carbon caps and trade etc. No single policy is sufficient!
		Energy efficiency	Is the single largest, most economic, environmentally friendly energy source yet to be comprehensively harnessed, using a suite of measures.
Context and Limits	Resources	Peak oil	The age of fossil fuel is coming to a rapid end. Depletion rates for oil (and other) fossil fuel have peaked or are about to peak. This leaves a gap to be filled as demand continues to grow.
		No limits	There are essentially limitless reserves of fossil fuels and their level of availability depends on prices. At higher prices more unconventional resources will be discovered and exploited. Some postulate that gas is not a fossil fuel, but renewably produced in the underground.
	Ecosystem integrity	Destroying the global commons	The ecosystem provides a limited amount of services. We damage these services by polluting too much or using too much. Since most do not pay for the damage they cause, they are free to continue destruction without restraint.
		Planetary boundaries	The limits to the use of these ecosystem services needs to be determined and boundaries established. Once we overstep them disaster will ensue.

D. Strategies for modern energy access: Develop strategies and supporting frameworks to help the poorest countries gain adequate, affordable access to modern energy services (at least to meet the MDGs) and prevent the more than one million deaths a year attributed to burning solid fuels in poorly ventilated housing.

E. Evaluation of ecosystem services: Undertake transparent evaluations of ecosystem services and their limits, to support discussions on their usage.

F. Develop methodologies for the integrated analysis of the systemic implications of meeting simultaneously global food, water and energy needs - given that each is essential and each may compete for common ecosystem (and other) services and affect each other.

There were several additional suggestions made during the feedback process, including:

1. On efficiency: It was suggested to emphasize and explicitly recognize potential rebound effects arising from efficiency measures. Some argued that the counteracting of efficiency gains by rebound effects may even need to be managed. It was proposed to do this by raising energy prices, in order to keep the effective cost of the energy service constant. This would avoid exposing end-users to rising costs and negative impacts on welfare, while sustaining the incentive for reducing energy use (Wilson 2012). Others argued that rebound effects are mostly limited (Laitner 2012). Furthermore, it was pointed out that limiting rebounds might be hard to achieve in a market economy. Efficiency of the existing stock of fossil power plants, as well as greater emphasis on gas as a transition fuel should be considered. Gains to be made here were large and economic (Lloyd 2012). As urbanization is a strong driver, there might be scope to develop energy efficiency standards specifically for cities (Messner 2012).

2. On access: The importance of access was suggested but emphasized that it requires the support of indigenous peoples, and that it should not be imposed in a top-down way (Victor 2012). It was noted that affordability increases as wealth is generated, calling for an emphasis on wealth creation and to prevent long-term dependence on subsidies and related support measures (Lloyd 2012).

3. On technology: It was suggested to develop a framework to engage and fund international technology cooperation for solutions that simultaneously address energy poverty, energy security and local and global environmental concerns (Grübler 2012).

4. On measures: It was suggested to implement market "facilitating" measures to enable sustainable solutions for clean energy access, energy efficiency, and sustainable urban designs, such as building efficiency standards, urban air quality standards, and capacity building for planning for sustainable urban mobility with emphasis on non-motorized and public transport. (ibid)

5. On empowerment: It was suggested to explicitly recognize and strengthen the role of rural and indigenous women in energy management. It was pointed out that women are not only end users of energy, but also managers at the local level, playing a role in the conservation of existing natural resources and in managing the renewable energy systems, such as solar and biomass. Women need cleaner cooking energy, but there is also a need for strengthening their capabilities in tree and water management, as well inclusion in local, national and internal bodies set to manage energy infrastructure (Kelkar 2012).

Finally, a cautionary note that the issues identified here are important but not new. Lack of political will and leadership have limited the adoption of these suggestions in the policy makers’ discourse in the past and will do so in the future, at both the international and local levels.

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1. Introduction

The present study is a component of the project entitled “Sustainable Development in the 21st century”, also referred to as SD21, which was carried out in preparation for the Rio+20 Conference in June 2012. The project was implemented by the Division for Sustainable Development of the United Nations Department of Economic and Social Affairs (DESA) and funded by the European Commission, Directorate General for Environment, Thematic Programme for Environment and sustainable management of Natural Resources, including energy (ENRTP).

The aim of the study was to offer a perspective of the choices, constraints and trade-offs that lie before decision makers in the energy domain for the next 30 to 50 years. Polarized and politicized views typically dominate the energy debate, at national, regional and global levels. This has made it increasingly difficult for energy decision-makers to untangle the evidential basis for developing consistent decision-making frameworks.

2. A Primer to the Global Debate on Energy and Sustainable Development

Here we discuss energy and its role in development that is sustainable; some aspects of our need for energy services, selected characteristics, interactions and impacts of energy systems; selected trends; perspectives that are often articulated in the energy arena; and then potential responses by policy makers. Readers fully familiar with energy systems may want to skip sections 2.1 and 2.2 and continue reading from section 2.3. Those who skip the primer may want to note that selected elements of this section are repeated in section 'Lessons learned and no regret suggestions’.

2.1. Energy and sustainable development

Affordable access to essential services underpins development. Energy fuels many such services. The 'energy-system' harnesses resources, transforms them to energy carriers that are used in appliances and machinery to provide those services. In order to provide services to current and future generations, the 'energy-system' itself needs to be sustainable. This 'energy system' may impact and interact with the economy, the environment (including other physical resource or commodity systems) and society. The effects of this impact and interaction should also be sustainably managed.

The energy decision maker is thus concerned with:

1. enabling appropriate, affordable and adequate service access;
2. ensuring the energy-system can do so in a sustainable manner; and
3. ensuring that the broader system interactions do not compromise the sustainability and sustained development.

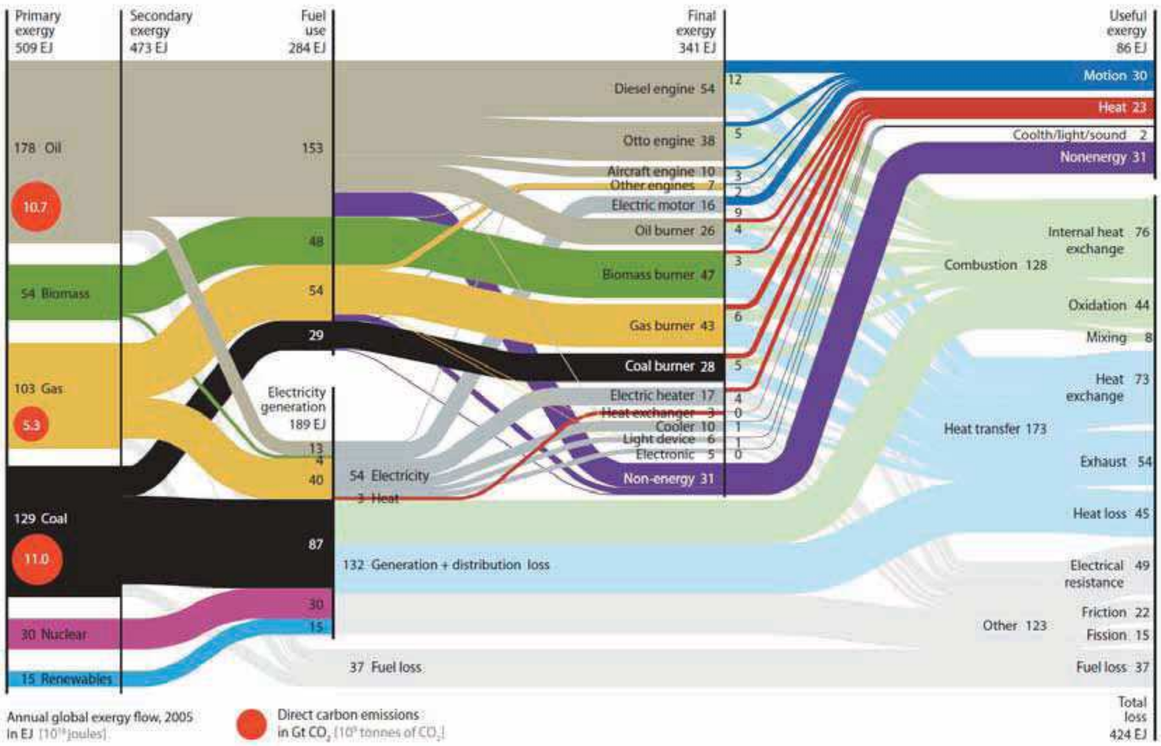
2.1.1. Access to a service

To most, 'energy' refers to a fuel or energy-carrier such as oil or electricity. However, these energy carriers are only means to an end. The end is the services that these energy carriers help to provide. 'Energy services' range from providing motive power and heat in industry, to information and communications technology in commerce, to cooking and refrigeration in a household. Without energy services, development of the socio-economy is not possible. Those services should be accessible to the user. They should be affordable and meet actual needs. An important element essential for sustainable development is affordable, adequate and appropriate access to energy services to society and the economy.

2.1.2. A sustainable energy system

The 'energy-system' consists of an array of technologies, processes, appliances and practices that convert resources to energy carriers to a service. On one end of the system are primary energy resources, such as coal, crude oil, uranium, wind and others. At the other end of the system are the energy-services, such as lighting, heating, motive power, telecommunication, IT, and others.

Figure 1. Global energy flows from extraction to useful exergy, 2005



Source: Cullen and Allwood (2009).

The energy system is thermodynamically inefficient. Much energy is wasted. In many instances, it may be economically efficient to waste it. This may be the case when the extra cost of purchasing more efficient machinery outweighs the cost savings gained from reduced energy purchases. There is however much evidence that a large proportion of the energy wasted in the system could be used economically, but is not being used due to policy failures, ignorance and financing constraints.

The energy system is integrated, and at various levels there is competition between energy carriers. The energy system consists of several sub-systems that are rather entrenched. They have specific regulations, extensive markets and strong important utilities. Fossil fuel markets such as oil and gas, as well as power markets are typically governed by special sets of rules. Incorrectly formulated, these market rules may hamper investment in alternatives. In some instances, subsidies, such as feed-in tariffs are implemented to encourage the entrance of new technologies, such as renewables.

The system is dynamic. While many individual components, or subsets, of the system may be unsustainable in the longer term, the objective is a sustainable supply of services. Thus, using of depletable resources is only unsustainable, if it prevents alternatives from meeting the required energy service in the future, or if it has some other negative impacts. Indeed, at a given point in time, it may be that the only affordable energy sources are depletable. Other examples of negative impacts include health impacts or irreversible environmental damage.

The physical structure of the energy system is not homogeneous. Some energy infrastructure is long-lived, whereas some appliances have relatively short lifetimes. Quick changes in the overall system can be difficult due to techno-physical constraints. If - for example - there was a need to move quickly from fossil fuels for electricity generation, it would require halting the use of power plant infrastructure that still has considerable economic value. But many power plants are designed to run for decades, meaning there is a strong economic incentive to continue their use until retirement. Furthermore, the construction of infrastructure to use alternative fuels can take several years. Rapid switches in the energy system can therefore be difficult. Energy infrastructure also differs strongly with respect to location, vintage and other attributes. In many least developed countries, the energy infrastructure is old and has low efficiencies. In some developing countries, recent growth has resulted in new investments in high performance infrastructure. In other settings, where stringent regulation is in place, environmental performance is typically high.

As demands in the system increase, resources deplete or production capacities become limited, pressure may be placed on specific pathways in the system. This is especially the case if there are a limited number of supply options or routes. The disruption of those options or routes, coupled with the slow change in certain energy infrastructure or limited alternatives can lead to price spikes and ultimately the breakdown of service supply.

This is particularly the case, where parts of the system are interwoven with common infrastructure, pathways or processes. For example, electricity relies on common transmission grids, oil may flow through a limited number of routes with limited extraction capacity, and a nuclear accident or burst wall of a dam may affect wide areas. This makes components in the energy system vulnerable to physical disruptions. Those vulnerabilities may be exposed by accidents (operational or natural) as well as for political reasons.

2.1.3. Interactions and impacts

The energy system has important interactions with and impacts on other ‘systems’, such as the environment, the economy and society.

The interactions can develop or damage each of these. For example, the emissions of pollution while burning fuels can harm human health (society), sick workers reduce the supply of productive labour (economy) and the pollution further damages ecosystems (the environment). Yet, the supply of electricity to low income users can reduce local air pollution (environment). It can lower the cost of services (economy), such as lighting. The availability of quality lighting improves education, and quality of life (society). And if the production, transport and use of electricity do not damage the environment beyond its carrying capacity, the (environmental) impact may be sustainably managed.

The energy system has impacts on physical systems. These include the natural environment, affecting the supply of ecosystem services. Several parts of the energy system depend on and affect ecosystem services. For example, naturally grown biomass is used as the dominant household fuel for over a quarter of the world’s population. Ecosystem services that are related to the energy system (directly or indirectly) are numerous, yet neither systematic quantified mapping, nor sense of relative value is available to policy makers or actors. This makes abuse of this common good almost unavoidable and potentially tragic.

Energy system interactions and impacts are felt in supply chains of other essential commodities. There is competition for commodities needed in other systems. For example, the global demand for sustainable supplies of food, water and energy continues to grow rapidly. Yet, the systems that supply each of these have common components. As demand grows, it is likely that competition and interactions will also. In many locations, fresh water is scarce. Freshwater is used in the energy system (for cooling, processing and hydro-generation), for food production (irrigation of crops and processing), for drinking and other services. Managing resources is a challenge, in view of several competing uses at various nexus points.

The energy system has a strategic role to play in the economy. Harnessing steam as an energy source powered the industrial revolution. At present, the energy system has many markets. These typically play a strategic role, directly and indirectly. Perhaps - as with coal mining - it offers high levels of employment and security. Perhaps - as with a petroleum exporter - it offers revenue and geopolitical leverage. While yet other impacts to the economy can include indirect effects associated with the construction of expensive facilities; or fuel import bills. The development of strategic economic sectors, such as petrochemicals or high-tech efficiency, chemical, renewable or nuclear generation can have significant economic spin-offs.

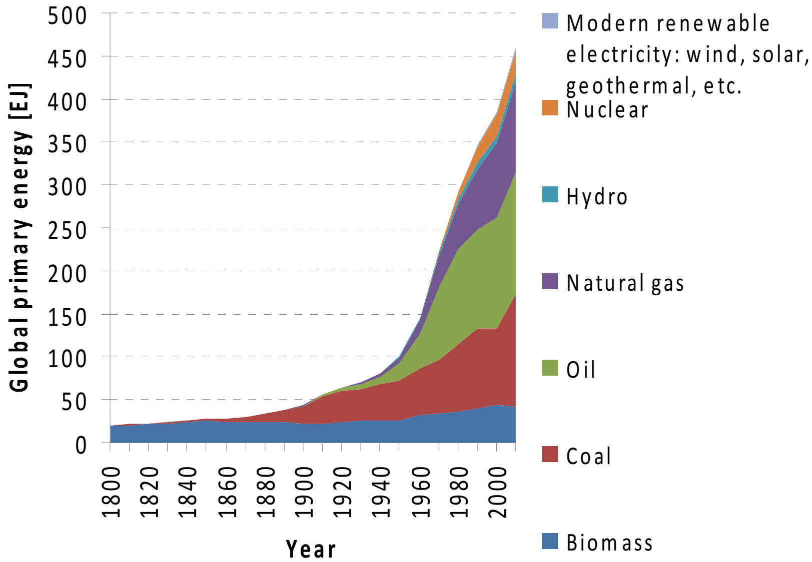
The energy system has inherent vulnerabilities and risks that pose societal, environmental and economic challenges. This results in varying levels of concern, mitigative action and exploitation. They have resulted in civil society protest, the formation of cartels of suppliers and consumers, and lobbies. Governments often take action to address these vulnerabilities, which in turn has economic consequences. Some emphasize a need for investments to increase energy self-sufficiency and suggest mandates for phasing out - or in - particular technologies or fuels. Others find these vulnerabilities acceptable and do not see a need for action. In recent years, a strong emphasis has been made to ensure the application of global market rules. These rules limit the power of producers to exert influence on supply. Infrastructure sharing and energy imports and exports also make for a valuable web of interdependence. They provide an avenue for trade and cooperation. Allowing for joint economic development, importers gain lower cost energy and exporters generate revenue.

Other social aspects of the energy system include basic levels of empowerment that are gained by access to affordable, appropriate service. These include reduced health impacts due to lower emissions, higher education rates that come with improved lighting and ICT. In order to deliver on the Millennium Development Goals (MDGs), energy services and access are needed to a greater or lesser extent for all. Furthermore, the use of these services unearths productive potential for economic activities that are otherwise unavailable. Thus an important interaction with society includes the delivery of services to tackle poverty and inequality.

2.2. Selected Trends

Global energy use has increased with technology change, population and economic growth over the very long-term. Dramatic gains have been experienced with rapid industrialization. The share of modern renewables has barely crossed the 1% threshold in 2010 and is thus too small to be noticeable in Figure 2.

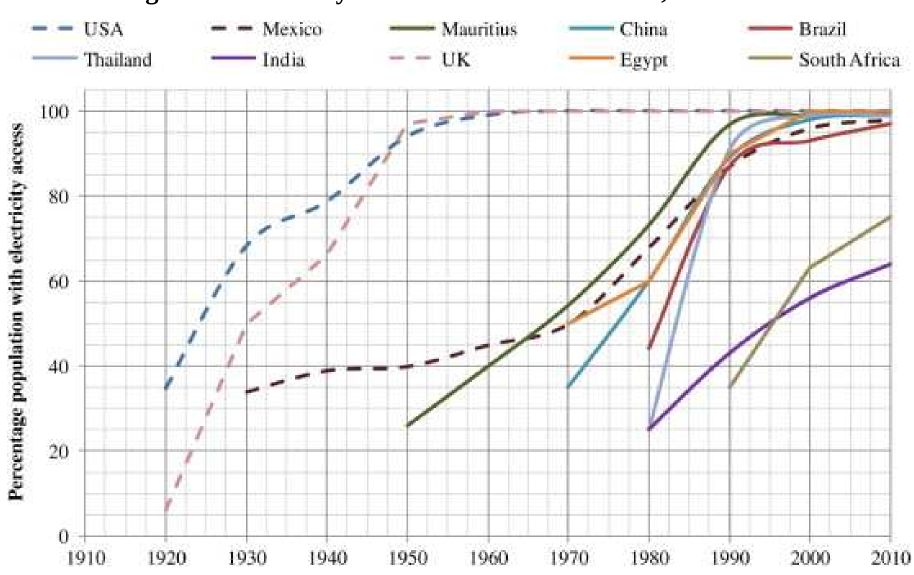
Figure 2. Global primary energy use, 1800-2010.



Data source: Smil (2010) and Tverberg (2012).

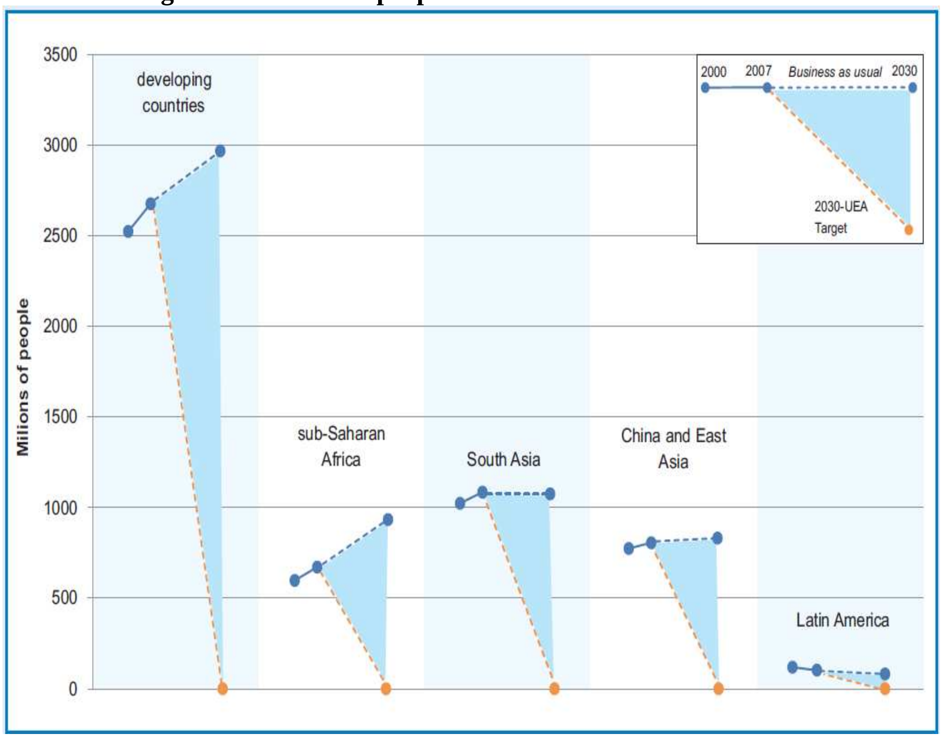
The energy system has driven economic growth and provided services to households. However, much of humanity is still without access to modern fuels. Access to electricity and modern fuels has improved (Figure 3), but has not kept up with population growth in most of the developing world (Figure 4). This has continued to marginalize the development potential of millions of people and businesses.

Figure 3. Electricity access in selected countries, 1920-2010.



Source: Bazilian et al (2011)

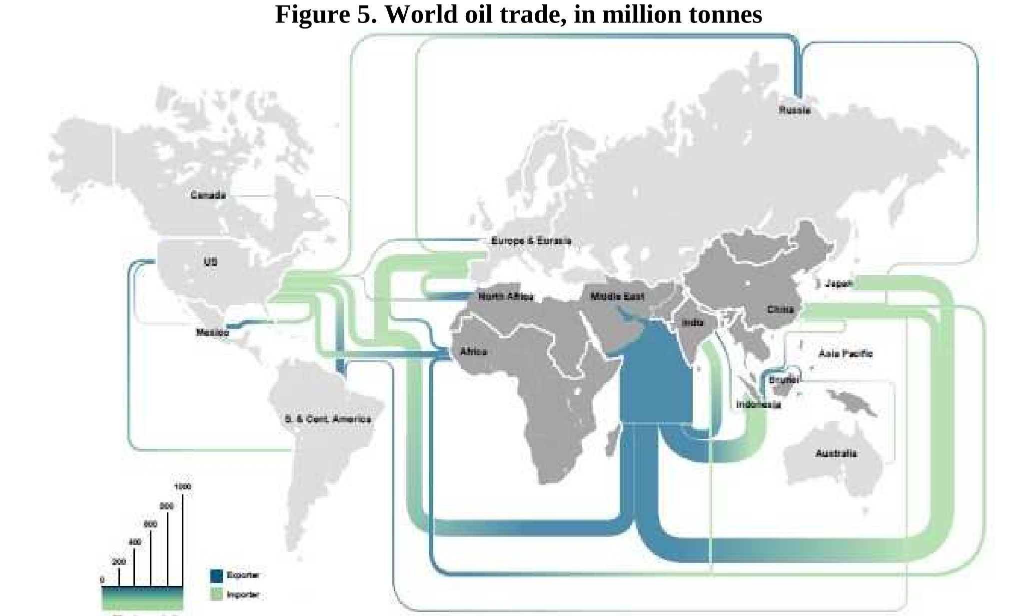
Figure 4. Number of people without access to modern fuels



Source: Bazilian et al (2011)

Energy system development has continued its reliance on fossil fuels. The effects of this include, amongst others: committing to new long lived infrastructure; and increasing trade levels and emissions. Global oil trade is currently at an historical high, and supply capacity has been constrained. This adds pressure to the limited number of strategic trade routes and exporters (IEA, 2011). However, there have been increased investments in renewable and nuclear energy. These act to improve energy independence, release pressure on constrained supplies of alternatives and reduce emissions.

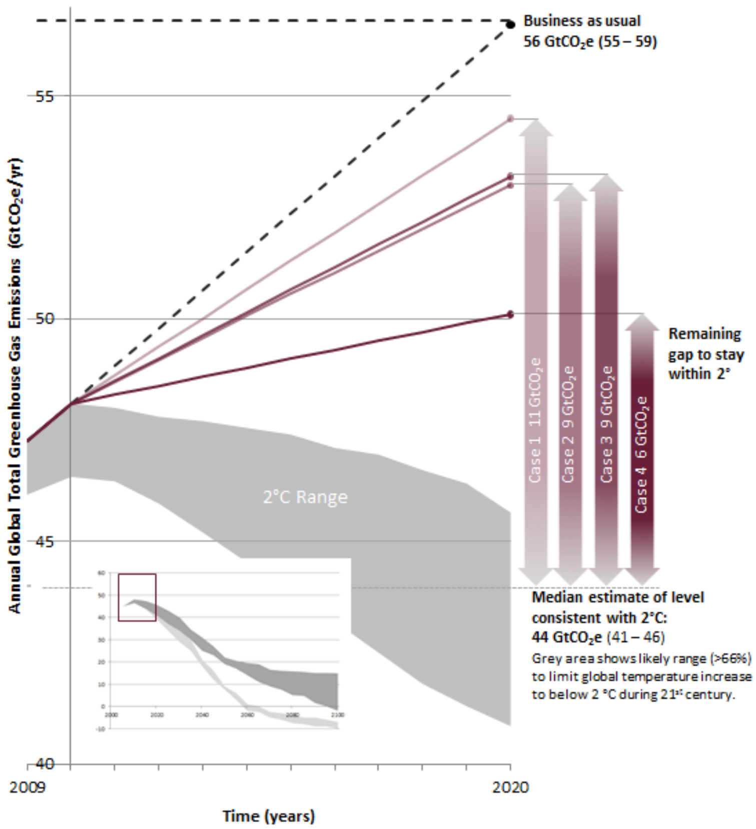
Figure 5. World oil trade, in million tonnes



Source: Standard and Chartered, 2012

It is difficult to quantify *all* impacts of the energy system. Yet, it is clear that energy-related GHG emissions have continued to rise. In view of the experience with GHG emissions reduction efforts of the past 20 years, it appears unlikely that emissions levels will be kept within what might be considered “safe limits”. Increasing evidence suggests that the energy system's demand for water for processing, cooling and hydro-generation is becoming constraining in some circumstances. And demand for irrigation, water pumping and purification is, in turn, increasing energy demand. There is also some evidence that, given current market structures, biofuel production increases food prices. These and other trends need to be better investigated and understood.

Figure 6. Differences between desired GHG emissions reductions and the sum of pledges (“emissions gap”).



Likely emissions end points, based on four different scenario futures:

Case 1: Unconditional pledges, lenient rules

Case 2: Unconditional pledges, strict rules

Case 3: Conditional pledges, lenient rules

Case 4: Conditional pledges, strict rules

All of which fall short.

Source: UNEP (2010)

2.3. Key perspectives in the current energy debate

Energy decision makers are faced with an array of important and sometimes conflicting perspectives. They are charged with making sense of these perspectives, evaluating their merits and where needed taking action. A selection of key world views often expressed in the energy debate are stylized in a provocative manner below. They often appear contradictory and the list is by no means comprehensive. We go on to discuss policy maker responses and the resulting call to action.

1. **Empower the poor:** Lack of access to electricity, safe heating, and cooking causes over a million of deaths a year, yet this has received little attention compared to GHG emissions mitigation.

2. **Security first:** Is there enough energy available when needed at the right price to ensure development? It is the priority and right of every national government to secure its energy supplies.

3. **Oh behave:** Behavior needs to change, since so-called 'planetary boundaries' will be exceeded, if current growth patterns continue. It may even be necessary for the 'de-growth' of rich nations, for equitable access to services.

4. **Development first:** Lower income countries should be encouraged to undertake sustainable development actions that are compliant with their drive to develop: nationally appropriate mitigation measures are needed.

5. **Biofuel is bad:** Using crops for large-scale biofuel production will lead to higher food prices for the poor, and increase our vulnerability to the climate.

6. **Energy technology revolution:** In order to meet global GHG emissions targets, the burning of fossil fuels with no capture and storage must be limited. Urgently, a rapid change is needed in energy system investments, including, inter alia, large-scale investments in renewable energy, energy efficiency, nuclear power, and carbon capture and storage.

7. **Sustainable energy technologies:** Investments should be made only in energy efficiency and renewables, since only renewable 'fuel sources' can ultimately be sustained.

8. **Nuclear renaissance:** Nuclear energy should be the preferred option, as it is not intermittent and it is clean. Plants require little land, but produce much power as well as material used for medical, security and other uses.

9. **Anti-Nuke:** Nuclear energy should be phased out, due to unacceptable risks at power plants, dangerous waste that remains radio-active for a very long time and might enable weapons production.

10. **Free the market:** Markets provide the best mechanism to determine what investment and R&D needs to take place in the energy system, therefore subsidies must be removed. Further, by getting everyone to play by transparent rules access to resources can be secured, as long as the price is right.

11. **Leverage learning:** As markets are entrenched, subsidies need to be provided, especially for renewable energy to help them compete with conventional fuels and secure necessary R&D.

12. **The polluter pays:** There should be a clear (exonerative or punitive) penalty charged for external costs incurred by damaging the ecosystem and society.

13. **The prime movers pay:** As damage to the ecosystem (including GHG emissions) were made by (now) rich countries, they should pay to fix the problem.

14. **Basket case:** Put in place standards, feed-in tariffs, measurement and verification, mandatory audits, carbon caps and trade etc. No single policy is sufficient.

15. **Energy efficiency:** Is the single largest, most economic, environmentally friendly energy source yet to be comprehensively harnessed – and should be done so using a suite of measures.

16. **Economic and financing limits:** Measures need to be put in place to improve access to capital for energy infrastructure.

17. **Peak oil:** The age of fossil fuel is coming to a rapid end. Depletion rates for oil (and other) fossil fuel have peaked or are about to peak. This leaves a gap to be filled as demand continues to grow.

18. **No limits:** There are essentially limitless reserves of fossil fuels and their level of availability is dependent on prices. As prices increase more unconventional reserves will be discovered and exploited. Some postulate that gas is not a fossil fuel, but renewably produced.

19. **Destroying the global commons:** The ecosystem provides a limited amount of service. We damage these services by polluting too much or using too much. However, as many do not pay for this damage, they are free to continue.

20. **Planetary boundaries:** The limits to the use of these ecosystem services needs to be determined and boundaries established. Once we overstep them disaster will ensue.

In broad terms, these perspectives could represent goals and strategies (1-4), means and broad policies (5-16) and contexts and limits (17-20).

2.4. A view on the perspectives

Some perspectives may have very different perceived importance and relevance, depending on the national, regional or international context of the policy dialogue as well as other specific circumstances.

Means to achieve similar targets in similar settings, even following similar analysis, may diverge. For example, Finland has a policy to increase its nuclear capacity. Germany has a policy to phase its nuclear capacity out. Yet, both have similar objectives, such as securing energy supply, while reducing greenhouse gas emissions.

The decision maker, in order to make sense of these and other perspectives, and in order to chart out a meaningful course, is left with sometimes unavoidable steps.

Based on feedback from proponents of the perspectives listed above, we identified selected actions that help bring consensus to decision making. These consensus building actions include:

A. <u>Scenarios and indicators:</u> Promote tracking the diagnosis, progress and scenarios of national, regional and global energy systems with a common set of 'strategic' sustainable development (SD) indicators.

B. <u>Energy assessments:</u> Promote platforms for transparent national and international energy assessments (tracking economic development, fuel flows, physical resource use and environmental impacts in a quantitative manner).

C. <u>Economic efficiency:</u> Assess opportunities to increase the economic efficiency of the energy system, especially - but not limited to - where these promote end-use energy efficiency improvements.

D. <u>Strategies for modern energy access:</u> Develop strategies and a supporting framework to help the poorest countries gain adequate, affordable access to modern energy services (at least to meet the MDGs) and to prevent the more than a million deaths a year attributed to burning solid fuels in poorly ventilated housing.

E. <u>Evaluation of ecosystem services:</u> Undertake transparent evaluations of ecosystem services and their limits, to support discussions on their usage.

F. <u>Develop methodologies</u> for the integrated analysis of the systemic implications of simultaneously meeting global food, water and energy needs - given that each is essential and each may compete for common ecosystem (and other) services and affect each other.

Actions A and B are necessary for analytical reasons to help diagnose and quantify the contexts and limits, determine means and broad policies in order to reach goals and strategies, with specific reference to the energy system. Actions C and D enable policy assessment for two important policy actions, while actions E and F provide important information currently not accessible to the decision-maker but vital for making short term policy with wide reaching effects.

Table 2 brings all the elements together that we have introduced so far. For each of the twenty perspectives on energy development (1-20), it indicates the relevant policy maker concerns (i, ii, and iii) and which of the six actions (A-F) might help bring about consensus among the perspectives or at least help better understand the disagreements between them. Actions A and B relate to specific analytical improvements. C and D are actions that address key issues around which there is little controversy, but much urgency. E and F relate to broader impacts of the energy system on the environment, but also other physical systems needed for humanity's sustained development.

Table 2. Perspectives, consensus building actions, and policy makers concerns.

			Concensus building actions Actions						Policy maker concern		
			SD Energy-related Indicators	Energy assesments	Promoting economic efficiency	Access assesments and support	Ecosystem assesments	Food, water and energy nexus	Access to adequate services	Energy system dynamics	Interactions with other systems
		Perspective	A.	B.	C.	D.	E.	F.	i.	ii.	iii.
1	Goals and strategy	Empower the poor	*	*	*	*			*		
2		Security first	*	*					*		
3		Oh behave	*	*			*	*		*	*
4		Development first	*	*	*	*			*	*	*
5	Means and broad policy	Biofuel is bad	*	*			*	*			*
6		Energy revolution	*	*						*	
7		Sustainable energy technologies	*	*						*	
8		Nuclear renaissance	*	*						*	
9		Anti-Nuke	*	*						*	
10		Free the market	*	*	*				*	*	*
11		Leverage learning	*	*						*	
12		The polluter pays	*	*			*				*
13		The prime movers pay	*	*	*		*				*
14		Basket case	*	*	*		*	*	*	*	*
15		Energy efficiency	*	*	*				*	*	
16		Economic and financing limits	*	*	*				*	*	*
17	Context and limits	Peak oil	*	*						*	
18		No limits	*	*				*		*	
19		Destroying the global commons	*	*			*	*			*
20		Planetary boundaries	*	*			*	*			*

2.5. Conclusion

This primer introduced notions related to the use of energy that will help sustain our development; cited various trends; highlighted key perspectives and; in turn these have suggested common steps required for the policy maker to build consensus and empower decision making.

Without empowered decision makers, national and international consensus will be shallow. Uncommon metrics will not allow common conversation. Without clear national analysis underpinning their commitments, participation in international dialogues, will be skewed toward well mobilized interests. Further, without an indication of the value of ecosystem services or tools to assess the broader effects of energy system development it will be difficult to develop consistent trajectories.

In summary, for a meaningful national and international energy dialogue commitment to appropriately empowering decision making, as well as to our populations are needed.

3. Twenty perspectives on energy and sustainable development

Next we delve deeper into selected perspectives that are often presented to the energy decision-makers, and report expert voices and feedback received. No attempt is made to tag experts with particular views. The purpose is not to be exhaustive. Instead, the aim is to sketch a "rhetorical landscape" through which policy makers need to navigate. Furthermore, sides are not taken and no critique offered of the perspectives and voices. All of the perspectives can point out supporting evidence and facts, and they sketch important aspects of the complex reality underlying the global energy debate. The purpose is explain the background for identifying actions to build meaningful consensus between the perspectives that appear so strongly divergent at first glance.

Robert Kates, Professor Emeritus of Brown University, and Independent Scholar, Initiative on Science and Technology for Sustainability.

Sustainability is extremely important for a world that is growing rapidly. In particular, 'the primary goals of a transition toward sustainability over the next two generations should be to meet the needs of a much larger but stabilizing human population, to sustain the life support systems of the planet, and to substantially reduce hunger and poverty (Kates, 1999).

The energy system powers humanity. The energy system as with all resource systems is needed in an appropriate incarnation to enable our sustained development. To do so prudently, a number of considerations are to be born in mind.

3.1. The energy perspectives

In the following, each of the stylized energy perspectives suggested above (see Table 1) is described in more detail by drawing on common arguments articulated in the literature and by providing illustrative quotations from well-regarded thinkers on energy.

3.1.1. Empower the poor

***Perspective 1. Empower the poor:* Lack of access to electricity, safe heating, and cooking cause over a million deaths a year, but has received little attention compared to GHG emissions mitigation efforts.**

Approximately three billion of world's population use biomass as the chief source of energy for cooking and heating. It is a cheap fuel, but comes at the cost of severe health impacts (UNDP, 2012). An estimated 1.3 million people die every year due to indoor air pollution, mainly in Southeast Asia and sub-Saharan Africa (IEA, 2012). Thus, access to cleaner and safer energy sources, such as electricity, for domestic use (e.g. lighting, heating, cooking etc.) is essential for achieving inclusive development (Bogdansk, et al., 2010).

K.V. Ramani, Senior energy consultant, United Nations Development Program (UNDP)

To meet sustainability challenges, poverty reduction is key. The role of energy in poverty reduction revolves around the issues of access, affordability and choice. Differences in country situation and priorities indicate that while sustainable energy is a common goal for the Asia Pacific region are large, the entry points to it will vary from one country to another. (Ramani 2004)

Some argue that access to affordable and adequate energy services is a "missing" Millennium Development Goal (MDG). In fact, such access is required to reach the MDGs and other agreed development goals, including those related to GHG emission reduction (WCA, 2011). For example, refrigeration of food or vaccines, cooking of meals or light for teaching are not possible without access to energy services. Yet, only small amounts of energy are required to provide basic services for the poor. Bringing universal access to modern energy services to almost 3 billion people would require only about 3 per cent higher global electricity generation, less than 1 per cent more demand for oil and less than 1 per cent more CO_2 emissions. Not having energy as a distinct goal, makes invisible the most important enabler of the MDGs, and thus dedicated infrastructure needs might simply be neglected.

According to this perspective, it is essential to give due consideration to improved energy service access in important forums and events like Rio+20 (WCA, 2011).

It is often the most vulnerable in poor societies that are at risk due to the effects of damaging development patterns. Women are both vulnerable and hold an important key to more sustainable development.

Govind Kelkar, UN-Women, South Asia Office

Rural and indigenous women's energy management roles need to be recognized and strengthened. Women are not only the end users of energy, but also managers at local level in terms of conservation of the existing natural resources and are increasingly playing an effective role in managing the renewable energy systems such as solar and biomass. Admittedly, women need cleaner cooking energy but there is also need for strengthening their capabilities in tree and water management as well as inclusion in local, national and international bodies set to manage energy infrastructure. (Kelkar 2012).

Women can contribute meaningfully towards environmental management to mitigate and adapt to climate change. This contribution can occur only if there is gender equality and their even involvement in each step of policy making toward a green economy. (Kelkar, 2009a).

Access to alternative livelihoods will be essential for communities and individuals to both adapt to climate change and contribute to GHG mitigation. Although the suitability of any alternative livelihood is dependent on the individual and circumstances in which they live. For example in Bastar, Chattisgarh, Gond and other areas adivasi women have developed their skills in traditionally male vocations such as in terracotta, bell metal and wood sculpture. These alternative skills could increase their economic resilience as the climate shifts, since they decrease women's dependency on agriculture or collection of NTFPs, which global warming is expected to impact negatively. (Kelkar 2009b).

Wolfgang Lutz, Director, Wittgenstein Centre for Demography and Global Human Capital

World population is likely to decline in long term. It is not today's energy intensive growth rate that brings the fertility rate down, but it's the level of female education (the trend is that even in the poorest countries, less educated women have more children). To be able to maintain the world population in acceptable range, it would be meaningful to invest in education.

3.1.2. Security first

***Perspective 2. Security first:* Is there enough energy available at the right price to ensure development? It is the priority and right of every government to secure its energy supplies.**

Policymakers often equate the attainment of energy security with reducing dependence on imported energy sources, diversifying supplies or securing sources of fuels, either by freeing up markets and/or supply routes (Cohen et al 2011). According to this perspective, every country must ensure that its supplies of energy are secure, in order to ensure its development. In China, for example, energy security has been categorized as a domestic economic development issue rather than a part of foreign policy for several decades (Jian, 2011). Historically, the UK nationalized the oil production of countries under its influence (Klare, 2008) and others continue to do the same. The quest for long-term energy supplies is becoming a matter of increasing regional competition with secure access to oil and gas a matter of national strategic consideration. This tension threatens actions to deal with pressing concerns such as climate change (Bazilian et al, 2011). At the very least, the combination of energy security and climate change concerns are unleashing a wave of policy initiatives and investments around the world that will fundamentally alter the way that we manage and use energy (LLOYDS 2012).

Christof Rühl, chief economist and vice president of BP

Climate change, carbon emissions and energy security point to the simple fact that no renewable source is currently capable of supplying a reliable energy base load. Natural gas could maybe be considered as an acceptable transition solution. Addressing climate change is crucial in order to reach any form of sustainable situation. However, any solution will continue to burn carbon containing fuels far into the future. Moreover the accelerated growth in developing countries and high shares of coal in their energy portfolios must be related to globally increasing CO_2 levels and rising emission content per unit of energy. These trends are also going to continue further into the future than many would prefer. (Rühl 2008, 2009 and 2010)

3.1.3. Oh behave

Perspective 3. Oh behave: ***Behaviour needs to change, since so-called 'planetary boundaries' will be exceeded, if current economic growth patterns continue. It may even be necessary for the 'de-growth' of rich nations, for equitable access to services.***

According to this perspective, it is essential that we change our behaviour. If we continue to spend our natural resources and assuming continued economic growth trends, we could face a drought of natural resources, sooner than mankind might imagine (Meadows et al 1972). We will have to (and can) find a way of achieving meaningful development without increasing GDP (Victor, 2006). In fact, current economic growth will simply have to slow down if we are to share our resources to face the current world challenges such as, climate change, health, education and population growth, with any measure of equity (Hillyard, 2009). Investment is needed in the ecological assets on which we depend. Further, we need to redefine prosperity beyond materialism and the current 'growth' based model (Jackson, 2010). Actions will require rich countries to reduce their economic growth targets and to provide support to the world's poorest (Arnsperger, 2011).

Peter A. Victor, Professor, faculty of environmental studies, York University.

'Learning to live within the limits of planet Earth in justice and in peace is the fundamental challenge of the 21st Century' (Victor, 2012). It is important to bear in mind that the economy is a subset of the biosphere. The economy is placing an excessive burden on the biosphere. Technology is not enough to solve the problems that we have created for ourselves. Thus, to tackle inequality, rich countries should

take the lead and manage without growth – or even de-growth. A key element to maintaining prosperity without growth is shorter working hours in developed economies and potential redefinition of social and economic systems. (Victor 2008, 2011, 2012)

One option to 'de-growth' may be to reduce population, or at least reduce population growth.

Thomas Buettner, Branch chief, United Nations Department of Economic and Social Affairs.

The share of the old in the population will continue to grow. However, decreases in fertility are needed for all countries for their sustainable development. (Buettner, 1995). *Yet, as an important measure for mitigating climate change, population development is often ignored*. (Buettner, 2008)

3.1.4. Development first

Perspective 4. Development first: ***Lower income countries should be encouraged to undertake sustainable development actions that are compliant with their drive to develop: nationally appropriate mitigation measures are needed.***

The global economy has grown – and the rich have become much richer. Yet, the plight of the poorer developing countries is woeful. Low income countries need to develop to provide basic necessities (Streeten et al, 1981). In the same way as developed countries were free to peruse their growth agendas, developing countries must now be free to do the same. Yet, this has strong implications for the planet's GHG trajectory (Muller, 2002). Projections indicate that developing countries play a large role in the success or not of meeting climate mitigation targets (Riahi et al, 2012). It is therefore essential that climate focused trajectories are found that are nationally appropriate. In fact, developing countries should seek sustainable development polices that do not compromise their economic growth (Danga, 2003). In short, if adopted, the 'green economy' should deliver real and equitable growth (UN, 2011a).

3.1.5. Biofuel is bad

Perspective 5. Biofuel is bad: ***Using crops for large-scale biofuel production will lead to higher food prices for the poor, and higher vulnerability to the climate.***

On 14 April 2008, the online African Energy News Review news service noted that food riots had killed five people in Haiti, adding, "The diversion of food crops to biofuel production was a significant factor contributing to global food prices rocketing by 83% in the last year, and causing violent conflicts in Haiti and other parts of the world." (Tenenbaum, 2008). In fact, changes to biofuel production in a single country can affect global food security. "*The fact that cassava is being used for biofuel in China, rapeseed is being used in Europe, and sugar cane elsewhere is definitely creating a shift in demand curves*," says Timothy D. Searchinger, a research scholar at Princeton University. "*Biofuels are contributing to higher prices and tighter markets*." (NY Times, 2011).

In 2008 and in 2011, there were spikes in world food prices. According to the New York Times (Foster, 2012), researchers are projecting that by 2013, food prices will soar to unparalleled heights, causing widespread hunger in the most vulnerable populations and social unrest, with an enormous potential for loss of human life. Research indicates that some crucial factors behind food price increases are the conversion of corn crops to ethanol and investor speculation on the agricultural futures market.

3.1.6. Energy technology revolution

Perspective 6. Energy technology revolution: ***In order to meet global GHG emissions targets, the burning of fossil fuels with no capture and storage must be limited. Urgently, a rapid change is needed in energy system investments, including, inter alia, large-scale investments in renewable energy, energy efficiency, nuclear power, and carbon capture and storage***

Cesare Marchetti, Physicist and Systems Analyst, Institute Scholar, IIASA.

There is an array of technical solutions to limits on the planet's growth.[1] *Renewables are, in comparison, unreliable and thin against the enormous power density of nuclear reactors that offer a good base load solution for future systems. Further, potentially limitless quantities of uranium are available from seawater - should a large shift to nuclear become reality.* (Marchetti, 2006).

Analysis of long waves in the world economy (Kondratiev cycles), Marchetti suggested that their influence is discernible in technological penetration patterns and that the introduction of Hydrogen is most certainly also following such a path. The first phase, i.e. idea introduction, is now complete. This leaves a half-century long second phase of technological development and launch that needs fostering in order to reach full technology exploitation. In summary it is suggested that there are enough technical solutions and potential innovations to meet global growth in the context of constraints, such limiting GHG emissions. (IIASA, 2012).

To meet the planet's growing needs and constraints, all technology options are needed and fast. World governments must start a US$45 trillion "*energy technology revolution*", or risk a 130 percent surge in carbon emissions by 2050 (IEA, 2008).

Jesse Ausubel, Director, Professor, Program for the Human Environment, Rockefeller University

Researchers and practitioners need to multiply the cleanliness, reliability, and safety of an energy system relying predominantly on natural gas. Total problems must shrink even as the scale of the gas system doubles and triples globally during the next couple of generations. (Ausubel, 2010).

The development of technology will inherently help to protect the environment. Historically energy sector technology and fuel use has seen a 'decarbonization'. Wood and hay have led to the use of coal and oil. There will be further development as even these carbon rich fuels are replaced with those that are hydrogen rich. These include natural gas and eventually nuclear. Given current knowledge, the ultimate fuel source involves a mixture of nuclear power and hydrogen, thus moving away from carbon emissions and assisting with balancing the climate issues we now face. (Wade, 2011).

Options needed (and some estimate annual investment requirements) include low-carbon energy from non-combustible renewables plus bioenergy (190 billion USD/year) carbon capture and storage (CCS) and nuclear (5-40 billion USD/year), as well as other infrastructure (260 billion USD/year) (van Vuuren et al 2012). Although started, much more is needed. The G8 group has agreed to commit to build 20 CCS plants by 2010 which is estimated to cost about US$ 30-50 billion – and further large scale investments are needed in other carriers. (WCA) It is suggested that the need is so great, that not even financial and economic crises should deter governments from a global energy revolution. (Nobuo, 2008)

[1] Marchetti was one of the first to consider hydrogen may be a useful energy carrier while tackling rising levels of CO_2 with an initial version of carbon capture and storage using the ocean as a carbon sink (IIASA, 2012).

Arnulf Grübler, Professor, Yale University

Technology is central in monitoring the actual impacts of climate change and addressing them. Present in every recognised driver of climate change, technology's effect on the environment is most often indirect through its influence on social behaviour and activities in terms of spatial pattern and magnitude. Currently, technology impacts are mostly indirect (via productivity gains, income growth consumption etc.), but in many instances it is impossible to separate direct and indirect effects. For example, agricultural productivity growth leads to more production/consumption (indirect effect), but also to afforestation of least productive agricultural land back to forests, a direct, and positive effect at least in OECD. (Grubler 1998).

In the future (consider for example carbon capture and sstorage (CCS) technologies) the "direct effect" impact of technological change could be much, much larger in a climate constrained world. Past experience with traditional pollutants point to a dominance of the direct (emission reduction) effect over the indirect one, or to the impact of lifestyles etc., on emission reduction.(Grübler and Riahi, 2010).

Furthermore, considerations of inherent innovation uncertainty and of the multitude of feedback effects from technological advances, make simple cause and effect approaches unacceptable, leaving the main GHG issue of energy generation and use to be solved by more complex models that focus on finding the right technology portfolios to reach a stabilisation scenario (Grübler and Riahi, 2010).

3.1.7. Sustainable energy technologies

Perspective 7. Sustainable energy technologies: Investments should be made only in energy efficiency and renewables,* *since only renewable fuel sources' can ultimately be sustained.

According to this perspective, renewable energies alone can meet 77% world energy demand by 2050, provided they receive appropriate policy support (IPCC, 2011). Combined with behavioural change and energy efficiency, there is no need to further develop the fossil fuel systems of Europe or to invest in nuclear power and yet meet stringent targets (SEI, 2010). With this in mind, and given that renewables do not deplete energy sources, they are the only viable and long term investment option for the energy sector. With aggressive investments and R&D prices will be reduced into the future. Furthermore, some modern, renewable energy sources are already cost-competitive today (IPCC, 2011).

Dolf Gielen, Head of analysis, International Renewable Energy Agency (IRENA)

Renewable energy should be used as much and as quickly as possible to overcome issues faced with the climate and energy access (Gielen, 2011). *The surface has just been scratched in terms of what can be done with renewable energy. Venture capital in combination with technological progress will open up many new avenues. This development should be accelerated.*

3.1.8. Nuclear renaissance

Perspective 8. Nuclear renaissance:* *Nuclear should be the preferred option, as it is not intermittent and clean. Plants require little land, but produce much power as well as material used for medical, security and other uses.

According to this perspective, nuclear investments are expected to rise even in the wake of Fukushima (IAEA, 2011). The life cycle emissions of nuclear are low compared to conventional renewable power plants (Weisser, 2007). Other low carbon energy sources require expensive storage and large areas to generate similar quantities of energy (Bryce, 2010). Nuclear has a history of providing reliable base-load electricity. France, for example, generates more than 60% of its electricity from nuclear (IAEA, 2011). The nuclear industry has many strongly positive spin-offs. Nuclear medicine, for example, treats millions of patients a year, and many of the isotopes needed come from nuclear power plants (WNN, 2008).

Hans-Holger Rogner, Chief, Planning and Economic Studies Section, International Atomic Energy Agency

High and volatile fossil fuel prices, the need for a base-load electricity supply technology with stable and predictable generating costs, rising energy demand in many regions, energy security and climate change considerations have fueled to rising expectations for nuclear power. These factors that contributed to the increasing interest in nuclear power before the accident at the Fukushima Daiichi nuclear power plant in March 2011 have not changed. Nuclear power, therefore, continues to play an essential role in the long-term energy mix of many countries. (Rogner 2011a&b, Rogner 2012 a&b)

There are several aspects related to the sustainability of nuclear energy. Nuclear power provides reliable base load electricity at affordable costs and contributes to energy diversification and hence energy security. On a life cycle basis, greenhouse gas emissions per kWh of nuclear electricity are very low and are comparable with the emissions of the best renewable technologies. GHG emissions originate predominantly from plant and nuclear infrastructure construction, uranium mining and fuel preparation (depending on the electricity mix used for enrichment) while the operation of nuclear power plants is essentially emission-free. Nuclear power operation avoids local and regional air pollution commonly associated with fossil fuel combustion and can be a potent climate change mitigation option. Moreover, it creates technological spin-offs and a high-skilled work force. As well, nuclear energy can provide energy services beyond electricity such as process heat, desalination or chemical fuels (hydrogen). Nuclear fuel resources are plentiful for many centuries to come.(ibid)

The sustainability of nuclear energy is challenged by several risks ranging from safety aspects, waste management, nuclear weapons proliferation, high up-front capital costs and public acceptance. The weights of these risks vary from jurisdiction to jurisdiction and need to be addressed and satisfactorily resolved through intense stakeholder involvement. From a sustainable development perspective, nuclear is a viable option as long as the benefits exceed the risks. (ibid)

Nuclear power is not a quick-fix solution to rising electricity demand and climate change. The lead times associated with the development of a national nuclear programme can be quite long, up to 10 years and more (e.g. establishing the necessary infrastructures ranging from a nuclear law, a competent regulatory institution, a comprehensive safety culture, a skilled and competent nuclear workforce (human resources), public information and a political decision making process). Plant construction and licensing can take between four and eight years. Considering these lead times, nuclear power plants are not short-term solutions but long term investments towards supplying an ever growing demand for energy at lowest environmental impacts. (ibid)

3.1.9. Anti-Nuke

Perspective 9. Anti-Nuke: ***Nuclear should be phased out, due to unacceptable risks at power plants, dangerous waste that remains radioactive for a very long time and might enable weapons production.***

According to this perspective, nuclear radiation has increased long-term cancer risks, as evidenced by the historical statistics of Chernobyl, Three Mile-Island, and the Fukushima region (Christodouleas et al., 2011). There is no 100% safe way to transport, dispose of or store nuclear waste, and the cost of storage has increased (Jeremy, 2006). Greenhouse gas (GHG) emissions from uranium mining have increased as it is getting harder and harder to mine (Sovacool, 2007). "*The crucial weak point is man as such, who is finally not able to control extremely complex systems in operation and in the planning of necessary safety precautions in the long run. The accidents of Three Mile Island, Chernobyl and Fukushima speak an all too plain language.*' (Pauli, 2012). Apart from waste and accidents, there is another security issue raised by nuclear technology that is a big concern: the proliferation of nuclear weapons. Plutonium from used fuel in nuclear reactors can be used for weapons; in 1974, India tested a bomb that incorporated plutonium from a research reactor (Landau 2011). According to this perspective, there is a clear link between the two.

3.1.10. Free the market

Perspective 10. Free the market: ***Markets provide the best mechanism to determine what investment and R&D needs to take place in the energy system, therefore subsidies must be removed. By getting everyone to play by transparent rules, access to resources can be secured, as long as the "price is right".***

According to this perspective, reducing the government's intervention in the energy sector would reduce prices for consumers and, especially in the current recessionary environment, would create thousands of good jobs for unemployed workers (IER, 2012). The market simply provides the best mechanism to provide lower cost services – as can be seen in almost all other consumer markets(IER, 2011). A well-functioning market increases the security of supply of goods (Nordhaus, 2010). At a national level, some would suggest that the open market clearly provides increased security and trade. Best et al (2010) point out that the free market nature of the Canadian energy sector is a strength, enabling energy security through increased trade and growth and ensuring that Canadian resources are developed and extracted. Further markets are needed, and they need to be operated well. In particular, they can help drive environmentally cognizant development. When market prices do not fully reflect environmental and social costs, consumers' choices are distorted (IEA, 2012).

3.1.11. Leverage learning

Perspective 11. Leverage learning through subsidies: ***Markets are entrenched and subsidies need to be provided, especially for renewable energy, to help them compete with conventional fuels and secure necessary R&D.***

According to this perspective, energy subsidies are necessary. Fossil fuels and nuclear have benefited from them in the past and are now entrenched. Given the dual need of having to supply clean, low carbon energy and provide a level playing field, subsidies are required for renewable energy development.

Furthermore, subsidies have important implications for climate change and sustainable development more generally through their effects on the level and composition of energy produced and used (UNEP, 2008). Renewable energy incentives can be integrated into carbon markets and support research, development and demonstration (RD&D) and leading to technological "learning" (DBCA, 2009). A subsidy limited in time could give countries a strong incentive to accelerate electrification.

Jeffrey Sachs, Director, The Earth Institute at Columbia University

Climate change is a devastating global issue that needs immediate action. Business (oil) lobbies constrain solutions, in the United States in particular. A tech roadmap is needed; expanding the use of existing technology is not enough to solve the problem. Global carbon levy is needed to: (1) help poor countries adopt new technology; and (2) fund R&D. Regional cooperation is required, especially in Africa, South-East and South Asia. For now, Europe might be seen as the 'best' model: having regional plans with financing considerations. A global network would help gather and expose useful ideas from around the world (Sachs 2011).

3.1.12. The polluter pays

Perspective 12. The polluter pays:* *There should be a clear (exonerative or punitive) penalty charged for external costs incurred by damaging the ecosystem and society.

Jack Powelson, Emeritus Professor of Economics, University of Colorado

"*Pure air, for example, is the common property of many. A company that fouls the air without paying for it receives a stolen profit, stolen from the people who suffer. Logging companies using federally built roads take advantage of external costs. Environmentalists should lobby to internalize the externalities by requiring firms to pay the costs of pollution. Loggers should pay for the logging roads. If everyone paid all costs (and passed them on in the price to the consumer), environmental degradation would sink to restorable levels*" (Powelson, 2002).

According to this perspective, regulatory and voluntary economic instruments that put a price on the services that nature provides are needed to dissuade businesses from plundering the natural resources on which their futures depend. The past 20 years have seen the emergence of a range of such instruments, from carbon markets aimed at capping the growth in greenhouse gas emissions to biodiversity offsets that allow businesses to compensate for unavoidable harm to a habitat. Governments now need to be creative about building on these and scaling them up to a level that will have a real effect. Imposing a price on natural resources and ecosystem services is by far the most effective way of forcing businesses to develop without damaging nature (Beyon and Jenkins, 2010). Payment for environmental services (PES) cannot be considered as panacea for biodiversity conservation, but they can present a promising tool notably to internalize indirect use values derived from ecosystems, such as water filtration functions of wetlands or storm protection functions of mangroves, that provide benefits to human beings outside the ecosystem and for which the traditional set of environmental policy instruments had long been deficient (Wertz-Kanounnikoff, 2006). Ecological Economists maintain that there needs to be a fundamental change in the basic assumptions and economic models so that ecosystem services are incorporated as internalities. (Lumb, 2002).

William D.Nordhaus, Sterling Professor of Economics, Yale University

There is doubt surrounding the efficiency of current climate change policies in particular with relation to the Kyoto protocol that included only 8% of global emissions in 2007 over a single reduction period ending 2012. A 'new angle' needs to be included in the climate change mitigation battle seeking help in social sciences to understand the links between our political, economic and social systems and generate efficient and effective solutions. While identifying three fundamental issues for climate change policies to tackle (e.g. emissions reduction overall level and trajectory, their distribution across countries, and the need to encourage participation of low-income and reluctant countries), recent research concludes that price-type approaches, i.e. CO_2 *taxation, are the most relevant and efficient tools and that they should be based on geographically harmonised market penalties per industry. Finally, for an efficient result to be reached it is critical that this carbon tax be set to equal the SCC (social cost of carbon assessing the added cost of an extra ton of carbon equivalent) for the considered area.*(Nordhaus 2007, 2011a & b).

3.1.13. The prime movers pay

According to this perspective, those who are the main cause of climate change must embrace and address their responsibilities, in line with climate justice. Developed countries must address their climate debt in all its dimensions as the basis of a fair, effective and scientifically sound solution to climate change (CJB, 2010). "*Developing countries are not seeking economic handouts to solve a problem we did not cause. What we call for is full payment of the debt owed to us by developed countries for threatening the integrity of the Earth's climate system.*" (UNFCCC, 2009). Wealthy countries have to pay for part of their debt to the planet by helping developing countries have a chance for sustainability (Brundtland, 2010). Rich countries have to take the lead. With financial and technical support from developed countries, South Africa for example will be able to reduce emissions by 34 per cent below "business as usual" levels by 2020 and by 42 per cent by 2025 (Zuma, 2011). Further, delay by developed country parties in implementing their commitments to reduce emissions will increase their climate debt to the developing countries and significantly constrain opportunities to achieve lower stabilization levels of greenhouse gases and increase the risk of more severe climate change impacts (CJB, 2010).

Thomas Schelling, Distinguished Professor, University of Maryland

In order to reduce carbon emissions, developed countries will have to pay more but will receive less of the benefits. The impacts of climate change will also be much greater for the poorer countries. It will be important to find ways to adapt as the climate changes while reducing carbon emissions. This will include a universal carbon tax and tradable permits based on country quotas (Schelling, 2002).

3.1.14. Basket case

***Perspective 14. Basket case:* Put in place standards, feed-in tariffs, measurement and verification, mandatory audits, carbon caps and trade etc.**

No one policy is enough to realize a development path that is sustainable. For example, to effectively limit GHG emissions, different sets of options should be considered, including subsidies, taxes, tradable permits/quotas, standards, targets and others, in a variety of combinations. These will differ from country to country. They will depend on local policies, institutions, experience and political situations (Watson, 1996).

Kejun Jiang, Director, Energy Research Institute, China

Technology is going to play an important role in China's climate change mitigation plans, energy saving and environmental protection. However, the technology strategy should be combined with energy and environmental policies. (Jiang, 2011).

Policy effects will also differ as a function of the energy-system, economic, social structure and relative economic scales (Freebairn, 2009). A mix of mitigation policies – rather than a single approach - for China has been shown to be most likely effective (van Vuuren et al, 2002). Similarly, an EU scenario analysis indicated that a 30% reduction in GHG emission can be achieved in EU countries within fifteen years by adopting an integrated and active climate protection and strategy (Wuppertal, 2005). A basket of policies and measures were shown likely to be effective for South Africa (Winkler ed. 2006).

Nebojsa Nakicenovic, Deputy Director, International Institute for Applied Systems Analysis (IIASA)

Climate change, social inequality and poverty are major issues that the world is currently facing, and there is an immediate need for a fundamental paradigm change to produce a shift towards more sustainable paths. The provision of affordable access to modern energy services and also the decarbonisation of the global economy is an immediate starting point (Nakicenovic, 2009).

Actions needed to get there will be greatly enhanced by adopting global goals and targets, such as: Providing universal access to cooking and electricity by 2030 to the world's poor. Reducing energy pollution (from energy activities) to comply with World Health Organisation air quality guidelines. And, amongst others, to limit anthroprogenically induced temperature change to at most, 2°C by 2100. (van Vuuren et al., 2012).

3.1.15. Energy efficiency

Perspective 15. Energy efficiency: ***Is the single largest, most economic, environmentally friendly energy source yet to be comprehensively harnessed – and should be done so using a suite of measures.***

John "Skip" Laitner, American Council for an Energy Efficient Economy

Technologies and technology policies exist which could reduce greenhouse gas emission sufficient to achieve the specified stabilization targets at relatively modest cost given the size of the world economy. Achieving energy productivity will involve having to deploy cost effective energy efficiency measures across the full economy in a highly coordinated way. (Hanson and Laitner, 2007; Laitner, 2009).

According to this perspective, improvements in energy efficiency have fueled growth silently and powerfully in much of the developed world. Energy efficiency technologies now provide 75 percent of all U.S. demands for energy services (Laitner, 2006). It is estimated that, without the (non-structural) energy efficiency changes experienced over the last 40 years, energy demand would be about 60% higher than it is today (IEA, 2008). And the potential for more reductions in use is high (UN-Energy, 2009).

Charlie Wilson, Tyndall Center for Climate Change Research

We need to combine technological innovation in processes and systems with policies and behavioral aspects bringing social sciences to the aid of behavior changing policy making. Faced with a growing energy demand, a low cost and low impact alternative to system expansion is related to reductions in household energy use which should become a real objective for utilities and governments alike. The best results would be achieved through efficiency increasing measures across the energy supply system, as opposed to conservation methods (i.e. demand reduction methods). Efficiency measures can be enforced through a number of policy means including building code acceptability levels, building permit requirements, or other zoning regulations. More generally we need to address climate change and sustainability issues with structured decision making tools in order to generate a clear, straightforward and well-structured decision process. (Wilson, 2012a; Wilson & Dowlatabadi, 2007; Wilson & McDaniels, 2007; Wilson & Chatterton, 2011).

Not only does energy efficiency help reduce emissions but it helps stretch energy resources and fuels further. Retrofitted and higher efficiency power plants can produce more per unit of input. Meanwhile, small volumes of electricity can produce more service. In particular in developing countries, there is the potential of investments (in some cases realized) in the most efficient technology options, as a much energy intensive industry is yet to be build. (UN-Energy, 2009)

Amory Lovins, Rocky Mountain Institute

After the industrial revolution, next is a revolution for 'natural capital'. The value chain of using natural resources to make profit without environmental costing / constraints has to change. By improvements in material technology and energy efficiency, we can protect our environment while also making more profit (Lovins, 2012)*. This involves active research, development and deployment of energy efficient solutions and renewable energy resources. These solutions have the potential to meet future energy needs at lower costs and are relatively unconstrained* (Lovins, 2010).

3.1.16. Economic and financing limits

Perspective 16. Economic and financing limits: Measures need to be put in place to improve access to capital for energy infrastructure.

According to this perspective, the lack of access to capital for the energy sector is a key issue for the developing world (GVEP, n.d.). Facilitation of the required financing may require the development of specialist bodies (IISD, 2012). These would build on existing efforts, providing access to analysis, expanding financing options and developing risk mitigation and cost recovery mechanisms. This requires the development and strengthening of appropriate institutional frameworks (UNDP, 2012).

Fatih Birol, Chief Economist, International Energy Agency

Global energy markets are becoming more interwoven and interactions have strong effects. As a result of the rapid growth in emerging economies, energy geopolitics is changing and brings new challenges. Regarding climate change, on the current policy trajectory we will exceed safe limits within the next 5 years. This is a call to action that is currently missing from the major global emitters. An internationally binding agreement is necessary and a price on carbon desirable. As 1.3 billion have no access to electricity and billions more rely on unsafe fuels for cooking and heating: There should be the global mobilization of public and private funds to provide basic energy access. At the same time government in LDC's need to establish appropriate political will and institutional structures. Further they should leverage instruments to provide an enabling environment, mitigating the risk of access related investments (IEA, 2011; Birol, 2012).

Van Vuuren, et al. (2012) suggest actions to improve the financing required for energy transformation, including providing stable framework conditions for energy investment, developing new financing sources for the developing countries and encouraging private investments and new business models to suppress the high investment burdens. In addition to the governmental level, commercial as well as non-profit organizations such as the Global Village Electrification Program (GVEP) can also contribute in supplying and arranging capital and investments for energy access initiatives (GVEP, n.d.).

Tariq Banuri, Tellus Institute, and former director of UN DESA-DSD

The primary focus of policy research and global agreements should be the de-carbonization of economic development. "Instead of treating climate stabilization and economic development as separate and equal, the strategy should be to re-integrate the two global policy goals, in part by separating responsibility (and funding) from action." (Banuri and Opschoor 2007).

3.1.17. Peak oil

***Perspective 17. Peak oil:** The age of fossil fuel is coming to a rapid end. Depletion rates for oil (and other) fossil fuel have peaked or are about to peak. This leaves a gap to be filled as demand continues to grow.*

According to this perspective, an estimated 86% of global primary energy comes from fast depleting fossil fuels namely oil, natural gas and coal. "Peak oil" refers to reaching the peak of most economical rate of oil production (Nelder, 2009). It is believed that out of the 48 oil producing countries of the world, 33 have reached the peak, including Kuwait, the Russian Federation and Mexico (Kuhlman, 2007). Therefore, a terminal decline in the global oil production is expected around the year 2012. The expected peak period for natural gas was estimated at somewhere between 2010 and 2020. For coal it is expected between 2020 and 2030 (Nelder, 2009), but there are at least five other reports that foresee "peak coal" to be reached even earlier (Grubb, 2011; Vernon, 2007).

Many estimates suggest annual depletion of the world's oil reserves at a rate of 6 %, whereas the annual production demand is increasing at a rate of 2.2 %. In other words, in every year at least 8% would need to be discovered and produced, just to keep the oil market stable (Gokay, 2011). This is equivalent to the need to add another Saudi Arabia every three years (in oil reserve and production terms, of course), in order to maintain stable reserve to production rates. At present, no single energy source can fill the gap to meet these requirements (Weyler, 2012). The gap created by the shortage of fossil fuels may not be filled by all of the renewable energy sources (solar, wind, geothermal) despite their rapid growth in the recent past (Nelder, 2009).

3.1.18. No limits

Perspective 18. No limits: ***There are essentially limitless reserves of fossil fuels and their level of availability is dependent on prices. As prices increase, more unconventional reserves will be discovered and exploited. Some suggest that natural gas is not a fossil fuel, but renewably produced.***

According to this perspective, the widespread past perceptions of a world shortage in fossil fuels in the near future have been proven wrong, due to the development of new methods of exploiting these fuels o meet demands (Fossil Fuel Foundation, 2010). Many proponents of this perspective believe that untapped reserves are higher than previously thought and will continue to supply the world's energy demand, as technologies for separating oil keep improving (Huber & Mills, 2005).

For example, recent discoveries in the Norwegian gulf support the idea that there is still sufficient production potential to meet the future demand. The Norwegian Petroleum Department reports that the major share of total output after 2020 will come from these as of yet undiscovered resources (Marshall, 2011). OPEC believes that fossil fuels will continue to supply more than 80% of the world energy by 2035 and also anticipate improvement in technologies to improve the recovery rates (OPEC, 2011).

Philip Lloyd, Professor, Cape Peninsular University of Technology

'Yeah, we ran out of oil in 1970, when the 25 years of reserves we had left in 1945 was exhausted. But the oil we ran out of was $2/bbl oil. There was an energy crisis, the price of oil shot up to an unheard-of $25, and suddenly the number of drill rigs in operation worldwide went from 1000 to 3500. It's happening all over again with natural gas, and shale oil soon to follow. So say it loud and clear – we are NOT going to run out any day soon.' (Lloyd, 2012).

There is no evidence that a tax on carbon will reduce consumption, and lots of evidence it will destroy wealth. There is a strong relationship between energy and wealth, and no real alternative to fossil fuels as South Africa's primary source of energy. The quantity of CO_2 we produce is insignificant in terms of the natural circulation between air, water and soil. IPCC reports and the Summaries for Policy Makers need to be examined as they may have led to a distortion of the science.(Lloyd, 2010)

Globally, there is a very strong relationship between energy consumption per capita and GDP per capita, such that the International Energy Agency uses GDP predictions as a basis for its energy consumption predictions. Moreover, over 80% of the world's primary energy comes from fossil fuels. Therefore, there is also a strong relationship between carbon emissions and GDP per capita. While many would welcome transition to a lower carbon world, it is going to take time and new technologies to remove 80% of our primary energy from the supply. It cannot happen overnight without major impacts on the global economy (Lloyd, 2012).

3.1.19. Destroying the global commons

Perspective 19. Destroying the global commons: ***The ecosystem provides a limited amount of service. We damage these services by polluting too much or using too much. However, as many do not pay for this damage, they are free to continue.***

According to this perspective, an important reason for the alarming rate of environmental destruction across the world is that the true value of ecosystems is largely invisible to markets (Bavon and Jenkins, 2010). From a sustainability perspective, damaging the global commons damages natural capital, ecosystem services, and the interdependent web of life that constitutes the planet's ecological life support system. No individual, organization, or nation-state has the "right" to damage these entities (Cairns 2003). Present standards of protection of the environment of the global commons, and the sense of responsibility of states, are far from perfect. Some attitudes have changed. This is due to new findings in scientific research and the development of new principles such as the polluter pays principle and the precautionary principle (Fitzmaurice, 1996). Critically, we must share the responsibility to protect and sustainably manage the global commons for the benefit of future generations, or face environmental devastation at levels far greater than almost any known threat to our long term survival, apart from nuclear war (Makwana, 2006).

3.1.20. Planetary boundaries

Perspective 20. Planetary boundaries: ***The limits to the use of these ecosystem services needs to be determined and boundaries established. Once we overstep them disaster will ensue.***

According to this perspective, our development is constrained by "planetary boundaries". These are limits to the damage to or services that can be drawn from our natural environment. This is much deeper than simply considering sectoral analyses of limits to growth aimed at minimizing negative externalities. There are boundaries which we should not cross, in order to avoid disastrous consequences (Rockström et al, 2009). Furthermore, there is an urgent need to implement planetary boundaries in global decision making. Setting boundaries is fine, but waiting to act until we approach these limits allows us to continue with 'bad habits' until it is too late to change them (Schlesinger, 2009). In fact, our current process for negotiating environmental limits is dangerous and flawed. For example, setting a limit on long-term atmospheric carbon dioxide concentrations merely distracts from the much more immediate challenge of limiting warming to 2 °C (Allen, 2009).[2] "*The planetary boundaries concept and its first estimate of numeric values give us an important warning call that must be heeded. Rather than get bogged down in detailed arguments about the weaknesses of the approach or the methods of analysis, we now have a tool we can use to help us think more deeply — and urgently — about planetary limits and the critical actions we have to take.*" (Molden, 2009).

Johan Rockstrom, Assistant Professor, Stockholm Resilience Centre.

Anthropogenic pressures on the earth system have reached a scale where abrupt global environmental change can no longer be excluded. It is proposed that a new approach to sustainability be developed by defining planetary boundaries within which we expect that humanity can operate safely. (Rockström et al. 2009).

[2] Please note that the global temperature does not only depend on atmospheric concentrations of greenhouse gases, but also on other factors such as land use changes and cloud cover.

3.2. Where to from here?

Dirk Messner, German Development Institute

A 'Great Transformation' in the energy sector is required. This is because the basic structures of the global economy need to be re-directed toward low carbon during the next decades to come: the global energy system, the global land use system, the urban systems/ the huge urbanisation push included. We identify only two other Great Transformations in the history of human mankind: the neolithic revolution and the industrial revolution (WBGU, 2011).

The costs of the climate impact will be enormous, if we do not act immediately (WBU, 2009a). It makes it urgent to speed and scale up [related initiatives]in the next 10 years (WBU, 2009b). Global cooperation is key to make this transformation happen. It is not only a technological challenge, social and organizational changes are very important too. Global governance successes are a precondition for the global low carbon transformation (Messner, 2010 and 2011). Further, taking advantage of 'lock-in' effects, effective existing technologies can be widely introduced in growing economies like China, India, Brazil and Russia (Humphrey et al 2009).

A useful start would include building up a "climate pioneer alliance" of countries moving into the low carbon direction. This could make a real difference in the global economy, signaling to the "rest of the world" that a significant low carbon cluster is emerging. In this alliance, joint activities could be: linking emission trading schemes, investing in joint low carbon/ energy efficiency R&D programs; investing in joint low carbon oriented PhD programs to build up the next generation of low carbon architects, managers and engineers (Messner et al 2011).

The perspectives described above offer insights to the difficulties that the energy policy maker needs to reconcile. They are divergent.[3] They are well argued. They are politicized. Yet, we share a common planet whose energy system is integrated and intertwined with the environment, economy and society at a local and global level. Reaching consensus on various issues may appear a daunting task that is, however, necessary.

Thomas M. Parris, Executive director ISciences

Sustainable Development is complex and hard to measure as there are no universally accepted indicators. 'We must improve the integration of sustainable development theory with the practice of characterisation and measurement and recognise that the process is as important as the product.' (Parris and Kates, 2003).

'One possible breakthrough at Rio+20 would be the definition of no more than 7 (and preferably 5) environmental outcomes with associated indicators and targets that could serve as the focus of international attention for the next decade. If I were to start, I would look at environmental outcomes related to food, water, energy, and climate.' (Parris, 2012).

[3] For example, some experts emphasize limits, whereas others believe there are essentially none. Some experts favour nuclear power and emphasize its economic and environmental performance, whereas for others it is a completely unacceptable or even immoral form of power generation. Some experts promote biofuels as modern, renewable and low-carbon energy form, whereas others consider biofuel production wrong and even evil which they consider responsible for hundreds of millions of people going hungry. There are many more of these examples.

In the next section we identify lessons-learned from the above perspectives and suggest several ‘no regret actions’ to which everyone should be able to agree, regardless of worldview. The conclusions are based on feedback from the experts who expressed the perspectives described above. In particular, they were asked which actions they’d consider useful and whether they could help building consensus commitments across worldviews at Rio+20. It is found that, not only is it possible to find useful and agreeable next steps, but that it is vital to do so.

4. Lessons learned and no regret suggestions

The perspectives presented in the previous section indicate that the decision maker needs to chart out the energy system future in a careful manner.

Bert de Vries, Professor, Department of Science, Technology and Society Utrecht University

Sustainability is becoming more and more popular but approaches for its assessment are often narrow. In order to do sustainable assessments, an appropriate integrated framework is needed. These assessments are essential to aid decision making especially with respect to supporting appropriate policies. (de Vries & Peterson, 2009)

Richard Tol, Professor, Department of Economics, University of Sussex

There is a need to apply economics and other mathematical techniques to environmental problems, in particular climate change. This offers the opportunity for an integrated assessment model of climate change. The impact of [having to deal with pressing issues, such as] climate change is relatively small. (The average impact on welfare is equivalent to losing a few per cent of income. That is, the impact of a century worth of climate change is comparable to the impact of one or two years of economic growth.) (Tol, 2009)

Markus Amann, Leader: Transboundary Air Pollution Program, IIASA.

Mathematical modelling is of great importance in untangling environmentally related sustainable development impacts. Allied to this, data collection must be well defined and result in comparable outputs. For example, in order to find acid rain effects and environmental pollution issues in Europe, it has been necessary to harmonize the data from this region on long term basis. Further, to collect and organize the wide range of complex data, mathematical modeling tools are essential. They enable us to formulate the inputs from various sources of emission and their possible consequences into the environment. Mathematical integrated model not only figures out the depth of the issue, but its predication is also very useful about making environmental future policy (Johansson et al. 2001).

The economic development influences changes in the energy, transport, industrial and agricultural systems, which are sources for pollutants emission that are responsible for poor air quality. In coming decades, it will be a tough challenge to maintain the level of air quality, as it has direct effect towards human health (CAFE, 2002)

In order to help map a useful way forward through these perspectives, attention is drawn to a limited number of energy system attributes and trends. From those various 'no regret' actions are suggested. Throughout this section, we will refer to Table 2 and its labelling which is therefore reproduced here as

Table 3. Please recall that numbers 1 to 20 referred to the energy perspectives, letters A to F to consensus building actions (described later), and numerals (i) to (iii) referred to policy makers' concerns.[4]

Table 3. Perspectives, consensus building actions, and policy makers concerns (Copy of table 2).

			Concensus building actions Actions						Policy maker concern		
			SD Energy-related Indicators	Energy assesments	Promoting economic efficiency	Access assesments and support	Ecosystem assesments	Food, water and energy nexus	Access to adequate services	Energy system dynamics	Interactions with other systems
		Perspective	A.	B.	C.	D.	E.	F.	i.	ii.	iii.
1	Goals and strategy	Empower the poor	*	*	*	*			*		
2		Security first	*	*					*		
3		Oh behave	*	*			*	*		*	*
4		Development first	*	*	*	*			*	*	*
5	Means and broad policy	Biofuel is bad	*	*			*	*			*
6		Energy revolution	*	*						*	
7		Sustainable energy technologies	*	*						*	
8		Nuclear renaissance	*	*						*	
9		Anti-Nuke	*	*						*	
10		Free the market	*	*	*				*	*	*
11		Leverage learning	*	*						*	
12		The polluter pays	*	*			*				*
13		The prime movers pay	*	*	*		*				*
14		Basket case	*	*	*		*	*	*	*	*
15		Energy efficiency	*	*	*				*	*	
16		Economic and financing limits	*	*	*				*	*	*
17	Context and limits	Peak oil	*	*						*	
18		No limits	*	*				*		*	
19		Destroying the global commons	*	*			*	*			*
20		Planetary boundaries	*	*			*	*			*

4.1. Selected perspectives: Goals and broad targets (perspectives: 1-4)

Energy services power socio-economic development. Without those services, communication, education, health services, economic and industrial activity are not possible. Those services should be accessible to the user. They should be affordable, and they should meet needs in a manner that is both technically and behaviourally appropriate. An important part of sustainable development is to get affordable, adequate and appropriate access to energy services to society and the economy (perspective 4).

[4] Recall that the energy decision maker is concerned with: (i) enabling appropriate, affordable and adequate service access, (ii) ensuring the energy-system can do so in a sustainable manner, and (iii) ensure that the broader system interactions do not compromise the planet's sustained development.

Addressing energy poverty and GHG emissions

Much of humanity is still without access to modern fuels. Access to electricity and modern fuels has improved, but has not kept up with population growth. Essentially this retards, sidelines and marginalizes the development potential of millions of people and businesses (Perspective 1).

While there are tradeoffs with meeting various goals, some of them are small. Achieving universal access by 2030 would increase global electricity generation by 2.5%. Demand for fossil fuels would grow by 0.8% and CO_2 emissions go up by 0.7%, both figures being tiny compared to those associated with energy security or climate change (IEA, 2011).

As demand for services increase, resources deplete or production capacities become limited, pressure may be placed on specific pathways in the system. This is especially the case, if there are a limited number of supply options or routes. The disruption of those options or routes, coupled with the slow change in certain energy infrastructure or limited alternatives can lead to price spikes and ultimately the breakdown of service supply (Perspective 2).

This is particularly the case where part of the system is interwoven with common infrastructure, pathways or processes. For example, electricity relies on common transmission grids, oil may flows through a limited number of routes with limited extraction capacity, and a nuclear accident or burst dam wall may affect wide areas. This makes components in the energy system vulnerable to physical disruptions. Those vulnerabilities may be exposed by accidents (operational or natural) or for political reasons. This often highlights concerns, such as the potential for nuclear accidents (Perspective 9).

Furthermore, various means and targets, aim to better deliver these nationally appropriate services. They include: freeing up the market (Perspective 10), improving economic energy efficiency (Perspective 15) and addressing economic and financing limits (Perspective 16), amongst others. Changing behaviour (Perspective 3) plays a potentially important role in providing equitable access in situations where supply may be constrained. An example of the latter is the USA, which enforced low speed limits in order to reduce gasoline use in cars following oil security concerns.

For each of the energy perspectives, a clear set of indicators is needed to diagnose the state of access to services across the socio-economy. In order to determine the current state and potential roadmaps to progress toward various goals and broad targets, both indicators (Action A) and energy assessments (Action B) are useful. In particular, assessments that promote energy access (Action C) and improve economic efficiency (Action D) would be required to develop energy efficient policy. The latter is being aimed at lowering the cost of the service to the consumer.

4.2. Means and broad targets & Context and limits (Perspectives 5-20)

The energy system is thermodynamically inefficient. Much energy is wasted. In many instances, it may be economically efficient to waste it. This may be the case when the extra cost of purchasing more efficient machinery may outweigh the cost savings gained from reduced energy purchases. There is however much evidence that a large proportion of the energy wasted in the system can be used economically (Perspective 15). However, it is often not being used, due to various policy failures, ignorance and financing constraints. With this in mind, it would be useful to assess opportunities to increase the economic efficiency of the energy system, especially (but not limited to) where these promote end-use energy efficiency improvements (Action D). This analysis would concern not only (i) the affordability of energy services, but also (ii) the energy system more broadly.

The system is dynamic. While many individual components, or subsets, of the system may be unsustainable in the longer term, the objective is sustainable supply of services. Thus, use of depletable resources is only unsustainable, if it prevents alternatives from meeting the required energy service in the future, or if it has some other impacts[5]. Indeed at a given point in time, it may be that the only affordable energy sources are depletable. It is with this in mind that concerns about 'peak oil' arise (Perspective 17). Implicit is the concern that once a resource runs out there will be no ready alternatives, preventing the supply of energy services. Furthermore, some proponents of investment only in renewable energy (Perspective 7) may ignore the utility to be gained from using low cost depletable - but ultimately replaceable - energy resources to meet various development goals. Over time, fossil fuels will deplete, yet demand continues to grow.

A conventional view on energy resources

Estimates of available fossils and nuclear reserves vary widely. The conventional view is that with increasing prices, there is more than enough available to meet growing needs in the next 50 years (IEA, 2011). Furthermore, large reserves of shale and other gas finds indicate that this 'lower carbon' fossil energy source may fuel future energy development. As these reserves are widely distributed they may relive some geopolitical constraints associated with trade.

Similarly, estimates of economically recoverable RE power vary. In the case of the latter, power density, intermittency, learning rates and storage technology are key concerns. Renewable energy sources are not evenly distributed. One project envisions converting solar energy to electricity in North Africa for import to Europe. This gives rise to new geopolitical constraints. However, in many regions and applications, the potential for cost effective renewable energy deployment is large. Africa alone could provide well over 60% of its power needs from renewable resources within the next fifty years (IRENA, 2011). This in turn frees up large quantities of fossil fuel reserves, available in the continent for export.

As fossil fuels are burned GHG, emissions are released. With current mitigation trends, it is unlikely that emissions levels will be kept within what are considered safe limits.

It has often been suggested that behavioural change (Perspective 3) is a rational response to reduce large stresses on the system, curbing the use of energy by the rich (Perspective 13), in particular. In many settings, the rich account for disproportionately higher energy consumption. Some argue that changing behaviour patterns is irrational, as if energy costs include (externality) penalties for their effects (to either mitigate or adapt to them), then consumption levels should simply be left to the market (Perspective 12). Some critics of this view point to divergent market rules, differences between taxing luxuries or essential goods and services, and they question the monetary valuation of the environment. In the context of GHG mitigation, one option is to impose a carbon tax. This avoids summarily taxing the use of energy but rather its effect, concurrently encouraging the development of lower carbon energy systems. Questions arise as to if this should be applied to everyone, including the poor. The poor are expected to be "priced-out" of the market as they might not be able to have access to affordable, alternative, energy-services upon which they will depend for their survival (Perspective 1). Another challenge that is often pointed out is the difficulty `to establish an appropriate monetary level of the carbon tax, and to ensure that it is

[5] Other impacts could include health impacts or irreversible environmental damage, for example.

established in a geo-economically fair manner. Fairness also calls for the need to establish obligations arising from emissions in the past which would not be readily captured by a carbon tax (Perspective 13).

In part GHG mitigation targets will not be reached because some energy infrastructure is long lived. Quick changes can be difficult due to techno-physical constraints. If - for example - there is a need to move quickly from fossil fuels for electricity generation, it would require halting the use of power plant infrastructure that still has considerable economic value. Many power plants are designed to run for decades, thus once invested in there is a strong economic incentive to continue their use until retirement. Further, the construction of infrastructure to use alternative fuels can take several years. Rapid switches in the energy system can be difficult. Combined with environmental and other concerns, there are strong calls for an ‘energy revolution’ (Perspective 6), a move to renewables (Perspective 7) a nuclear renaissance (Perspective 8), support to accelerate energy technology learning (Perspective 11), as well as freeing up the market (Perspective 10). In each case, the energy decision maker would do well to have a ready set of indicators to evaluate the energy infrastructure situation (Action A) and assessments of each 'means or broad measure' (Action B).

It is however strongly argued that while there is dynamism in the energy sector, its inertia can be immense. Avoiding dangerous obstacles to development, such as meeting GHG mitigation targets, may be difficult - much like the Titanic avoiding icebergs. Hence, the common call for the adoption of a comprehensive basket of policies tailored to specific circumstances (Perspective 14).

Why a comprehensive basket of policies may be required

The potential of higher energy prices to limit energy related impacts is uncertain. Depending on the study, region and sector taxes from between 90 (IEA, 2011) to 400 (UN, 2011b) dollars per ton of CO_2 are required before related mitigation targets are met. Higher numbers reflect high dependence on infrastructure (for the case quoted, this is specific to the transport sector in Europe). As the turnover of energy system stock and lifestyle changes are likely to be slow, short and (even) medium term adjustments are slow. This may imply that in order to effect fast change in the system, sets of policies that extend beyond price may be useful.

For example, consider the evolution of a future energy system that emits what are considered 'safe' levels of GHG emissions. The rates of technological change implied by many scenarios are much higher than historical rates. Carbon intensity needs to drop strongly. This involves a move to low carbon technologies. At the same time a drop in energy intensity by around 35% from 2010 to 2035 is needed according to the IEA (2011). As a benchmark, despite climate related politics and awareness raising for the last 20 years, fossil fuels have not diminished in importance, and carbon intensities are decreasing at a slowing rate. From the period 1990 to 2003, emissions intensity dropped by 1.4% per year. Yet, from 2003 to 2008 they dropped only 0.6% (CAIT, 2012). From 2009 to 2010 however, GDP grew by less than a percent, yet global emissions increased by over 5% (IEA, 2011).

As existing markets are entrenched there is often a call to remove subsidies on fossil and nuclear energy sectors. At the same time, there are calls to subsidize the introduction of renewables - or new infrastructure (such as rail systems or electric cars). Others argue that a well-functioning market will best allocate investment in the energy system and call for the removal of all subsidies - as subsidies in the long run are not sustainable (Perspective 10).

As components of the energy system are often 'bulky' and long lived, they are also expensive. They require long lead times to construct. Charging for the use of this infrastructure normally only occurs (if it occurs) after it becomes operational. This can require significant up-front funding. For countries with limited budgets, these options may require external financial assistance (Perspective 16).

Global goals, local imperatives and international financing

Divergent mandates, goals and financing constraints can lead to difficult trade-offs and contention. For example, the World Bank recently lent money to South Africa to build, amongst others, a coal-fired power plant. From a national development point of view this was strongly positive. It will help produce low cost electricity, improving economic affordability. It will help improve energy security and sustain jobs in the mining sector. Yet, at the same time it will contribute future GHG emissions, a global problem (Bazilian et al, 2010).

As a measure to advance the energy system technology stock in countries – 'particularly LDC's - encouraging technology transfer is a potential measure (Perspective 16). More advanced technologies may have higher efficiencies, or in the case of renewables, replace the need for fossil fuels. As such there are interesting trade implications. For example, purveyors of advanced technologies substitute energy exporters, having an effect on the trade balance of both.

There is much inertia in the transport system and its use of oil. Apart from crude, there are alternative sources, such as coal, gas and biomass. Such oil can often be absorbed into the existing petroleum distribution system with conveniently little change. Biomass derived oil, has the advantage that once used, its feedstock can be re-grown and captures carbon in the process. However, there is concern that growing biofuel crops can cause harmful competition. Forest-land, or food-crop land may be displaced to make way for biofuel crops. In the case when food crops are displaced, they may be grown elsewhere. This in turn may result in newly cultivated land encroaching on sensitive areas such as forests. Further, various measures used to increase feedstock growth can require energy that may negate some of the carbon savings. Fertilizer is typically GHG intensive in its production and use, while irrigation may affect water management efforts, and requires energy for pumping (Perspective 5).

Broadly speaking, the energy system has impacts on physical systems (Concern iii). These include the natural environment, affecting the supply of ecosystem services. Several parts of the energy system depend on and affect ecosystem services. Ecosystem services that are related to the energy system (directly or indirectly) are numerous, yet neither systematic quantified mapping, nor sense of relative value is available to policy makers or national analysts. This makes abuse of this common good unavoidable (Perspective 19). This necessarily requires an assessment of the role and evaluation of related ecosystem services (Action E). Energy system interactions and impacts are felt in supply chains of other essential commodities. Some of those interactions compete for commodities needed in other systems. For example, the global demand is increasing for sustainable supplies of food, water and energy. Yet, the systems that supply each of these have common components. As demand increases, it is likely that competition and interactions will also become more pronounced. In many locations, fresh water is scarce. Yet, water is used in the energy system (for cooling, processing and hydro-generation), it is used for food production (irrigation of crops and processing), and it is required itself for drinking and other services. Managing this resource, given several competing uses, at various nexus points, is a challenge. Given that we may encroach on limits (Perspective 20) developing methodologies to assess resource are important (Action F).

A rich diversity

At an international level complications are compounded. Although energy is traded globally between states, states and regions differ greatly in terms of the role of energy production, trade and use. Many countries have economies that depend on the export of fuels, and thus are dependent on the status quo of the energy system continuing. Meanwhile, others are looking for an opportunity to profit from energy system changes or to avoid economic damage associated with limited changes (or limited action). Some are desperately energy poor, with limited budgets, in which case the imposition of extra penalties or restrictions may further retard their growth. Others are rich and consider their relatively wasteful energy use patterns a right to be purchased and protected. Therefore, common actions need to be nationally and locally appropriate and empower creative solutions to the range of energy challenges we face.

4.3. Charting a path: selected consensus building actions

Here we suggest what we consider useful steps to empower decision-making and the further the sustainable use of energy services.

4.3.1. Common energy metrics and vocabulary

The diagnosis of the health of the energy system, its development and interactions require metrics that can be quantified. The quantification should embody, in a common vocabulary, indicators needed to move towards a shared and richly diverse future.

Many countries may lack such indicators, making decision making at a national level difficult. In turn this makes communication between stakeholders and nations difficult. Without clear and common definitions it is challenging to: contribute to, articulate, assess or negotiate sustainable development goals and targets. To this end, it would be useful for a consistent set of indicators - or indicator development/application guidelines - to be further encouraged and applied.

In the context of international interactions, it is important that indicators are common, so that, for example, one ton of CO_2 emitted in one country equals one ton emitted in another. However, some metrics may be situation specific and not easily comparable, an example of which is the share of expenditures on energy services which may be a function of both expendable income and situation-specific energy prices.

At a national level, indicators help provide a measure of the health of an energy system. Over time they can help measure development progress. Certain types of indicators (such as tons of CO_2) can be aggregated over countries and provide regional or global information. At an international level, indicators may help measure progress. They may help communicate useful information to national decision makers.

Suggested Action A: ***Promote tracking the diagnosis, progress and scenarios of national, regional and global energy systems with a common set of 'strategic' SD indicators.***

This action is useful for measuring attributes of all of the perspectives presented.

4.3.2. Energy systems analysis

Quantitative analyses of the energy system, using modern energy planning tools, endow decision makers understanding the implications of different development pathways. They can support engagement for consensus building on common energy system 'goals and targets', 'means and broad policies'' or 'context and limits', at a national and international levels.

National energy systems analysis help making sense of the system. This is particularly important, since each system is unique. Explorative scenarios can be useful to explore: 'contexts and limits', the consequences of doing nothing, the feasibility of reaching various goals and targets' or implementing different 'means and broad measures'.

Efforts could be encouraged to understand longer term global energy trajectories and their effects on related systems. Implications from the global to the regional and national levels need to be deduced and articulated. At present, these two types of assessment (global and national) are often not reconciled, for a number of reasons. Yet, the national policy maker is faced with short term and urgent decisions that may affect longer term national, regional and global development.

Suggested Action B: ***Promote platforms for transparent national and international energy assessments, tracking economic development, fuel flows, physical resource use and environmental impacts in a quantitative manner.***

This is useful for assessing - to varying degrees - all of the perspectives raised in this note.

4.3.3. Investigating options for a more energy and economically efficient systems

The genesis of 'energy systems analysis' was to ensure the financial feasibility of energy investments and their operation. The investments were needed to underpin economic and social development. However, if they were unaffordable, they could not be sustained. Evidence suggests that many of the world's energy systems could be re-configured not only to reduce emissions, or increase energy security, but also improve economically. This results in more affordable energy services which are important to households and businesses. Some countries have limited resources and need to know how best to allocate them to promote development. Others may wish to explore how best to exploit those resources.

Suggested Action C: ***Assess opportunities to increase the economic efficiency of the energy system, especially (but not limited to) where these promote end-use energy efficiency improvements.***

This action will specifically help shed light on perspectives 1, 4, 10, and 13-16.

4.3.4. Adequate and affordable access to energy services

Specialized national assessments are needed, in order to provide the energy services essential for the achievement of the Millennium Development Goals (MDGs), such as lighting, safe cooking, heating and ICTs. Assessments need to consider requirements not only in terms of energy technology, but also in terms of institutions, regulations, financial flows, and risk allocation.

Suggested Action D: ***Develop strategies and supporting frameworks to help the poorest countries gain adequate, affordable access to modern energy services (at least to meet the MDGs) and prevent the 1.3 million (or so) deaths a year attributed to burning solid fuels in poorly ventilated housing.***

This action will specifically help shed light on perspectives 1 and 4.

4.3.5. Valuing ecosystems and quantifying their limits

Regular assessments should to be undertaken at a local and international level, in order to identify, assess interactions with and value ecosystem services. It is important to determine the carrying capacity of our environment for different levels of activity and types of development. At a national level, this may relate to maximum amounts of fuel-wood that can be re-grown, in view of land constraints. At an international level, it may relate to emissions and climate change.

While there are strongly divergent views on the value of the environment, it is clear that we rely on its services. Some distinguish between essential services (e.g., provision of water), and non-essential services (e.g., a nice view). Related negotiations have had no outcomes in some instances, but have led to global actions to conserve elements of ecosystems in other instances (e.g., fishing quotas on depleting species). Some argue that a process for assigning a monetary value on ecosystem services, though controversial and (some may argue, woefully) inefficient, is needed - decision makers may require such a signal to trade off 'energy system' investments with ecosystem care.

***Suggested Action E:* Undertake transparent evaluations of ecosystem services and their limits, to support discussions on their usage.**

This action will help shed light on perspectives 3, 5, 12-14, 19 and 20.

4.3.6. Finding climate, land-use, energy and water strategies (CLEWS).

The sustained supplies of food, energy and water are crucial to development. Critically, they are linked. All are exposed to rapidly growing global demand. All have resource constraints. All are common goods and involve international trade and have global implications. All have strong interdependencies with each other as well as with climate change and the environment. All relate to security issues as they are fundamental to the functioning of society. All have been the source or are at the heart of wars and make future wars more likely. All operate in heavily regulated markets, and yet policy makers and technology developers do not have toolkits for making sound, integrated and systematic assessments of policy or technological solutions. However, they need to make decisions and they need to make decisions urgently.

***Suggested Action F*: Develop methodologies for the integrated analysis of the systemic implications of meeting simultaneously global food, water and energy needs - given that each is essential and each may compete for common ecosystem (and other) services and affect each other.**

This action will help shed light on perspectives 3, 5, 14, and 18-20.

Care needs to be taken with, and importance placed on actions E and F. They clearly transcend the typical domain of the energy decision maker, but imply a burden to coordinate activities with others. The same logic applies to decision makers whose activities in turn encroach on energy system issues. Without proper attention, poor coordination and contradictory trajectories may well ensue.

4.4. Common ground and caveats

This report discussed a series of well argued, but strongly divergent perspectives, and suggested six common consensus-building actions. The question remains whether the suggested consensus building actions would in fact be supported by leading thinkers and decision-makers.

Throughout the last two sections of this report, ideas and suggestions of leading thinkers on energy, have been presented and illustrated through quotations contained in the highlighted text boxes. Each of the thirty thought leaders were contacted, of which 15 responded who were then asked whether taking on the suggested consensus building actions (A-F below) would be useful recommendations in an international setting such as the UN Conference on Sustainable Development. 14 thought leaders responded to provide more detailed feedbacks on the six actions A to F:

A. Promote tracking the diagnosis, progress and scenarios of national, regional and global energy systems with a common set of 'strategic' sustainable development indicators.

B. Promote platforms for transparent national and international energy assessments, tracking economic development, fuel flows, physical resource use and environmental impacts in a quantitative manner.

C. Assess opportunities to increase the economic efficiency of the energy system - especially (but not limited to) where these promote end-use energy efficiency improvements.

D. Develop strategies and supporting frameworks to help the poorest countries gain adequate, affordable access to modern energy services (at least to meet the MDGs) and prevent the more than one million deaths a year attributed to burning solid fuels in poorly ventilated housing.

E. Undertake transparent evaluations of ecosystem services and their limits, to support discussions on their usage.

F. Develop methodologies for the integrated analysis of the systemic implications of meeting simultaneously global food, water and energy needs - given that each is essential and each may compete for common ecosystem (and other) services and affect each other.

Only two of the respondents suggested dropping any of the proposed actions. One suggested dropping A and F, another suggested dropping B and E. C and D were seen as useful by all. It is interesting that even given the very, very diverse overall perspectives, more than 90% of respondents saw the six consensus building steps as useful or very useful.

At the same time, respondents voiced a number of reservations and caveats and suggested additional steps.

Respondents thought that the analysis provided was "obviously very realistic", that only modest progress was expected at Rio+20, and that the suggested initiatives might move negotiations into the right direction, the results of which might have "interesting leverage effects". Respondents also suggested that the proposal was helpful in that is was neutral, which, however, might not be welcome by everyone, as it might be seen as exposing concealed biases.

Respondents raised a number of concerns, including that, while ecosystem valuation was important, there the ecosystem monetization in action E might be carry the risk of non-acceptance by those who find commoditization of nature unacceptable in principle. It was suggested that these and related efforts would become more attractive, if they were clearly linked to environmental and climate co-benefits. The need for clear targets was also expressed, for which the suggested steps might be important enablers.

There were several additional suggestions made during the feedback process, including:

- On efficiency: It was suggested to emphasize and explicitly recognize potential rebound effects arising from efficiency measures. Some argued that the counteracting of efficiency gains by rebound effects may even need to be managed. It was proposed to do this by raising energy prices, in order to keep the effective cost of the energy service constant. This would avoid exposing end-users to rising costs and negative impacts on welfare, while sustaining the incentive for reducing energy use (Wilson 2012). Others argued that rebound effects are mostly limited (Laitner 2012). Furthermore, it was pointed out that limiting rebounds might be hard to achieve in a market economy. Efficiency of the existing stock of fossil power plants, as well as greater emphasis on gas as a transition fuel should be considered. Gains to be made here were large and economic (Lloyd 2012). As urbanization is a strong driver, there might be scope to develop energy efficiency standards specifically for cities (Messner 2012).

- On access: The importance of access was suggested but emphasized that it requires the support of indigenous peoples, and that it should not be imposed in a top-down way (Victor 2012). It was noted that affordability increases as wealth is generated, calling for an emphasis on wealth creation and to prevent long-term dependence on subsidies and related support measures (Lloyd 2012). Reference was also made to the UN Secretary General's 'Sustainable Energy for All' initiative, which includes specific targets for access and increasing the capacity of renewable energy and that the term 'nexus' should be included in action F (Gielen 2012).

- On technology: It was suggested to develop a framework to engage and fund international technology cooperation for solutions that simultaneously address energy poverty, energy security and local and global environmental concerns (Grübler 2012).

- On measures: It was suggested to implement market "facilitating" measures to enable sustainable solutions for clean energy access, energy efficiency, and sustainable urban designs, such as building efficiency standards, urban air quality standards, and capacity building for planning for sustainable urban mobility with emphasis on non-motorized and public transport. (ibid)

- On empowerment: It was suggested to explicitly recognize and strengthen the role of rural and indigenous women in energy management. It was pointed out that women are not only end users of energy, but also managers at the local level, playing a role in the conservation of existing natural resources and in managing the renewable energy systems, such as solar and biomass. Women need cleaner cooking energy, but there is also a need for strengthening their capabilities in tree and water management, as well inclusion in local, national and internal bodies set to manage energy infrastructure (Kelkar 2012).

Finally, a cautionary note that the issues identified here are important but not new. Lack of political will and leadership have limited the adoption of these suggestions in the policy makers' discourse in the past and will do so in the future, at both the international and local levels.

References

AGECC (The Secretary-General's Advisory Group on Energy and climate change AGECC) (2010). *Energy for a sustainable future*. Available at http://www.un.org/millenniumgoals/pdf/AGECCsummaryreport[1].pdf

Allen, M. (2009). *Planetary boundaries: Tangible targets are critical*. Nature Reports Climate Change. 23 September 2009. http://www.nature.com/climate/2009/0910/full/climate.2009.95.html

Antonia V. Herzog et. al. (2001). *Renewable energy: a viable energy choice*. http://rael.berkeley.edu/sites/default/files/old-site-files/2001/Herzog-Lipman-Edwards-Kammen-RenewableEnergy-2001.pdf

Arnsperger, C., (2011). *De-growth and an Economic Kyoto Protocol*. Available at http://p2pfoundation.net/De-growth_and_an_Economic_Kyoto_Protocol

Ausubel, J., (2010). *Generations of Methane*. http://mydocs.epri.com/docs/CorporateDocuments/EPRI_Journal/2010-Summer/1021445_WiredIn.pdf, Electric Power Research Institute.

Ausubel, J. (2012). Director, Professor, Program for the Human Environment, Rockefeller University. *Personal communication*.

Banuri, T., & Opschoor, H. (2007). *Climate Change and Sustainable Development* (Research report submitted to the United Nations/Division of Economic and Social Analysis, New York). New York: United Nations, DESA.

Bayon, R. and Jenkins, M. (2010).*The Business of Biodiversity*. Nature, Volume 466, July 8th, 2010. http://siansullivan.files.wordpress.com/2010/09/bayon-and-jenkins.pdf

Bazilian, M., Hobbs, B., Blyth, W., MacGill, I., & Howells, M. (2011). *Interactions between energy security and climate change: A focus on developing countries*, Energy Policy, Elsevier, vol. 39(6), pages 3750-3756, June.

Bazilian, M., Nussbaumer, P., Rogner, H., Williams, E., Brew-Hammond, A., Foster, V., Kammen, D., Pachauri, S., Howells, M., Niyongabo, P., Musaba, L., O Gallachoir, B. and Radka, M. (2011). *Energy Access Scenarios to 2030 for the Power Sector in Sub-Saharan Africa*. Nota di Lavoro. Fondazione Eni Enrico Mattei. http://www.feem.it/userfiles/attach/2011912934264NDL2011-068.pdf

Best, A., Denault, A., Hebabi, M., Liu, X., Samson, J & Wilson, P. (2010). *What Does Energy Security Mean for Canada?* Canadian Security Intelligence Service.

Birol, F. (2012). *Interview*, Regeringskansliet: IEA's chefsekonom om energiprognosen. http://www.regeringen.se/sb/d/15433/a/182413

Bloomger (2011). *Global Trend in Renewable Energy Investment 2011*. http://www.newenergyfinance.com/WhitePapers/download/50

Bogdansk, A., Dubois, O., Jamieson, C., and Krell, R., (2010). *Making Integrated Food-Energy Systems Work for People and Climate*. http://www.fao.org/docrep/013/i2044e/i2044e.pdf

Brundtland, G. (2010). *Balancing People, Planet and Profit: The future of Business Sustainability*. http://Bigthink.Com/Ideas/19251

Bryce, R. (2010). *The Real Problem With Renewables*. http://www.forbes.com/2010/05/11/renewables-energy-oil-economy-opinions-contributors-robert-bryce.html

Buettner, T. (1995). *Sex differentials in old-age mortality*. Population Bulletin UN. 1995; (39):18-44

Buettner, T. (2008). Quoted in: The Population Problem, Nature Climate Change. http://www.nature.com/climate/2008/0806/full/climate.2008.44.html

Cairns, J. (2003).*The Unmanaged Commons: A Major Challenge for Sustainability Ethics*. http://www.mnforsustain.org/cairns_j_unmanaged_commons.htm

Christodouleas, J., Forrest, R., Ainsley, C., Tochner, Z., Hahn, S., and Glatstein, E. (2011). *Short-term and long-term health risks of nuclear power plant accidents*. New Eng. J. Med., 364, 2334–2341, http://www.nejm.org/doi/full/10.1056/NEJMra1103676

CJB (Climate Justice Brief) (2010). *Climate Debt.* http://www.wdm.org.uk/sites/default/files/01.Climate.debt_.pdf

Clean Air for Europe (CAFE) Programme (2002). *Baseline Scenarios*. Report: B4 3040/2002/340248/MAR/C1.

Cohen, G., Joutz, F. and Loungani, P. (2011). *Measuring Energy Security: Trends in the Diversification of Oil and Natural Gas Supplies*. IMF Working Paper.

Cullen, Jonathan, and Julian M. Allwood (2009). *Prioritising energy efficiency opportunities for practical change. University of Cambridge*. Poster presented at the Institute of Physics. http://www.lcmp.eng.cam.ac.uk/wp-content /upl oads/081111-iop-poster.pdf

Daschle, T. et al. (2007). *Food for Fuel?* Foreign Affairs, September/October 2007. http://www.foreignaffairs.com/articles/62845/tom-daschle-c-ford-runge-and-benjamin-senauer/food-for-fuel?page=show

DBCA (Deutsche bank climate change advisory). (2009). *Paying for renewable energy: TLC at the right price (achieving scale through efficient policy design*. https://www.dbadvisors.com/content/_media/1196_Paying_for_Renewable_Energy_TLC_at_the_Right_Price.pdf

De Martino S., and Le Blanc, D., (2010), *Estimating the Amount of a Global Feed-in Tariff for Renewable Electricity*, DESA Working Paper No. 95, ST/ESA/2010/DWP/95 http://www.un.org/esa/desa/papers/2010/wp95_2010.pdf

de Vries, B. (2012) Professor, Department of Science, Technology and Society Utrecht University. *Personal communication*.

de Vries, B.; Petersen, A. (2009). *Conceptualizing sustainable development: An assessment methodology connecting values, knowledge, worldviews and scenarios*. Ecological Economics 68 (2009) 1006-1019

Fitzmaurice, M. (1996). *Liability for Environmental Damage Caused to the Global Commons*. Reciel, Volume 5, Issue 4, 1996.

Ford Runge, C. and Senauer, B. (2008). *How Ethanol Fuels the Food Crisis*. Foreign Affairs, May 28, 2008.

Fossil Fuel Foundation, (2010). *Advantages and Disadvantages of Fossil Fuels*. http://www.fossilfuel.co.za/Advantages-Fossil-Fuels.aspx

Foster, J, (2012). *Spike in Food Prices Projected by 2013*. The New York Times, March 7, 2012

Freebairn, J (2009). *Carbon Taxes vs Tradable Permits: Efficiency and Equity Effects for a Small Open Economy*. http://www.victoria.ac.nz/sacl/cagtr/pdf/freebairn.pdf

Gielen, D. (2012) Head of analysis, IRENA (International Renewable Energy Agency). *Personal communication*.

Gielen, D. (2011). *Global Frameworks to Support Renewable Energy Policy*. Brasilia, September

Gokay, B., (2011). *Past peak oil - life after cheap fossil fuels*. http://www.publicserviceeurope.com/article/705/past-peak-oil-life-after-cheap-fossil-fuels

Grubb, A., (2011). *Peak Oil Primer.* http://www.energybulletin.net/primer.php

Grübler, A. (2012) Professor, Yale University. *Personal communication*.

Grübler,A. and Riahi, K. (2010). *Do governments have the right mix in their energy R&D portfolios?* Carbon Management, October 2010, Vol. 1, No. 1, Pages 79-87.

Grübler,A., (1998). *Technology and Global Change*.[Internet] Cambridge: Cambridge University Press, http://www.cambridge.org/servlet/file/store6/item2464272/version1/item_9780521543323_excerpt.pdf

GVEP (Global Village Energy Partnership), (not dated). *Access to finance*. http://www.gvepinternational.org/en/business/access-finance

Hanson, D., Laitner, S., (2007). *Technology Policy and World Greenhouse Gas Emissions in the AMIGA Modeling System*, Energy Journal

Heaps, C., Erickson, P., Kartha, S., and Kemp-Benedict, E. 2010.Europe's Share of the Climate Challenge Domestic Actions and International Obligations to Protect the Planet. http://www.sei-international.org/mediamanager/documents/Publications/Climate-mitigation-adaptation/europes_share_heaps_09.pdf.pdf Stockholm Environment Institute.

Hillyard, D. (2009). *Last chance to change our behavior*. http://news.bbc.co.uk/2/hi/science/nature/8242410.stm

http://www.unwomensouthasia.org/assets/ADIVASI-WOMEN-ENGAGING-WITH-CLIMATE-CHANGE-UNIFEM1.pdf

Huber, P., Mills, M., (2005). *Oil, Oil, Everywhere*. http://www.manhattan-institute.org/html/_wsj-oil_oil.htm

Humphrey, J., Gu, J. and Messner, D. (2009). *Global Governance and Developing Countries*. *The impact of Asian Drivers on the developing world*, in: World Development, Vol.36, Nr. 2, 274-292

IAEA (International Atomic Energy Agency) (2011). *Reference Data Series 1*. http://www-pub.iaea.org/MTCD/Publications/PDF/RDS1_31.pdf

IEA (International Energy Agency) (2008). *Energy Technology Perspectives: Scenarios and Strategies to 2050*. Paris: IEA

IEA (International Energy Agency). (2011). *World Energy Outlook*, OECD, Paris

IEA (International Energy Agency). (2012). *Implication of energy poverty on health and environment*. www.iea.org/weo/implication.asp

IEA (International Energy Agency) (2012). *Energy Market Reform*. http://www.iea.org/subjectqueries/keyresult.asp?keyword_id=4148 Accessed, May 2012.

IEA (2008). *IEA urges $45 trln "energy revolution" to halve* CO_2. http://in.reuters.com/article/2008/06/06/us-g8-energy-iea-idINSP11620220080606

IEA (2009). *CCS technology roadmap*. http://www.iea.org/roadmaps/ccs_roadmap.asp

IER (Institute for Energy Research) (2012). *About us*. http://www.instituteforenergyresearch.org/about-us/ Accessed. May 2012.

IER (Institute of Energy Research) (2011). *Why Free Markets in Energy*. http://www.instituteforenergyresearch.org/2011/07/08/why-free-market-in-energy/

IER (Institute of Energy Research) (2012). *Wind Power and the Free Market*. http://www.instituteforenergyresearch.org/2012/01/04/wind-power-and-the-free-market/

IIASA (International Institute for Applied Systems Analysis) (2012). Institute Scholars: Cesare Marchetti – Biosketch, [online], (Updated 24th January 2011). http://www.iiasa.ac.at/Research/INS/marchetti-bio.html [Accessed:2012-03-09]

IISD (International Institute for Sustainable Development) (2012). *News - OAS Dialogue Examines Governance of Sustainable Energy and Climate Change*. http://climate-l.iisd.org/news/oas-dialogue-examines-governance-of-sustainable-energy-and-climate-change/

IPCC (Intergovernmental Panel on Climate Change) (2011). *Special Report on Renewable Energy Sources and Climate Change Mitigation.* http://srren.ipcc-wg3.de/report

IRENA (International Renewable Energy Agency) (2011). *Prospects for the African Power Sector*. http://www.irena.org/DocumentDownloads/Publications/Prospects_for_the_African_PowerSector.pdf

IRENA (International Renewable Energy Agency) (2012). *Preparatory commission*, Newsletter 4. http://www.irena.org/DocumentDownloads/newsletter/IRENA_newsletter_4.pdf Accessed: April.

ISDP (Institute for security & development policy) (2012). *Research – Energy, security and cooperation*, http://www.isdp.eu/research/energy-security-and-cooperation.html Accessed: April.

Jackson, T. (2012). Professor of Sustainable Development, University of Surrey. *Personal communication*.

Jackson, T. (2010). *Economic reality check*. *TEDGlobal 2010*, Filmed Jul 2010; Posted Oct 2010, http://www.ted.com/talks/tim_jackson_s_economic_reality_check.html

Jackson, T. (2012). *About time - Examining the case for a shorter working week*. London School of Economics, http://www.youtube.com/watch?v=nqI951u9emQ

Jeremy R. (2006). *Nuclear Energy: Still a Bad Idea*. http://www.commondreams.org/views06/0929-33.htm

Jian, J. (2011). *China's Energy Security: Prospects, Challenges and Opportunities*. http://www.brookings.edu/~/media/Files/rc/papers/2011/07_china_energy_zhang/07_china_energy_zhang_paper.pdf The Brookings Institution.

Jiang, K. (2011). *Potential Secure, Low Carbon Growth Pathways for the Chinese Economy*. PP.30, January.

Johansson, M.,Alveteg, M.,Amann, M.,Bak, J.,Bartnicki, J.,Ekqvist, M.,Forsius, M.,Frohn, L.,Geernaert, G.,Gimeno, B.,Guardans, R.,Karvosenoja, N.,Martín, F.,Posch, M.,Suutari, R.,Syri, S., (2001). *Integrated Assessment Modeling of Air Pollution in Four European Countries*,Water, Air, & Soil Pollution Earth and Environmental Science, Volume: 130, Issue: 1

Kates, R., with National Research Council, Board on Sustainable Development, (1999). *Our Common Journey: A Transition Toward Sustainability*, National Academy Press. http://rwkates.org/pdfs/b1999.01.pdf

Kelkar, G., (2009a). *Adivasi Women Engaging With Climate Change*.

Kelkar, G., (2009b). *Climate Change and Livelihood Practices: Mitigation and Adaptation among Adivasi Women. A Roundtable with the UN Special Rapporteur on the right to Food*, Chennai, India (30/3/2010). http://www.pwescr.org/PWESCR_RTC%20Report%20Final_30-7-2011.pdf, Programme on Women's Economic Social and Cultural Rights

Kelkar, G., (2012). UN-Women, South Asia Office. *Personal communication*.

Klare, M., (2008). *Rising Powers, Shrinking Planet: The New Geopolitics of Energy* (Henry Holt & Company, Incorporated, ISBN 9780805080643.

Kuhlman, A., (2007). *Peak Oil: The end of oil ages*. http://www.oildecline.com/

Laitner (2009). *The Third Industrial Revolution and the Economic Imperative of Energy Efficiency*, http://www.huffingtonpost.com/john-a-/third-industrial-revolution_b_981876.html, Huffinton Post.

Laitner et al. (2007). *The American Energy Efficiency Investment Market*. A White Paper prepared for the Energy Efficiency Finance Forum. Washington, D.C.: ACEEE

Laitner, J. (2012). American Council for an Energy Efficient Economy. *Personal communication*.

Laitner, J. (2006). *The Energy Efficiency Technology Resource*. Real Climate Economics. http://www.realclimateeconomics.org/briefs/Laitner_Energy_Efficiency_Technology_Resource.pdf

Landau, E. (2011). *Why (or why not) nuclear power*. CNN. http://articles.cnn.com/2011-03-26/us/nuclear.energy_1_nuclear-power-commercial-nuclear-reactors-nuclear-projects/2?_s=PM:US , March 26.

Lloyd, P., (2012). Professor, Cape Peninsular University of Technology. *Personal communication*.

Lloyd, P., (2010). *Climate Change*, Available: http://www.businessday.co.za/articles/Content.aspx?id=116212, Business Day.

Lloyd, P., (2012), *Personal communication*.

Lloyd's (2012). *Sustainable security: Strategic risks and opportunities for business*. http://www.lloyds.com/~/media/Lloyds/Reports/360%20Energy%20Security/7238_Lloyds_360_Energy_Pages.pdf, Accessed: April.

Lovins, A. (2010). *Reinventing Fire*. http://www.youtube.com/watch?v=8H2jnmJ6ZEw

Lovins, A. (2012). *Natural Capitalism: The Next Industrial Revolution*. http://www.youtube.com/watch?v=1zfO3HW6xCw Accessed: April.

Lumb, J.(2002). *Economic Valuation of Ecosystem Services*. Quaker Eco-Bulletin, Volume 2, Number 6 November/December 2002. http://quakerearthcare.org/Publications/QuakerEcoBulletin/QEBArchive/QEB-PDF/QEB2-6-ecoservices.pdf

Lutz, W. (2009). *Social Challenges and Demographics - IHDP Open Meeting 2009*, (Plenary Social Challenges and Demographics by IHDP Secretariat's channel), http://www.youtube.com/watch?v=4ilvNzgz_Zs&list=PLACC3278F7A6AF419&index=1&feature=plpp_video

Makwana, R. (2006). *The Global Commons - Our Shared Resources.* January 2006. http://www.stwr.org/land-energy-water/the-global-commons-our-shared-resources.html

Mamouda, M. N. A., Thomas, J.-P., Sarr, S., and Dafrallah, T., (2010). *Energy in the National Adaptation Programmes of Action (NAPAs) in Africa*, Policy Paper. Energy, Climate Change and Poverty Alleviation. http://www.gnesd.org/Downloadables/GNESD_PolicyPaper.pdf

Marchetti, C., (2012) Physicist and Systems Analyst, Institute Scholar, IIASA. *Personal communication*.

Marchetti, C., (2005). The Hydrogen and Fuel Cell Letter website, August 2005 Perspectives: *Hydrogen Pioneer Cesare Marchetti Still Bets on Nuclear Power as Primary Source*, http://www.hfcletter.com/issues/XX_8/stories/440-1.html

Marchetti, C., (2007). *Half a century of pushing the Hydrogen Economy idea*, some personal memoirs, keynote speech World Hydrogen Technology Convention Montecatini Terme, 6/11/2007). http://www.cesaremarchetti.org/archive/electronic/Montecatini07.html

Marchetti, C., (2006). *Long-term global vision of nuclear-produced hydrogen*, Int. J. Nuclear Hydrogen Production and Application, [online], 2006, Vol. 1 (1), p.p. 13 – 19

Marshall, S., (2011). *Norway raises drill costs alarm*. http://www.upstreamonline.com/live/article283060.ece

Meadows, D., Meadows, D., Randers, D., & Behrens, W., (1972), The Limits to Growth. New York: Universe Books. ISBN 0-87663-165-0

Meadows, D.H., Meadows, D.I., Randers, J., Behrens III, W.W., (1972). *The limits to growth*. Available at: http://web.ics.purdue.edu/~wggray/Teaching/His300/Illustrations/Limits-to-Growth.pdf

Messner, D., (2010). *Four lessons from the present global financial crisis for the 21st Century: An essay on Global Trafsmormation from a European perspective*, in: Ashwani Kumar/ Dirk Messner (eds.): Power shifts and Global Governance, London, 31-44.

Messner, D. (2011). *Drei Wellen globalen Wandels: Global Governance Dynamiken in der ersten Hälfte des 21. Jahrhunderts*; in: Harald Welzer/ Klaus Wiegandt (eds.): *Perspektiven einer nachhaltigen Entwicklung*, Frankfurt, 275-307 (engl: D. Messner (2011), Three waves of global change: the dynamics of global governance in the first half of the 21st century, in: Thomas/ Fues/ Liu Youfa (eds.): Global Governance and Building a Harmonious World. A comparison of European and Chinese concepts for international Affiars, Studies of the German Develoment Institute, bonn, 9-39

Messner, D. (2012). German Development Institute. *Personal communication*.

Messner, D., Schellnhuber, J., Rahmstorf, S. and Klingenfeld D. (2010). *A budget Approach. A framework for a global transformation toward a low carbon economy*, in: Journal of Renewable and Sustainable Energy, No.2, Vol. 3.

Mijin C. (2011). *Government Should Invest in Renewables and Clean Energy*. http://www.policymic.com/debates/2834

Molden, D. (2009). *Planetary boundaries: The devil is in the detail*. Nature Reports Climate Change. 23 September 2009. http://www.nature.com/climate/2009/0910/full/climate.2009.97.html

Müller, B., 2002. *Equity in climate change*. http://www.oxfordclimatepolicy.org/publications/documents/The_Great_Divide-Executive_Summary.pdf

Nakicenovic, N. (2009). *Energy research and technology for a transition toward a more sustainable future*. Book chapter in: Global sustainability - a Nobel Cause, H.J. Schellnhuber et al., (eds.) Cambridge University Press. http://www.nobel-cause.de/potsdam-2007/book/NobelCauseBook_chapter21.pdf

Nelder, C., (2009). *The End Of Fossil Fuel*. [Online] http://www.forbes.com/2009/07/24/peak-oil-production-business-energy-nelder.html

Nobuo, T. (2008). *WEO Calls for Global Energy Revolution Despite Economic Crisis*. http://www.iea.org/press/pressdetail.asp?press_rel_id=275

Nordhaus, W. (2007). (Oxford Journals – Economics & Social Sciences) Rev Environmental Economics and Policy, Vol.1(1), p.p.26 – 44. http://nordhaus.econ.yale.edu/nordhaus_carbontax_reep.pdf

Nordhaus, W. (2011a). *The Architecture of Climate Agreements*, Bulletin of Atomic Scientists, January 2011, Vol. 67(1), p. 9 – 18. http://nordhaus.econ.yale.edu/documents/BAS_Nordhaus_Jan11.pdf

Nordhaus, W. (2011b). *Estimates of the Social Cost of Carbon: Background and Results of the RICE-2011 Model*, Cowles Foundation Discussion Paper, October 2011, No. 1826, http://nordhaus.econ.yale.edu/documents/CFDP1826.pdf

Nordhaus, W. (2010). *The economics of the Copenhagen accord*. International Energy Workshop. Stockholm.

NY (New York) Times (2011). *Rush to Use Crops as Fuel Raises Food Prices and Hunger Fear*. http://www.nytimes.com/2011/04/07/science/earth/07cassava.html

OPEC, (2011).Opec Bulletin 12/11-1/12. [Online] http://www.opec.org/opec_web/static_files_project/media/downloads/publications/OB12_012012.pdf

Parris, T. (2012). Executive director ISciences. *Personal communication*.

Parris, T., and Kates R. (2003). *Characterizing and Measuring Sustainable Development*. Annual review of Environment and Resources, pp 559-586.

Pauli, E. (2012). *One Year after Fukushima: Is Nuclear Power Phase-out a Feasible Alternative?* http://www.globalresearch.ca/index.php?context=va&aid=29936

Powelson, J. (2002). The Classical Liberal Quaker Letter # 44.

Ramani, K. (2004). *Energy for sustainable development: Challenges for Asia and the Pacific and lessons from UNDP projects in the region*. Chapter 1: Energy for Sustainable Development. http://regionalcentrebangkok.undp.or.th/documents/reports/UNDPEFSD-December04.pdf

Riahi, K., F. Dentener, D. Gielen, A. Grubler, J. Jewell, Z. Klimont, V. Krey, D. McCollum, S. Pachauri, S., Rao, B. van Ruijven, D. P. van Vuuren, and C. Wilson. (2012). *Energy Pathways for Sustainable Development*. In: The Global Energy Assessment: Toward a More Sustainable Future. IIASA, Laxenburg, Austria and Cambridge University Press, Cambridge UK.

Riahi, K., Grübler, A., Nakiecenovic,N., (2006). *Scenarios of long-term socio-economic and environmental development under climate stabilization*, Technological Forecasting and Social

Change, [Online], September 2007, Vol. 74 (7), p.p. 887 - 935. http://www.sciencedirect.com/science/article/pii/S0040162506001387

Rockström, J. et al (2009). *Planetary Boundaries: Exploring the Safe Operating Space for Humanity*. Ecology and Society, Volume 14, No. 2, Article 32. http://www.ecologyandsociety.org/vol14/iss2/art32/

Rockström, J., W. Steffen, K. Noone, Å. Persson, F. S. Chapin, III, E. Lambin, T. M. Lenton, M. Scheffer, C. Folke, H. Schellnhuber, B. Nykvist, C. A. De Wit, T. Hughes, S. van der Leeuw, H. Rodhe, S. Sörlin, P. K. Snyder, R. Costanza, U. Svedin, M. Falkenmark, L. Karlberg, R. W. Corell, V. J. Fabry, J. Hansen, B.Walker, D. Liverman, K. Richardson, P. Crutzen, and J. Foley. (2009). Planetary boundaries:exploring the safe operating space for humanity. Ecology and Society 14(2): 32. [online] http://www.ecologyandsociety.org/vol14/iss2/art32/

Rogner, H. (2011a). *Hans-Holger Rogner, International Atomic Agency at the UN COP 17 climate talks*, [interview] http://www.youtube.com/watch?v=1K2zo9GyPmc [Accessed: 2012-03-09]

Rogner, H. (2011b), *Hans Holger Rogner* (April 2011), [interview], Bangkok 2011: 16th AWG KP & 14th AWG LCA http://www.climate-change.tv/hans-holger-rogner-april-2011 [Accessed: 2012-03-09]

Rogner, H. (2012a). *World Nuclear Association website*, Hans-Holger Rogner [Online] http://www.world-nuclear.org/sym/2005/rognerbio.htm [Accessed:2012-03-09]

Rogner, H. (2012b). Chief, Planning and Economic Studies Section, International Atomic Energy Agency *Personal communication*. April.

Rühl, C. (2008). *Profiles Salzburg Global Seminar – The Global Energy Fulcrum: Asian Development and International Response*, http://www.salzburgglobal.org/current/includes/FacultyPopUp.cfm?IDSPECIAL_EVENT=1569&IDRecords=126104

Rühl, C. (2009). *BP: We should see volatility increase*, EU news and policy debates internet site, http://www.euractiv.com/energy/bp-see-volatility-increase/article-175922

Rühl, C. (2010). *Global Energy After the Crisis*, Foreign Affairs, March/April 2010, Vol. 89 (2), p.p. 62 – 75, http://www.aral.de/assets/bp_internet/trinidad_and_tobago/STAGING/home_assets/christof-ruehl-global-energy-after-crisis.pdf

Sachs, J. (2011). *Sachs on Rio+20*. Available: http://www.earth.columbia.edu/videos/watch/335

Schelling, T., (2002). *Greenhouse effect*. Available: http://econlib.org/library/Enc1/GreenhouseEffect.html

Schlesinger, W. (2009). *Planetary boundaries: Thresholds risk prolonged degradation*. Nature Reports Climate Change. 23 September 2009. http://www.nature.com/climate/2009/0910/full/climate.2009.93.html

SEI (Stockholm Environment Institute) (2009). *Europe's share of the Climate Challenge*. http://sei-us.org/Publications_PDF/SEI-EuropeShareOfClimateChallenge-09.pdf

Smil, V. (2010). *Energy Transitions: History, Requirements, Prospects*. Published by Praeger, 2010. ISBN-10: 0313381771.

Sovacool, B. (2007). *What's Really Wrong With Nuclear Power?* http://scitizen.com/future-energies/what-s-really-wrong-with-nuclear-power-_a-14-1256.html

Standard Chartered, (2012). *Greasing the global economy: a global research on macro financial outlook.* Mar-2012 - BCCT Committee - Banking & Finance - Standard Chartered Bank Research

Streeten, P. et al. (1981). *First Things First, Meeting Basic Human Needs in the developing countries*. World Bank.

Tenenbaum, D. (2008). *Food vs. Fuel: Diversion of Crops Could Cause More Hunger*. Environ Health Perspect. 2008 June; 116(6): A254–A257. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2430252/

Tol, R. (2009). *Why Worry About Climate Change?* ESRI Research Bulletin 2009/1/1. Dublin: ESR

Tol, R. (2012) Professor. Department of Economics, University of Sussex. *Personal communication*.

Tverberg, G., (2012). World energy consumption since 1820 in Charts. Energy Bulletin, 16 March 2012, http://www.energybulletin.net/stories/2012-03-16/world-energy-consumption-1820-charts.

UN (United Nations) (2011). *Working Towards a Balanced and Inclusive Green Economy*. http://www.unemg.org/Portals/27/Documents/IMG/GreenEconomy/report/GreenEconomy-Full.pdf

UN (United Nations) (2011a). *Working Towards a Balanced and Inclusive Green Economy*. http://www.unemg.org/Portals/27/Documents/IMG/GreenEconomy/report/GreenEconomy-Full.pdf

UN (United Nations) (2011b). *World Economic and Social Survey 2011. The Great Green Technological Transformation*. New York.

UN, IPCC (2011). *Renewable energies can meet world's power needs.* http://www.smartplanet.com/blog/intelligent-energy/un-renewable-energies-can-meet-worlds-power-needs/6145

UNDP, (2012a). *Universal access to modern energy for the poor*. http://www.undp.org/content/undp/en/home/ourwork/environmentandenergy/focus_areas/sustainable-energy/universal-access.html

UNDP, (2012b). *Sustainable Energy*. http://www.undp.org/content/undp/en/home/ourwork/environmentandenergy/focus_areas/sustainable-energy.html

UN-Energy (2009). *Policies and measures to realize industrial energy efficiency and mitigate climate change*. http://www.un-energy.org/sites/default/files/share/une/un_energy_2009_policies_and_measures_to_realise_industrial_energy_efficiency_and_mitigate_climate_change_small.pdf

UNEP (United Nations Environment Programme) (2008). *Reforming Energy Subsidies: Opportunities to Contribute to the Climate Change Agenda*. http://www.unep.org/pdf/pressreleases/reforming_energy_subsidies.pdf

UNEP (United Nations Environmental Programme) (2011). *The Emissions Gap Report*. www.unep.org/publications/ebooks/emissionsgapreport

UNFCCC (United Nations Framework Convention on Climate Change) (2009). *Ideas and proposals on the elements contained in paragraph 1 of the Bali Action Plan*. Page 44. http://unfccc.int/resource/docs/2009/awglca6/eng/misc04p01.pdf

Van Vuuren D. et al, (2002). *Energy and emission scenarios for China in the 21st century—exploration of baseline development and mitigation options*. http://www.sciencedirect.com/science/article/pii/S0301421502000708

Van Vuuren, D.,Nakicenovic, N., Riahi, K., Brew-Hammond, A., Kammen, D., Modi, V., Nilsson, M. and, Smith, K., (2012). *Rio+20 Policy brief no.8: An energy brief for a planet under pressure*. http://www.planetunderpressure2012.net/pdf/policy_energy.pdf

Vernon, C., (2007). *Coal - The Roundup*. [Online] http://europe.theoildrum.com/node/2726/

Victor, P. (2006). *Managing without growth*. http://www.greenparty.ca/sites/greenparty.ca/files/attachments/peter_victor-no_growth.pdf

Victor, P. (2008). *Sustainable development commission; Managing without Growth*; 24 April, http://www.sd-commission.org.uk/publications.php?id=773

Victor, P. (2011). *Managing without Growth*. http://vimeo.com/16906655. Steady State Economy Conference, Leeds.

Victor, P. (2012). Professor, faculty of environmental studies, York University. *Personal communication*.

Victor, P. (2012). Victor, Peter Alan, FES faculty members. http://www.yorku.ca/fes/wa/FacultyProfiles/app/profile/5174, Accessed April.

Wade, N., (2011). *A Passion for Nature, and Really Long Lists*. The New York Times, April 25, 2011. http://www.nytimes.com/2011/04/26/science/26ausubel.html?pagewanted=all

Watson, R. (1996). *Policies and Measures for Mitigating Climate Change*. World Bank. http://www.gcrio.org/ipcc/techrepI/techsumm.html

WBGU (German Advisory Council on Global Change) (2011). *World in Transiation: A Social Contract for Sustainability*. Berlin http://www.wbgu.de/fileadmin/templates/dateien/veroeffentlichungen/hauptgutachten/jg2011/wbgu_jg2011_kurz_en.pdf

WBGU (German Advisory Council on Global Change). (2009a). *Climate Change as a security Risk*, http://www.wbgu.de/fileadmin/templates/dateien/veroeffentlichungen/hauptgutachten/jg2007/wbgu_jg2007_kurz_engl.pdf

WBGU (German Advisory Council on Global Change). (2009b): Solving the climate dilemma: The Budget Approach. Berlin. http://www.wbgu.de/fileadmin/templates/dateien/veroeffentlichungen/sondergutachten/sn2009/wbgu_sn2009_en.pdf

WCA (World Coal Association). http://www.worldcoal.org/carbon-capture-storage/financing-ccs/

WCA, 2011. *Rio+20 Must Address Energy Poverty*. [Online] http://www.worldcoal.org/resources/ecoal/ecoal-current-issue/rio20-must-address-energy-poverty/

Weisser, D. (2007). *A guide to life-cycle greenhouse gas emissions from electric supply technologies*, Energy, Volume 32, Issue 9, September, Pages 1543-1559

Wertz-Kanounnikoff, S. (2006). *Payments for environmental services – A solution for biodiversity conservation?* IRE. www.i-r-e.org/fiche-analyse-143_en.html

Weyler, R., (2012). *Peak oil is real and will stunt any economic recovery*. [Online] http://www.publicserviceeurope.com/article/1648/peak-oil-is-real-and-will-stunt-any-economic-recovery

Wilson, C. (2012a). The Environmental Law Reporter, 2012, *Social Norms and Policies to Promote Energy Efficiency in the Home*, http://elr.radcampaign.com/news-analysis/38/10882/social-norms-and-policies-promote-energy-efficiency-home [Accessed: 2012-03-08]

Wilson, C. (2012b). Tyndall Center for Climate Change Research. *Personal communication*.

Wilson, C., Chatterton, T. (2011). *Multiple models to inform climate change policy: a pragmatic response to the 'beyond the ABC' debate*, Environment and Planning A, 2011, Vol 43 (12), p.p. 2781 – 2787, Available: http://www.envplan.com/epa/editorials/a44404.pdf and http://www.envplan.com/abstract.cgi?id=a44404, [Accessed: 2012-03-08]

Wilson, C., McDaniels, T. (2007). *Structured decision-making to link climate change and sustainable development*,[internet], Institute for Resources, Environment and Sustainability – University of British Columbia - Vancouver – Canada, Published in: Robinson,J., Bizikova, L., Cohen, S., 2007, Climate Policy: Integrating Climate Change Actions into Local Development [google-book], Earthscan: 8 – 12 Camden High Street, London NW10JH, UK.

Wilson,C., Dowlatabadi, H. (2007). *Models of Decision Making and Residential Energy Use*, Annual Review of Environment and Resources, November 2007, Vol. 32, p.p. 169 - 203 First published online as a Review in Advance on June 26, 2007 , Available:http://www.annualreviews.org/doi/abs/10.1146/annurev.energy.32.053006.141137?journalCode=energy

WNN (World Nuclear News) (2008). Date set for Petten reactor's return. http://www.world-nuclear-news.org/RS_Date_set_for_Petten_reactor_s_return_1510081.html 15 October.

Wuppertal. (2005). *Policies and Measures to reduce Greenhouse gas emissions in the EU*, http://awsassets.panda.org/downloads/target_2020_low_res.pdf

Zuma (2011). President of South Africa, in an address to the Copenhagen summit on 18 December. http://www.un.org/en/africarenewal/vol23no4/african-chorus-on-climate- change.html