Results of the Club of Amsterdam Lab on 'Old and New Energy'

A Brief for the European Foresight Monitoring Network – www.efmn.eu
By Paul Holister. Based on material from attendees of Club of Amsterdam Lab on 'Old and New Energy', April 2007**,** moderated by Humberto Schwab**.**

The Old and New Energy Lab was designed to generate potentially viable, and possibly novel, plans of action for dealing with current and future energy issues by leveraging brainstorming methods designed to generate innovative thinking and bypass preconceived ideas and assumptions. These processes tapped into backgrounds and expertise of 'thought leaders' chosen for their diversity so as to maximise the fertility of discussions.

Context and Challenges Addressed

Diminishing reserves of fossil fuels, climate change, geopolitical factors and a wave of technological advances are bringing complex pressures to bear on the landscape of energy generation and consumption.

Change seems inevitable, but understanding change, anticipating its impacts, and being ready to react appropriately, is always challenging in all but the simplest of human situations. This is especially the case in an environment where a limited set of modes of operation have been entrenched for an extensive period of time, as is the case with the energy landscape. This can make it very hard for people to think 'outside the box'. Arguably, such thinking is very much needed at the moment when it comes to energy.

Thus the challenge addressed at the Energy Lab was to bypass preconceptions and traditional ways of thinking and open up as broad a field of consideration as possible and then validate the ideas generated with some tangible, realistic scenarios.

Methodology / Approach

A combination of techniques was applied, led by a practised exponent of these techniques. In particular, a combination of Socratic discourse and a future scenario method were applied.

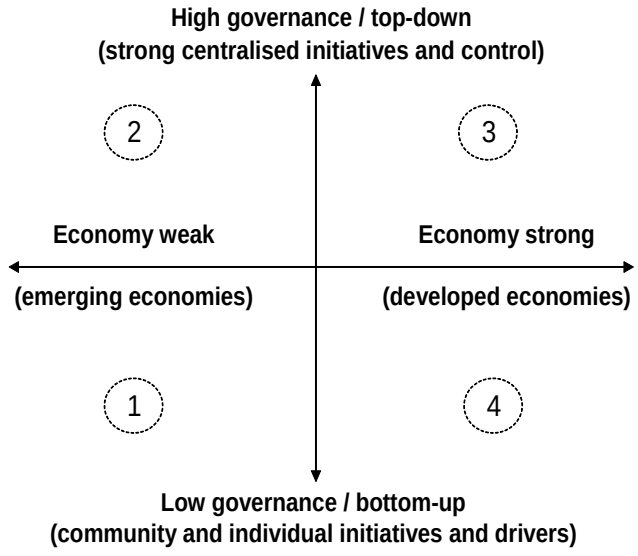
More specifically, participants were first asked to identify a set of values that they might consider relevant. These were encouraged to be broad yet, if possible, fundamental. Examples of choice made ranged from (equal) access to resources, the future of our children, freedom, quality of life, conflict prevention, stability and so on.

From this basis the Socratic discourse and other techniques were applied that opened up discussion to the broadest possible level. Many observations of situations, trends, constraints etc. emerged from this. Participants agreed on many points but some were more contentious.

The 'facts' from these discussions were then used as the building blocks for exercises in the future scenario method. The values that had been identified earlier, and revised, were used to drive the scenarios, which were to be of a positive future 10 years hence (after all, the goal here is to envisage possible solutions leading to the realisation of the identified values).

Four scenarios were created by choosing two drivers of change. The two chosen were **governance** and **economy**. Though these were considered the two most important or useful drivers by this particular group, there is nothing absolute about the choice of drivers or even the number of drivers considered.

Taking these two drivers as axes of a graph allowed the creation of four different situations representing the combination of extreme cases of both drivers, in which scenarios were to be built (it is then, of course, possible to envisage intermediate situations). The following graph depicts this, with the four scenario environments shown in the numbered circles.



Note that the creation of scenarios goes beyond identifying important trends and factors (be they political, cultural, technological, etc.) but also explores the way in which these factors can and might interact, positively or negatively (even

though positive aspects were actively sought, negative interactions inevitably came to light as part of the process).

It must be remembered, though, that these scenarios are not predictions but simply tools to take discussion from the exploratory stage and into at least the identification of potential solutions.

Participants
For exploratory exercises such as brainstorming, it is important to choose participants who are in a position to understand the various constraints within which to judge ideas, whether technological, economic, political or social. The four 'thought leaders' had backgrounds including:

- analysis of new technologies and their impact
- understanding (and addressing) corruption and conflict resulting from exploitation of natural resources and international trade systems
- energy resource analysis and prediction in the context of the International Energy Agency
- nuclear policy and law

Other participants brought along a mixture of technical and commercial knowledge.

The thought leaders were:

- Nathalie Horbach - Centre for Energy, Petroleum and Mineral Law and Policy, University of Dundee
- Simon Taylor - Director and Co-Founder, Global Witness
- Christof van Agt – Independent participant, formerly at the International Energy Agency
- Paul Holister – Technology impact consultant

The process was led by Humberto Schwab, Director, Club of Amsterdam, Innovation Philosopher

Content and Findings

Following the suggested structure of EFMN briefs, the observations resulting from the Energy Lab in terms of trends and forces will be split into socio-economic or cultural, and technological or sectoral.

The four scenarios created, which fed off the identified trends and forces, will then be outlined before looking at identified opportunities and challenges, which are in turn fed by the scenarios.

1. Identified socio-economic or cultural trends/trend breaks
The following is a list of socio-economic and cultural trends and forces identified and discussed to varying degrees at the lab.

- Rising energy production costs.
- Climate change and the drive to reduce greenhouse emissions.
- Increasing dependence on reliable energy supplies for the continued running of the developed world.
- Desire for less dependence for energy on nations or regions with questionable stability.
- Concern about impending (to debatable degrees) scarcity of fossil fuels combined with increasing demand from rapidly-advancing nations such as China and India.
- Increasing global tension relating to energy supplies (whether this trend was short- or long-term was contentious) and the possibility of resulting conflict (resource wars).
- Environmental concerns about nuclear energy.

Some trends can be considered as resulting from some of the above trends and forces, such as

- Increasing interest in alternative energy sources
- Increasing interest / efforts in energy conservation
- Development of carbon trading schemes

2. The set of technological and sectoral trends/trend breaks that are anticipated in the Foresight Programme

The following is a bullet-point list of technological and sectoral trends and forces identified and discussed to varying degrees at the lab.

- Capability (in some markets) for energy purchasers to also sell to the grid
- Choice (in some markets) over source of energy bought
- The nanotechnology 'revolution' impacting multiple energy-related technologies (particularly solar, fuel cells and batteries)
- Multiple parallel and rapid advances in solar generation technologies promising greater efficiency and/or lower cost
- Advances in fuel cell technologies across many application sectors
- Significant advances in storage technologies, primarily batteries and super/ultra-capacitors
- Promising developments in low-grade heat utilisation offering promise for efficiency and geothermal energy
- Smart materials hitting the market that allow energy savings, such as coatings for windows that are electrochromic, IR-blocking etc.
- Increasing competitiveness of coal-to-liquid products
- Advances in hydrogen production and storage
- Potential developments in artificial photosynthesis
- Potential for high-temperature lossless (superconducting) electrical transmission

3. The four scenarios

In the methodology section we showed how the four scenarios to be developed were to be framed in environments represented by the combinations of the extremes of levels of governance (central planning versus individual and social drivers) and economic strength (emerging versus developed countries).

It should not be forgotten that the two axes chosen for the scenario space, though arrived at through discussion, are a matter of choice, as is the choice to have only two axes (and thus four scenario spaces).

The scenarios are not meant to be solutions or predictions but simply exercises in what might be possible, and are deliberately designed to be optimistic views of a situation 10 years hence. The creation of the scenarios allowed disparate ideas to be brought together in a framework where interactions and socio-economic and political realities could be considered.

The purpose, then, is to open the mind to what could be, thus enabling those engaged, or those reading about the results, to see solutions where they might not have been seen before. Unfortunately, not all the scenarios were expanded into as full a picture, nor recorded in as much detail as others, but hopefully still serve the intended purpose. The differing style of the scenarios reflects the fact that they were generated by different groupings of participants.

3.1. Scenario 1 – 'Harvesting Energy' (emerging economy, minimal governance)

The environment for this scenario was imagined to be a poor, sub-Saharan country, perhaps Mali, with village communities dominating the demographics, poor access to resources, and minimal infrastructure. The village in this scenario was assumed to be remote but not overly far from a principal city.

The one resource that is plentiful is sunshine. With substantial reduction in costs of photovoltaics (a likely case for the future) and a little outside help (maybe charities, maybe microloans), village communities could begin to provide themselves with electricity. This would initially be used for lighting and would allow increased productivity in certain areas and more flexibility in trading of traditional staples such as vegetable and meat produce (through refrigeration, for example).

With a small resulting boost to the local economy and ever-decreasing costs of photovoltaics, it would become possible to expand generating capacity. This could be used to support production of many things, but direct energy sales would be particularly attractive in a future where fossil fuel was expensive and supplies were unreliable.

The village would thus become a supplier of power, from solar energy. Improved battery technologies and increasing fossil fuel prices would lead to an increase in electric or hybrid vehicles and even the use of batteries in households and other small village centres that could not yet take the leap to generation but could at least purchase batteries and pay to have them recharged.

At this point the village has effectively shifted from subsistence agriculture to 'farming' sunlight, with batteries as the means of distribution. The village no longer needs to fear famine in times of drought as food (and even water) can be bought in.

As a supplier of power for transport, more vehicles would pass by. Normally this would lead to improvements in transport–related infrastructure, such as road and rail. This would likely involve investment by government, a case where some top-down, centralised influence, though not essential, could accelerate change, even if the government is simply acting in a self-interested and reactive fashion. (Note that another government-led accelerator would be support for a microloan system.)

Along with transport infrastructure it would be possible to lay cables for electrical transmission, thus allowing supply of electricity directly to the nearby city, where demand is great over too small an area for effective local generation. Besides, the village already has the generating capacity, the expertise to manage it, and plentiful low-value land to expand into. It makes sense for the city to buy from the village's solar farms. The village thrives as a result.

Communication infrastructure improves, partly planned along with the infrastructure developments and partly improvised where needed. A village once without electricity would now have it in abundance and be able to buy computers, first for communal use, then for individuals, and the community would have access to the internet. Educational opportunities would be increased dramatically. In this scenario it was envisioned that the village, being a small highly-co-dependent entity by virtue of its earlier challenging existence, would recognise the value of education and treat it as a priority for the group. Over time the community would become generally well-educated and thus capable of even more diverse and complex commercial activities.

Ultimately, though probably not in the 10-year time frame, the solar energy could be captured in a fuel created by artificial photosynthesis, allowing more efficient export of the energy over greater distances and opening up the solar farming model to communities more remote from the cities that represented the main markets. Water would need to be imported for the synthesis, which might limit how much the approach would displace the use of batteries, but importing water is certainly preferable to importing oil.

In discussions of this model it was noted that it is more likely to work in a resource-poor country. There are a lot of cases of countries that are undeveloped but possess natural resources where the government is simply asset-stripping.

3.2. Scenario 2 – 'Central Energy Planning' (emerging economy, strong central governance)

This scenario was for a top-down organised society with an emerging economy. China was taken as a good example to use in the scenario, for which the motto was: "Things have to be

done in a planned and organised fashion, otherwise they won't happen."

Despite the booming economy, much of the traditional communist philosophy still permeated the government. Equal sharing of resources is considered an important cornerstone of society and the government can regulate distribution in order to realise this.

Additionally, a government can plan for the long term, benefitting not just present but also future generations.

Short-term thinking and individual advantage, though more present of late with the growth of new businesses, must be put aside for benefit of the collective, especially for something as fundamental as the energy to power the nation.

The need for more energy at the start of the scenario is urgent, if the rapid pace of growth is to be maintained. The obvious first solution was coal, which the country had in abundance. Coal-fired power stations proliferated and commercial entities were allowed to dominate this to start with, which had the effect of speeding up the expansion but with little attention paid to environmental concerns. This, however, was the quick fix part of the plan. China was already becoming more sensitive to its image in the world and the major cities were already choked with fumes, which, even though these were largely from vehicles rather than power stations, made the air quality issue clearly a part of the problem.

Additional factors dominant in the formulation of the plan were the need to import oil for fuel for vehicles, the need to transport energy over great distances and the fact that coal, though plentiful, was not without limits.

Coal-to-liquid schemes using state-of-the-art nanocatalysis were used to produce clean diesel to help ease the dependence on oil imports.

A massive research effort was embarked upon to develop lower-loss electrical transmission technologies based on high-temperature superconductors. These would be doubly important because of the need to find an alternative to coal, with solar photovoltaic being the choice.

The plan was to develop massive solar 'plains', the like of which the world had never seen, in the country's remote, arid and impoverished west, thus also having the advantage of bringing employment and commerce to the region and addressing some of the unwelcome imbalance that the rapid development near the coast had brought about.

The electricity so produced, supplemented by wind farms, was sent to the energy-hungry coastal areas along the increasingly efficient power lines.

The expertise in solar energy led to plastic sheets that could simply be rolled out and connected at the edges and which had nano-engineered structures that took the highly efficient initial step of photosynthesis but fed the liberated electrons into the superconducting transmission lines.

As had happened earlier with the centralised push towards certain areas of research perceived as critical, China soon became a world leader in these technologies and exported photovoltaics and transmission technologies to the rest of the world.

In the cities of the East, as the supply of electricity from the west increased, electric and hybrid cars were encouraged (and manufactured). The coal that previously generated electricity was used increasingly to produce diesel and the dependence on foreign oil rapidly dropped to zero.

3.3. Scenario 3 – 'Energy Caps and Taxes' (strong economy, strong central governance)

This scenario is based on an environment with strong government and central planning in an affluent economy. Sweden, which aims to become oil-free by 2021, might be an example of the sort of country that could apply such an approach.

The principal mode of action is to introduce a progressively increasing carbon tax at individual and corporate levels. A flexible power supply network in place of a monolithic centrally-controlled grid allows individuals to avoid carbon tax by purchasing energy from sustainable sources, which in turn encourages the creation of these sustainable sources, even down to the level of generation by individual households, where surplus energy is sold back to the grid.

Also stimulated is the use, by industries such as logging or paper-making, of waste to produce energy, whether for their own use or for biofuel for sale.

Return on investment for using energy-saving technologies in housing and transport would be encouraged, and more so if the tax was sophisticated enough to impose a cost on manufacturers for the lifetime emissions of their products. This would, for example, encourage building companies to incorporate energy-saving technologies that they would otherwise not be attracted to because though they bear the cost, the completed building (assuming they do not maintain ownership) recoups that cost gradually for benefit of the owner, not the builder.

Thus careful design of the taxation would achieve maximum results (another example would be tax breaks on biofuel that came from waste, with less or none for biofuel from primary biomass).

Although substantial change could be brought about by the tax alone, substantially more could be achieved by government support for, or creation of, large-scale developments such as

geothermal energy generation, hydroelectric and combined heat and power schemes.

3.4. Scenario 4 – 'Communicating Energy' (strong economy, minimal governance)

This scenario could be seen as representing the answer to the question, "What can we, as individuals in developed nations, do to help resolve energy-related issues?" To be effective, there needs to be a general will in the population and effective communication to facilitate understanding and community-wide action. In the age of the internet the latter is certainly possible on a nationwide scale, and even a global scale.

Analogies for the sort of actions that might be seen are the growth in popularity of 'organic' produce or that of 'fair trade' products, both of which evolved out of grass roots concern.

In fact the food analogy points to areas where immediate action is possible, such as buying local produce rather than that shipped great distances. This is already happening in many European countries (often in combination with organic approaches, with produce sold at local markets).

The food analogy also illustrates the sort of limits that individual action might face – some studies have suggested that one of the ways an individual in the developed world can most drastically reduce their carbon emissions is to give up meat. It is hard to imagine more than a few people going far in this direction.

Another prominent recent phenomenon that is representative of this scenario is carbon offsetting, by individuals or companies, particularly when taking a flight.

There are numerous examples of such actions that can be taken on an individual or community level, from switching the lights off behind you (considered to be 'normal' behaviour in some societies but not others) to car pooling, or capturing rainwater to water your garden, through to more radical (some would say bizarre) cases such as moving into a yurt community and running your van on locally-grown sunflower oil.

The key to all this is communication, to create a culture of willingness and a sense of responsibility, combined with the knowledge of what action can be taken.

To some extent this scenario is happening now. How it might be different 10 years from now is probably largely a matter of degree but undoubtedly there is a limit to how much can be achieved without some top-down initiatives (or economic imperatives) added to the mix.

Opportunities and challenges that might arise from the trends/trend breaks

The challenges faced by the developed world in the light of rising energy costs, dependence on imports, impending (at some point) shortages of fossil fuels, vulnerability to interruptions in energy supply and the problems of global warming are all well known.

The apparent feasibility of all the scenarios points more to opportunities than challenges, but the fact that all but one of the scenarios could conceivably address all the main energy issues suggests a challenge: Scenario 4, 'Communicating Energy', seems to indicate that, at least in the developed world, 'people power' is not enough to address the issues. Economic and practical pressures would achieve the necessary changes eventually but it is probably not advisable to wait for the hurricane to prove that you should not have made your house of straw.

Thus top-down governmental action may well be necessary for the developed world. This begs the question of whether it is there or forthcoming. If the answer isn't a resolute 'yes' then this certainly represents a challenge to be taken seriously.

As for opportunities, much in the scenarios speaks for itself, but the case of Scenario 1, 'Harvesting Energy', is striking in that it paints a picture of a dramatic improvement in the quality of life of some of the most disadvantaged people on the planet given only certain technological advances that are by no means unlikely and a small amount of capital. It was in fact a surprise during the development of the scenario to see it unfold so smoothly.

The scenarios were, of course, deliberately chosen to paint a positive picture and there is much of a political and economic nature that could make things turn out quite differently. But the consensus at the Lab was that <u>all</u> the scenarios were perfectly credible, which means they probably do represent real opportunities.

Conclusion and Policy Implications/Impact

Though much focus up to this point has been put on the scenarios developed at the lab, the information provided under the standard headings below is drawn from the full two days of intensive discussion and debate.

Any misrepresentations of the opinions of the group are the responsibility of the author of this brief.

1. Key issues raised with particular relevance for policy-making

Oil dependence is a danger that needs addressing regardless of views about 'peak oil'

Despite much disagreement in the group about 'peak oil' and how close this point might be, all present seemed to agree that

action should be taken now to reduce the developed world's dependence on oil.

Solutions to the problems being faced will be diverse
Different environments are likely to beg different solutions and the diversity of technological developments that bear on the issues prevent simple answers and argue for multiple possibilities to be investigated. I.e. there, as yet, is no silver bullet.

In the developed world government action is probably essential
The risks are sufficiently high and the time needed to change the way energy is produced and used sufficiently long that this is not a situation where appropriate change can be expected to arise from market and social forces. Pro-active action from government is almost certainly necessary to avoid the risk of severe economic disruption.

In the under-developed world, small changes or actions may have a large and lasting positive effect
As one of the scenarios demonstrated, when tackling the issue of poverty on a global scale, there may be a possibility of achieving much with little, given certain technological shifts.

2. The solutions and/or adaptations that will be required to tackle challenges and benefit from opportunities
The variation across the four scenarios that were developed suggests that multiple lines of attack will be needed in parallel, covering energy conservation, alternative forms of generation, and storage and transmission technologies. The best solution or combination of solutions for a given region will vary with external factors (climate, population density, access to water, etc.) and with developments in numerous interacting technologies.

Given this diversity and uncertainty there would seem to be two key general recommendations to make:

- Analyse the energy situation in a systematic and inclusive manner, and continually reanalyse.
- Invest in energy-related R&D broadly.

It seems likely that solutions will themselves be more complex than the current rather monolithic systems; thus flexibility within and between systems of generation and consumption are likely to be useful.

It is worth noting from the generation viewpoint that only two sources of energy that are currently achievable can be considered sufficient for global needs in the long term and truly sustainable. These are solar and geothermal.

Areas of technological focus to be considered are diverse and include (some of these have already been mentioned):

- Solar (photovoltaic, chemical and thermal, using a variety of technologies)
- Fuel cells (various aspects)
- Batteries, super/ultra-capacitors
- Transmission technologies
- Fuel synthesis (e.g. artificial photosynthesis)
- Technologies for carbon sequestration (e.g. nanoporous membranes)
- Coal-to-liquid, gas-to-liquid, waste / biomass-to-liquid etc.
- Nuclear fission
- Geothermal
- Thermoelectrics for low-grade heat conversion
- 'Smart' materials for windows etc.
- Lighter / stronger metals, ceramics and composites
- Efficient lighting

3. Identified priorities and focus for action
The Energy Lab was more about identifying possibilities than identifying priorities but the scenarios did illustrate that appropriate focus can vary dramatically depending on the existing situation.

For example, Scenario 2 clearly makes the case for a focus on coal in the short term for China, if the aim is energy independence, given the substantial coal reserves there.

In some cases ramping up nuclear generating capacity might be considered as a short-term measure, if it could be done sufficiently quickly (a much-debated point).

For countries in lower latitudes, solar (in various forms, including biomass) will be more quickly economic than in higher latitudes, where geothermal may be a more appropriate area on which to focus.

However, in all cases where energy supply is a potential issue, conservation makes sense as a priority. This is also the area that gives the most rapid return on investment. Scenarios 3 and 4 illustrated two ways this might be achieved in developed countries.

4. Identified critical factors and key players in shaping the future
As mentioned before, Scenario 4 suggests a need for centralised, government-led action in developed countries, yet highlights that much can be done through increased public awareness and communal action.

Much of the rest is down to technological developments and their impacts on the economic competitiveness of certain technologies. Though solar emerged from the Lab as the winner in terms of chief long-term global energy sources, the means of capturing it, transporting it and using it produced no clear favourites. The range of possibilities from domestic to industrial to automotive applications in a diverse range of environments only suggests as a critical factor that all options should be kept open and all avenues of research explored.