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Global Agenda

White Paper on Energy 2050: What Does It Take for Reality to Meet Aspirations?

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Preface

The relationship between human needs and energy sources has often progressed incrementally. Growth in population and in affluence has led to a demand for increased energy use, and energy sources have been developed to meet that demand. But there have been times when humanity has found major new ways to harness nature. These discoveries include fire, taming horses, using dams to create waterpower, steam engines, and in more modern times the discovery of oil and how it could be used. At those pivotal times, humanity greatly increased our ability to shape and change our environment, explore new worlds and support an ever-increasing population. The magnitude of those changes has also led to: social and environmental challenges, including deforestation, the health effects of mining and other resource extraction; wars, as each discovery has multiplied our destructive power; and today's deep concerns about climate change and other resource challenges, including those relating to water and food.

Today the evidence points to a need for another transformative time. Society expects a great deal from the existing energy architecture, and in particular from the way it must develop over the next 40 years. The energy architecture must respond to a growth in population from 6.8 billion to 9 billion people, and an increase in affluence in the most populated countries so they can enjoy those fruits of modern life that the Organisation for Economic Co-operation and Development (OECD) countries have enjoyed for so long. It must also deliver affordable energy to the 1.4 billion people who do not have access to electricity and to the 3 billion who use solid fuels – wood, charcoal, coal and dung for cooking and heating.

People want a future that includes an ever-improving standard and quality of living, especially in the developing world, and they want energy to support progress as it has done in the past; but the world is not on a path to get there. Today in a country like Japan, as in most OECD countries, the average person lives a lifestyle that requires the equivalent of 4.3 hectares of resources. But the actual resources available to Japan are on average equal to 2.2 hectares per person. For billions of people around the world, there is a great unfulfilled need to achieve standards of living that will come closer to those of OECD countries. But OECD countries have achieved their living standards based on resource extraction, a way of life that would be unsustainable if everyone in the world now were to act in the same way. Therefore, either non-OECD countries will need to accept lower living standards, or the world must accept resource scarcity, which in turn threatens the living standards of all. Or materially different ways of supplying and using energy must be found.

Solutions can be identified relating to all of the major uses of energy, although they will be difficult to implement. In the built environment, the most critical question is how improvements can be implemented in megacities in the developing world, where infrastructure and governance are generally underdeveloped compared with, for example, the 1950s in the United States. In creating a "smart city", innovations in governance and urban planning are at least as important as technological advances.

In the transition to a **new energy architecture**, changes will be slow and a single solution will be very unlikely; markets will help to deliver massive growth around the world in many forms of energy and its transportation for example through the promotion of a certain type of fuel. However, markets will not be sufficient because current growth rates will exacerbate resource scarcity, which in turn will mean that the growth rates demanded by non-OECD countries will be compromised. If growth continues as projected, carbon emissions will increase unabated.

Energy reform, which would encourage the creation of a **new energy architecture** that improves living standards for everyone, would happen more quickly if large numbers of people want it to happen. However, today very few people get involved in the energy decision-making process, with a major exception being the proposal of a specific project.

The year 2050 may seem distant, but because of long lead times, the focus must be on what can be done within the next five years. This white paper on energy 2050 raises 10 questions that need to be addressed in the development of a **new energy architecture**.

10 Questions to Answer

1. Can the historical connection be broken that sees economic growth lead to energy growth, which leads to greater environmental effects?

2. Can affordable solutions be found and implemented, including the provision of greater access, for the developing world, which is where most of the energy growth will be?

3. Can realistic scenarios for 2050 that achieve society's goals be found, so today's actions will move the world in the right direction at the right speed? Good work has been done to create many scenarios for a **new energy architecture** by 2050, but the most realistic scenarios do not lead to where the world needs to go, and the scenarios that lead to where the world needs to go are not the most realistic.

4. Can lifestyle choices be made that focus on the enjoyment of energy rather than on its consumption?

5. How can the built environment become significantly more energy efficient at a reasonable cost?

6. How can the movement of people and goods be reduced while maintaining population growth and expanding economic activity?

7. Which materials will use extremely low energy or result from much greater recycling, helping to meet the increasing need for materials for infrastructure and products?

8. How can a movement be built towards the use of energy sources that supports society's aspirations and captures the public imagination given that energy is a vital need but people do not see the link between the energy they use and where it comes from?

9. What governance changes need to happen and at what level (for example, local, city, state, regional, worldwide) in order for inertia and natural forces to work towards a **new energy architecture** that supports rather than threatens everyone's dreams?

10. What innovations in technology, human endeavour, organization and personal activity will enable change?

These 10 questions recur throughout the report, which is structured around three main topics:
– Breaking the link between economic growth and energy use
– Reducing energy consumption
– Making changes leading to a **new energy architecture**.

Reflecting on the issues and potential solutions in the path to the transition to a **new energy architecture**, this paper considers the contributions received from experts from various industries and sectors, including mobility, energy security, urban design, engineering and biotechnology, who shared their ideas on life in 2050 and what role energy will play. Special emphasis has been placed on the opinions of young leaders since they will lead the efforts to shape the global agenda during the next 40 years. Some of their answers and ideas are included throughout this paper.

Bob G. Elton
Lead author, Vice-Chair of the Global Agenda Council on New Energy Architecture (2012)

The Challenge: Breaking the Link between Economic Growth and Energy Use

Historically, growth in population, capital and productivity generates GDP growth, which in turn promotes greater energy consumption, which then drives environmental effects. At least one link in this chain must be broken or humanity faces very large increases in emission levels and other detrimental environmental effects.

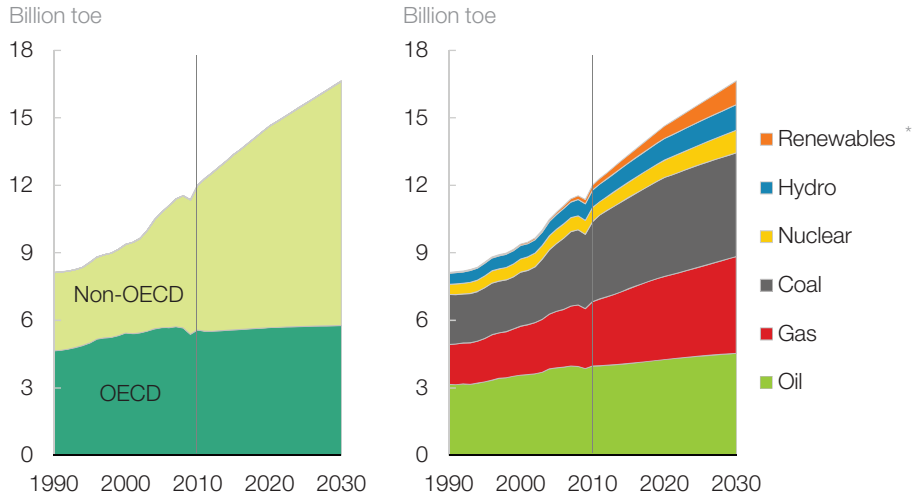
Energy is not something that we seek to consume for its own sake we want to enjoy its effects of heating, lighting, power, safety, etc. If we can achieve that enjoyment without consuming as much energy, it should be possible to lead a more sustainable life. One way to reduce energy consumption is by increasing efficiency in energy generation and transportation processes. The US Department of Energy calculates that in the US, only around 46% of the energy generated actually reaches consumers – and that figure is much smaller when we consider how much energy is used but not enjoyed.[1]

Challenges in OECD and non-OECD Countries

Great leaps forward in living standards have been made in OECD countries, clearly due to the discovery and exploitation of vast energy resources. These energy reserves have enabled economic progress, finding new ways to make things, travel, live, etc. Improved standards of living have spurred population growth. At the same time, it has meant that people are consuming a larger share of the earth's resources and depleting many of them. OECD countries have a large margin for error in the way they plan a **new energy architecture** moving forward.

Excluding immigration, population growth in OECD countries has largely levelled off. These countries possess the wealth that allows them to make choices that some parts of the world cannot afford. They have access to technologies that can reduce their energy consumption and thus make energy, transportation and other systems more efficient. Their infrastructure – both the physical infrastructure in cities, and other infrastructure, such as their governance and regulatory structures - allow them at any time to identify challenges and opportunities and adjust to them. This is not to say that they will indeed make the best choices, but at least they have the ability to do so.

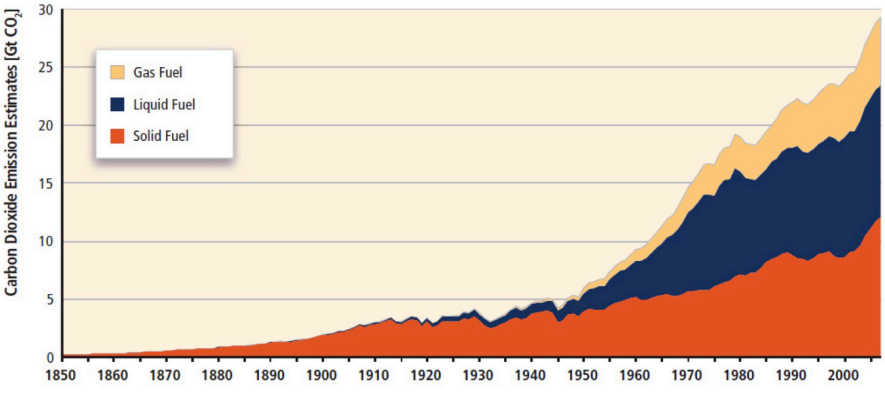
Figure 1: Energy consumption by fuel and type
Source: Energy Policy by Christof Rühl, Paul Appleby, Julian Fennema, Alexander Naumov, Mark Schaffer (2012)



In the developing world, the challenges are very different. These countries will experience most of the world's expected population growth and most of the world's per capita GDP growth from 2012 to 2050. And many non-OECD countries do not yet have the wealth, technology or infrastructure to make the fine-tuned changes that developed countries can make. Additionally, the issue of energy access lies firmly in the non-OECD world.

Furthermore, if we look back in history, the expansion of the US economy in the 1950s was highly correlated with greater and more intensive energy consumption. GDP per person was much higher in real terms than it is in non-OECD countries today. This means that the speed of their development given their starting point will pose a significant number of challenges. If non-OECD countries have to pay more for their energy than OECD countries have been

Figure 2: Global CO2 emissions from fossil fuels, 1850-2007
Source: IPCC, Renewable Energy Sources and Climate Change Mitigation
Fennema, Alexander Naumov, Mark Schaffer (2012)



1 Lawrence Livermore National Laboratory: Estimated US energy use 2009.

paying, then their economic growth will be curtailed, and it will be much harder for them to achieve a higher quality of life. No-one can ignore the need of fast-growing, less affluent countries to have enough energy at a reasonable price in order to meet their targets for poverty reduction.

Energy Access Issues

As many as 1.4 billion people on the planet do not have access to electricity, and 3 billion use solid fuels for cooking and heating. This issue is especially prevalent in sub-Saharan Africa, India and some other regions in South Asia. It is hard to envision that in 2050 such a large proportion of the population will still be excluded from the energy system. It is better to imagine what the world could be if energy access was a basic human right, and what improvements in health, environment, education and economic management universal access to electricity would bring.

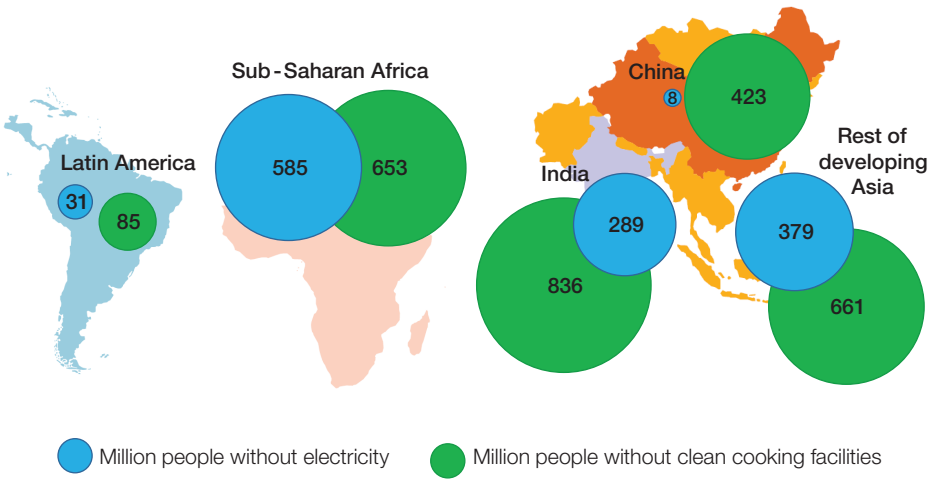
There is no dispute about the numbers of people without access to electricity, or of those who still use traditional biomass for cooking and heating. There is also no dispute about the consequences that the lack of access to energy sources brings to those people and countries most affected, consequences that include: an estimated 1.6 million deaths a year, mainly among women and children, from emphysema and other respiratory diseases;[2] lower educational levels; a disproportionate effect on women and girls that therefore compounds the development problem; a lower ability to start and run businesses; and increased environmental damage.

There are many organizations, large and small, working on this problem. The amount of money spent on fuel by the people at the bottom of the pyramid is significant, a situation that could create market opportunities to reduce the numbers of people without energy access more quickly than otherwise. A good example of forays into this area is the Lighting Africa project. The project is on the right track to achieve its initial goal of providing energy access to1.5 million people, but it acknowledges that its long-term goal of connecting 250 million people to electricity grids by 2030 will require significant scaling up.[3] The conversation about energy access often takes place in the context of development aid and corporate social responsibility. It is equally valid to say that the energy system, while it achievements much, still fails to deliver electricity to 22% of the global population and still sees 45% of individuals using traditional biomass for cooking.

Such a system is not successful in meeting the needs of the world today. One way of addressing the issue of energy access may be by integrating it into the larger framework of a **new energy architecture**, rather than treating it as a separate issue to be dealt with by a different set of guidelines and actors.

> **“I would like to see an India where there are no power supply interruptions, where transportation costs are within the means of all Indians, where there is less air pollution and where energy access (especially for home use such as lighting and cooking) is no longer a privilege …. Industrialization, which implies dramatically increased energy uptake, is an imperative to ensure there are enough jobs for burgeoning populations such that social stability is maintained.”**
>
> Rajeev Mantri, Founder and Executive Director, Navam Capital, India; Global Shaper, World Economic Forum

Figure 3: Number of individuals without access to electricity (in millions)
Source: IEA, World Energy Outlook, «Energy for All: Financing Access for the Poor», Oct. 2011



2 World Bank, *Energy The Facts.*
3 *Lighting Africa Progress Report, 1 July 2010-30 June 2011*, 2012.

Energy 101 – Supply and Demand

Different energy sources are used across industries and sectors and there are many sources of energy supply. Nevertheless, it takes a long time to change energy architecture because of the lead times involved in making investments, and so up to 2030 many futures are already determined.

> **History demonstrates that energy transition generally takes a long time. It took almost a century before oil overtook coal as the number one energy source…It is really after 2030 that the energy system could start to look different as the cumulative effect of innovation and technological advances makes its full presence felt.**[4]

Dan Yergin, Chairman, IHS Cera, USA

The apparently unexpected appearance of shale gas has certainly allowed for significant changes in the energy matrix for the US, for example, but it was not an overnight success. Usually energy discoveries add to the mix of the energy architecture but do not suddenly replace existing sources. It is not likely that we will be able to find one unique solution to address energy-related issues in the future.

Historical tendencies reveal that the use of certain fuel sources declines when they are overtaken by newer and cheaper alternatives. Regulations have played an important role, though more in developed countries than in developing ones: often a richer country might limit the use of a particular fuel source while a poorer country cannot afford to do so.

Existing Vision 2050 Scenarios

Great work has been done to create many scenarios for a **new energy architecture** for the year 2050, but the most realistic scenarios do not get the world to a good place, and the scenarios that get the world to a good place are not very realistic. There must be a connection between our actions in the short term and the vision of how people want to live in 2050. Many scenarios have been developed that describe the range of possible futures. Broadly speaking they can be divided into three categories:

Firstly, there are scenarios, for example the Shell Energy Scenarios to 2050, that look at a range of possible futures extrapolating from today. They generally show:
- High growth rates in population, GDP per capita and energy demand in non-OECD countries, and
- Increased energy supply to match the demand side, which shows continued reliance on fossil fuel-based sources, with increasing percentages of renewable fuels.

These scenarios often refer to an "all of the above" approach, meaning that all currently available energy sources will be needed to develop and expand to meet demand. These scenarios can also be characterized as reasonably consistent with each other – they may make a range of assumptions about future growth, but even at the lower end of the range a very large increase in demand would be expected. Many scenarios predict that energy demand will double by 2050. Organizations such as the International Energy Agency (IEA) and IHS CERA also generate scenarios over different time horizons.

Secondly, there are scenarios that show what the future would look like based on the assumption of a particular fuel mix as an end point. This could include no or low reliance on fossil fuels, a large or very small contribution from nuclear power, etc. These scenarios can be seen as a rallying cry to action because the authors generally agree that the world is not on the path they recommend. For example, the *WWF Energy Report: 100% Renewable Energy by 2050* states that switching to 100% renewable energy is the only option, while projecting that by 2050, energy demand can be 15% lower than it was in 2005. It also lays out a series of investments that would be needed, and points out that these investments will begin to pay off in around 2040.

Thirdly, there are less concrete visions and scenarios that highlight a range of possible solutions and express optimism in the ability of mankind to find technological and other improvements that will give us solutions. This optimism is based on the past ability of mankind to do just that. The scenarios are very helpful, and they can help realize the potential gaps among:
- How people hope we will live in 2050;
- The situation today; and
- The range of actions being considered today, and their likely results.

Most of these scenarios assume broadly speaking that the historic relationship among population growth, GDP per capita growth and energy demand will continue. Therefore, they do not assume that demand-side solutions can break that relationship.

Our Limitations in Finding Solutions – Cognitive Constraints and Behavioural Biases

The challenge is bigger than it should be because of the way people look at solving problems. Sean Cleary, in a text he adapted from "Cognitive Constraints and Behavioural Biases", in *Learning from Disaster*,[5] explains the difficulties in grappling with the complexity of the natural systems in which people are embedded. The mismatch between the complexity of the natural systems in which we are embedded and our limited capacity to understand their workings makes it difficult to devise optimal energy policies. The text recommends that we:
- Clarify the issues the best we can and ensure that we do not contribute to confusion and irrational fears
- Communicate openly and honestly, sharing what we know while admitting what we don't, seeking to advance understanding
- Focus the conversation on what must be done in terms of policy, pricing and changed behaviour.

The problem is not small, as Cleary points out, because there is a need to "encourage humanity to distinguish human satisfaction from excessive production, accumulation, consumption and waste." Individually and in families people are capable of doing this. Collectively, groups of people have not been.

4 Yergin, Daniel, The Quest: Energy Security and the Remaking of the Modern World, Penguin Books, 2011, p. 715.
5 Useem, Michael and Howard Kunreuther, eds, "Cognitive Constraints and Behavioural Biases", Learning from Disaster, Pearson, 2008.

A Possible Solution: Reducing Energy Consumption

Making Lifestyle Choices that Focus on the Enjoyment of Energy

First, are people capable of choosing lifestyles based on criteria other than that of consumption? That is challenging. For example, how much actual value is there in the ability to consume asparagus and avocados throughout the year in Frankfurt and New York, or wines from France, Germany, Italy and New Zealand, as well those from Chile and the US, in a restaurant in Shanghai, Singapore or San Francisco? Do there need to be full service plates on the platforms at hotel buffets even if this results in discarding more than half of the food? Although many would agree that the size of meals could be reduced, it is a very difficult task to develop this idea into concrete actions.

Individuals act in a way that suggest they aspire to lifestyles which may be attainable only to the extent they are limited in number. For everyone to achieve these lifestyles, the consequences in terms of resource depletion would be unsustainable. The forces that drive policy-makers and the public to want growth and prosperity are likely to be unstoppable; it is the way in which we allow ourselves to define that prosperity that can change. GDP and similar measurements are understandably crude ways to describe increased economic activity. These measures include nothing qualitative, they measure negative as well as positive activity, and they do not try to connect with our desires.

> **I believe that credit will be reduced in the future. Spending without being responsible for it will be reduced.**

Khalid Koser, Deputy Director, Geneva Centre for Security Policy, Switzerland; Member, Global Agenda Council on Migration

The better people can explain to themselves, to each other and to policy-makers what they want to enjoy, the more possible it is to disconnect the natural need to improve lives from the assumption that increasing GDP per person will do that. Most measures of happiness and well-being tail off when wealth increases. A 2009 study on alternatives to GDP led by then French President Sarkozy, led by economists Sen, Stiglitz and Fitoussi, was one of a number of developments to the concept of looking for alternatives. (The economics of well-being. Justin Fox, HBR Jan-Feb 212). Today these ideas seem both appealing and very hard to implement. Even without adopting new measures, it is legitimate to ask in what ways incremental GDP growth will influence standards of living and what role energy will play.

Increases in energy and other costs may force a change in the way people live...

China today is, like the United States in the 1950s, enjoying sustained economic growth with an increased standard of living for many citizens as a result. But the consequences of a sustained boom in the US post-war economy, with an increasing but much smaller population and a higher level of infrastructure to begin with, are arguably very different from those of similar growth in China today. Will China and its citizens aspire to the American dream, or will there be a Chinese alternative rooted not only in the realities of managing the risk of resource scarcity, but also rooted in Chinese tradition?

JUCCCE Chairperson Peggy Liu is working with a coalition of government, corporate, sustainability experts and storytellers to visualize and activate a compelling alternative - the China dream.

"The initiative is unique in that the approach uses a combination of soft power (Western style storytelling) and hard power (municipal policies) to instil sustainable behaviour by changing people's habits through reimagining prosperity in a new national identity. To create sustainable behaviour, ironically JUCCCE is eradicating the language of sustainability. Instead, the China dream emphasizes traditional Chinese values of 'harmony' as defined by 'balance', 'flow' and 'respect', which takes people 20% of the way to sustainable behaviour already. The question is how to overlay local traditional values on top of modern realities. And how to leverage people's pride in crafting this new national identity, as well as make this new vision of prosperity personal and local."

Today this issue is often framed as a choice between enjoyment and environment. It is perhaps more of a choice about the way in which fast growing countries will choose to develop, and how they will frame their aspirations. In the OECD countries, people consume and pay for far more goods and services - and energy - than they actually use; they use far more than they enjoy. That OECD model will not be sustainable in the world as a whole, as far as 2050.

> **Quality of life does not necessarily have to be associated with the abundance of material. It really depends on what you think a good lifestyle is. For example, sharing or renting, using the same thing for a long time, or being able to enjoy nature are wonderful aspects of life.**

Reina Otsuka, CEO, Ecotwaza Co., Japan; Global Shaper, World Economic Forum

> **Innovations in technology will make cars completely clean. There will be interaction between urban and private mobility. There will be many people that will not be willing to pay a lot for mobility.**

Reiner Feurer, Senior Vice-President, Corporate Strategy and Planning, Environment, BMW Bayerische Motoren Werke, Germany; Member, Global Agenda Council on Personal Transportation Systems

The 2011 Fukushima nuclear disaster marked itself as a historic point of departure in transforming 'already-energy-efficient' Japan into a 'super-energy-efficient' society. A tide of technological innovations combined with the effect of policy incentives has given a bigger share to renewable energy in the energy mix. More importantly, the people have awoken with the need for new lifestyle and quality of life. In this context, an increasing number of people have chosen to live in the once-depopulated countryside with modest arable land, which allows them to be quasi-self-sufficient in basic food and locally available energy such as solar, wind and small hydro. They consider the quality of life not necessarily in terms of GDP influenced by an old Asian value of life.

By this time, the total population has decreased to below 90 million, enabling them to support the total economic and social activities without nuclear power, which had phased out by the mid-2040s.

Vision for Japan in 2050
Tatsuo Masuda, Professor, Nagoya University of Commerce and Business Graduate School, Japan; Member, Global Agenda Council on New Energy Architecture

Making the Built Environment Significantly More Energy Efficient

The largest increases in population will come in cities in the developing world. It is in these cities that the greatest challenges will be had in achieving the future that we want. Energy constraints are a large subset. How can a megacity in sub-Saharan Africa, the Philippines or Pakistan develop an energy architecture that supports the aspirations of its people?

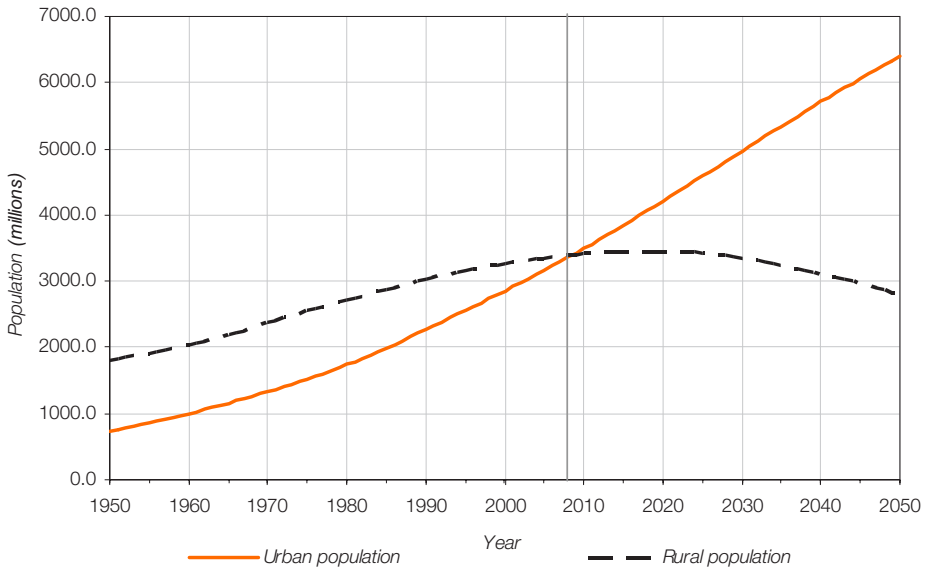
The task was hard, but manageable, for the US when it urbanized after the Second World War. For countries that are one-quarter as wealthy as the US was then, and where central planning is difficult to achieve for many reasons, what can they realistically expect to achieve and at what cost? The more well-off fast-growing countries like China may have choices that others do not.

One test for scalable proposed solutions to improve the energy efficiency of cities might be the example of Lagos. *Urban sustainability in the context of Lagos mega-city,* a 2010 research paper by Adetokunbo Oluwole Ilesanmi raises some interesting questions. He and his sources point out how different Lagos' growth has been, with rapid urbanization taking place in cities with the lowest levels of economic development, which is the opposite of the way in which Europe developed. Megacities in the non-OECD world have significant health issues, including air quality; they combine great economic opportunities with severe unemployment; and these cities

I believe that time in 2050 will become one of our biggest priorities. We will have 'technology time' and 'no technology time'. For example, when you are talking to people going on a vacation nowadays, they say, 'I am on a vacation. I am totally unplugging and not bringing my phone or computer.' In the future, people will continue seeking for places where there is no Internet or phone access as a way to force themselves to 'unplug'.

Wong Ling, Programme Officer, Bill & Melinda Gates Foundation, USA; Global Shaper, World Economic Forum

Figure 4: Global rural and urban populations 1950-2050
Source: United Nations, Department of Economic and Social Affairs, Population Division (2006). World Urbanization Prospects: The 2005 Revision. Working Paper No. ESA/P/WP/200



offer the possibilities of hope and despair at the same time. Ilesanmi concludes that there are many infrastructural priorities, and this reality should guard against naïve assumptions about how energy efficiency might be achieved, in particular relying on technological improvements as the main or only approach.

Urban planning in non-OECD megacities may be based on principles similar to those that are in vogue in the OECD, but the challenges are very different, and the barriers to implementation higher. Nevertheless, it is arguably here that many of the most important solutions may be found.

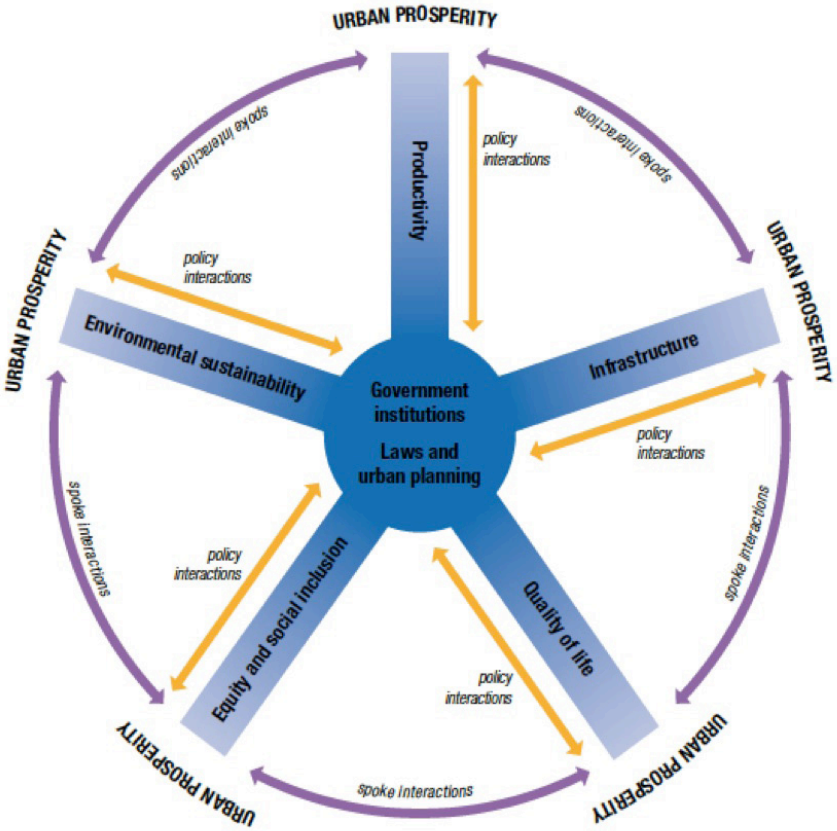
Sean Cleary also writes about the increasing effects of climate change and the disproportionate impact they are having on cities in countries that are less able to deal with them. More than half the world's people now live in urban centres, and that number will rise to over two-thirds before 2050.

Sharply rising urban populations associated with higher vehicle use, greater energy generation, and the concentration of industries in and around cities and towns are key sources of greenhouse gas emissions. Although today's cities occupy only about 2% of the Earth's landmass, disproportionately in coastal areas, they consume 75% of the world's energy, and account for at least 75% of global pollution. Urbanization drives up energy consumption: a 1% increment in urban population is reported to increase energy consumption by 2.2 per cent.[6] Cities also tend to be 1 C to 6 C warmer than surrounding landscapes, depending on their size.[7]

The United Nations Human Settlements Programme (UN-HABITAT) estimates that by 2050, as many as 200 million people could be displaced by climate change "…unleashed by development and manipulation of the environment".[8] The high concentration of cities on coastlines and near floodplains accounts for this.

Rapid urban growth and efforts to curb city sprawl are also leading to further densification. This reduces motor fuel usage per capita and limits new highway development to serve commuters, but confronts city planners, managers and residents with new challenges – enabling maintenance of infrastructure, refuse removal and delivery of supplies to businesses in congested neighbourhoods, and retaining, or improving, the quality of life in more populous boroughs. Making

Figure 5: The wheel of urban prosperity
Source: UN Habitat, State of the World's Cities, 2012-2013



cities efficient and habitable in the face of rising urbanization requires innovative urban design, coordinated planning and effective engagement.

UN-HABITAT has developed a *Wheel of Urban Prosperity* to indicate the scale of the integrated planning and execution needed to address the challenge.

While cities have several characteristics in common, they are also different in many ways. Four urban archetypes may help reflect on the challenges of design, planning and adaptation:

- Pre-industrial [medieval, renaissance and baroque] European, eastern Mediterranean and Asian towns of cultural significance: Space within and between buildings is at a premium; modern electrical wiring and water and sanitation piping is rudimentary; waste disposal poses challenges, and architectural conservation may trump redevelopment, although not in Shanghai or Beijing
- Industrial-age cities and regional towns from New York to Toronto, Chicago to Johannesburg and Sydney – that are defined by city cores surrounded by suburbs, linked by highways, other commuter thoroughfares and metropolitan rail links. Most of these cities have followed a similar path of outward migration to leafy suburbs, hastening inner city decline and the development of distributed growth poles, followed by urban regeneration.
- The new post-industrial mega-cities – Singapore, followed by Dubai, Doha, Abu Dhabi, and scores of new cities in China, as well as the economic cities emerging in the Kingdom of Saudi Arabia. These new cities offer superb opportunities for use and exploration of new energy-efficient design concepts and technologies, but the urban planning designs employed in most – high-rise buildings clustered tightly together – is exacerbating strains on ecosystems.
- The burgeoning slums on urban peripheries: The largest urban agglomerations are in low-income countries. Between 2010 and 2020, 95% of global population growth will be in urban areas and the bulk of these economic migrants (632 million) will swell the areas surrounding cities in developing countries. Between 2000 and 2010, the number of slum dwellers in developing countries rose from 767 million to 828 million. This might reach 889 million by 2020.[9]

6 World Business Council for Sustainable Development (WBCSD), Energy Efficiency in Buildings: Business realities and opportunities, October 2007, p 28.
7 United States Environmental Protection Agency, http://www.epa.gov/heatisland.
8 United Nations Human Settlements Programme (UN-HABITAT), Cities and Climate Change: Global Report on Human Settlements, 2011.
9 UN-HABITAT, Cities and Climate Change: Policy Directions, 2011.

While each of these four groups of built environments confront urban planners with particular challenges, the last category poses the most extreme, apparently intractable, demands. Incomes per capita in these exploding megalopolises are between one-sixth and one-third of those in the US when it reached urban residency of 65% in 1950, municipal planning and implementation capacity is generally weak, and very high concentrations of people in fragile informal settlements inhibit large-scale provision of energy and sanitation infrastructure. An assessment of the situation in Brazil in 2007/2008 may be instructive: "…some metropolitan agglomerations grow more than 3% yearly, causing social-territorial segmentation and the aggravation of violence. The Ministry of Cities estimates that 6.6 million Brazilian families are homeless, that 11% of urban houses have no access to drinking water and that almost 50% are not linked to the sewage system. Slums are multiplying … in municipalities of every size. 57.8 million Brazilians live below the poverty line… and 32.7 million …have no social assistance protection."[10]

Over the horizon to 2050, cities also need to prepare for the effects of warming oceans, melting ice, rising sea levels, more frequent storm surges and the inundation of riverine floodplains. The impact of Hurricane Katrina on New Orleans, forcing mass relocation and extensive reconstruction, or the 2010 floods in Pakistan, which left one-fifth of Pakistan's land area underwater and impacted 20 million people, are indicators of the likely scale. Few countries have the response capability of the United States.

This threat can be successfully met only by significantly changing patterns of production, consumption and wastage. As HSBC noted in 2011, the global economy's ecological footprint "has doubled since 1966."[11] In 2007, we were using the equivalent of 1.5 planets to support our consumption, while over 1 billion people were still underfed and lacked access to electricity and sanitation. By 2030, our footprint is set to become two planets' worth, and 2.8 by 2050.

Reducing the Movement of People and Goods

Oil was not initially intended as a transportation product – it was expected to be mainly used as a lighting and heating source before electricity challenged it. But the discovery of commercially exploitable oil enabled the automobile, which in turn introduced millions of people to a new type of freedom. Cities that were designed for much fewer than 100 cars per 1000 people have already seen the negative effects of increased car usage, straining to accommodate demand on roads. Will car ownership increase in line with economic growth, or will it be restricted until new forms of energy or new ways of thinking about transportation take over?

Will international air travel continue to be regarded as attractive and necessary, and if so, will fuel sources move significantly away from fossil fuels? Taking one annual long range jet aircraft trip uses up as much energy per individual as does driving 40 kilometres per day in a car for a year.[12]

Will the propensity to move goods around continue to be driven by globalization, or at some point will it either be too physically hard to move goods to and around modern megacities, or that the costs of doing so, including resources used, have forced more local solutions? Similarly, are people in those megacities going to continue to travel further to find work or for their other activities? Or will those cities be planned in a way that reduces that travel? Will that planning take place through individual actions, or more centrally, or maybe both? Ideally, there will be a clear distinction between the movement of people and goods that serves the vision of how people hope to live in 2050 – for example air travel might link with the desire of people to experience a connected world – and that which does not, such as excessive commuting.

Using Materials that Use Extremely Low Energy

> **"I believe that in the future designers will be challenged to innovate for dual use of space so that it is possible for a workspace to morph into a living space. There is a clear need to reduce mobility due to resource constraints and traffic."**
>
> Sheila Sri Prakash, Founder and Chief Architect, Shilpa Architects, India; Member, Global Agenda Council on Design Innovation

Many materials used to make things are dug up from the earth. These include paper and other wood products, metals, non-metal materials and petroleum products. For some materials, such as iron, the recycling process allows scrap material to be collected and reused; for others, such as petroleum products, recycling has not been developed to the same extent. In the ageing infrastructure of many cities, great amounts of materials can be recycled.

The percentage of materials recycled will increase, and recycling activities can be prioritized to help meet energy needs. To start with, the methods used to recycle materials must be energy efficient. This can be done by a combination of better use of existing technology and the development of new methods. In addition, products must be designed so it is easier to separate different materials when they are no longer used, reducing the energy needed to separate these materials. For example, if product manufacturers were made responsible for the total life cycle of the materials effectively providing a service to use the product, rather than the product itself then this could provide an incentive to manufacturers to design goods that are intended to be recycled. Dr Hiroshi Komiyama's work *Vision 2050: Roadmap for a Sustainable Earth* contains a clear analysis of the subject. The challenge is in creating conditions that ensure the right incentives are in place to achieve better results.

> **"Car ownership — essentially a free ride on under-priced fuel, roads, air pollution, etc. — cannot be viewed as an individual's human right as it has been in the West. Mobility should be more appropriately priced."**
>
> Chandran Nair (Founder and CEO, Global Institute for Tomorrow, Hong Kong SAR

10 da Silveira Lobo, Maria, http://www.thenextlayer.org/node/298.
11 HSBC Research report, The World in 2050: Quantifying the Shift in the Global Economy, January 2011.
12 David J.C. Mackay, Sustainable energy-without the hot air, 2009.

Moving Forward: Making Change Possible

Building a Movement towards Energy that Supports Our Aspirations

Throughout the centuries, there have been great examples of mass movements that have enabled a change in perspective, which in turn have led to greater human achievements. For example, the Black Death led to the widely shared agreement that collective action was needed to achieve better sanitation. In cases such as this, action might be taken quickly because the nature of the problem is capable of being well understood and shared.

Other transformational changes have been motivated by an increased recognition of the need to address unequal or unfair realities in order to allow more general progress – for example, the civil rights movement in the US and various movements towards greater rights for women in many countries. These movements have typically featured a wide variety of approaches and inspiration from many fronts simultaneously, often with disagreements among the protagonists about the right approach to follow. They have also been characterized by a combination of strong and varied leadership not necessarily by established holders of power and growing public support as the issues were better known.

Energy reform, which would encourage the creation of a **new energy architecture** that improves living standards for everyone, would happen more quickly if large numbers of people want it to happen. Involvement by citizens in energy issues usually happens in response to a visible issue, such as: where there is a major problem with a facility, such as Fukushima; where a controversial project is proposed; where there are shortages because of a black out; or where there are major price increases. Because energy decisions are focused on the very long term, they can often be unpopular in the short term, and thus gathering political support is hard.

Energy companies and other leaders in the energy system may not always be comfortable engaging with citizens, but without greater energy literacy we will not see the changes we need. Considering the contributions of the leaders we consulted for this paper, especially the younger leaders, we find a persistent theme: a belief, or a requirement, that there would be greater citizen involvement in world affairs generally, that would lead to a transformation from how things are done today.

> **I question whether there is enough age representation around the key decision-making tables. I question whether the hardest but perhaps greatest initiatives can realistically be expected to be pursued in respect of energy agendas for 2050, when representatives are already too old in the current day to bear any accountability except in the short term for the results of their decisions. The later we leave it, the greater the risk there will be of conflict should protectionism and competition for resources become a persuasive option on the table due to desperation.**

Christopher Geary, Chief Operating Officer, Asianet Group, Hong Kong SAR; Global Shaper, World Economic Forum

Action must be taken today in the move towards solutions for 2050 because the lead times in energy are so long. Action today will happen only if there is pressure to make it happen, and pressure can only be applied if today's leaders believe there is a constituency that demands action. There must be a clear focus on greater involvement by citizens, especially those who will be most personally affected by the 2050 future – the young generations.

Changes in Energy Governance

Energy issues are often regional or worldwide, but their governance has generally been national. The energy industry has large and powerful actors, and great change will most likely be easier to the extent that these companies are motivated to move towards an energy architecture that will help. This will take better and stronger governance at the national level.

> **Governments will play an important role in this transition period to 2050 by implementing a number of reforms. However, this is easier to say than to do. Another question is what kind of reforms do we actually need? Looking from the individual perspective, I believe that it is necessary to encourage individuals to actively participate in the governance process. Individuals need to actively engage in the reform-making process or at least be aware of the kind of reforms that have been introduced.**

Lin Boqiang, Director, China Centre for Energy Economics Research, Xiamen University, People's Republic of China; Member of Global Agenda Council on Energy Security

But governments will not adopt policies that will make them very unpopular unless they can see political benefits. Removing fuel subsidies or creating city-wide policies that deliver a sounder long-term energy architecture in exchange for short-term pain are examples of difficult policies.

Climate science, systems thinking and mathematical simulations are essential and must be used more extensively and in more sophisticated ways in the future, but stylized assertion of the accuracy of tentative insights in intellectual dogma will not move large numbers of people to abandon their biological habits and prejudices, sacrifice their short-term interests or adopt new policies. In an ideal world, people will move towards a future where national interest can be maximized through greater regional cooperation:

Current rigid national boundaries will give way to regional states, each of which will encompass 10 or more states in the same region. This expanded state will make it possible to introduce more coordinated energy and environmental policies, leading to better international policy coordination.

Nagoya University of Commerce and Business Graduate School students (Nagoya, Japan)

No more nations, more global union with free travel…more people of mixed race…we evolve our consciousness to learn how to make better decisions and there is more community cooperation…. education becomes a right everywhere.

Sauder Business School students, Vancouver, Canada

There is a clear synergy between the interests of OECD and non-OECD countries:

At an international level, advanced economies and developing countries need to work together so that cutting-edge energy technologies, which are typically with the former, can be launched in the markets that are growing the fastest.

Rajeev Mantri, Founder and Executive Director, Navam Capital, India; Global Shaper, World Economic Forum

But recent events have increasingly shown that one cannot wait for changes made from the top, and that there is a wider group that needs to be involved:

I think the government will play a smaller role than most people would think. In the long run, the state will become less important...We need to start thinking about the new actors in governance, which include civil society, people's movements, the corporate sector – they are becoming increasingly important.

Khalid Koser, Deputy Director, Geneva Centre for Security Policy, Switzerland; Member, Global Agenda Council on Migration

Targeting Innovations in Technology, Human Endeavour, Organizational and Personal Activity Will Enable Change

The human race has progressed through a series of innovations. There is a belief buried in us that humanity can meet any challenge by innovating. Paradoxically, that can sometimes stop people from trying to solve the biggest problems that they face. How is it possible to articulate the most important areas for innovation, understand the scale of innovation needed, celebrate great innovations in this space, and even more importantly find ways to help them scale up?

In *The Quest*, Dan Yergin explains: "what provides for reasoned confidence is the increasing availability of what may be the most important resource of all – human creativity …The energy solutions for the twentieth century will be found in the minds of people around the world. And that resource base is growing. The globalization of demand may be shaping tomorrow's needs. But it is accompanied by a globalization of innovation."[13]

If the need for that innovation now is defined to ensure that energy supports the aspirations of people for their lives in 2050, will the world achieve that type, scale and impact from innovation? Is there agreement on the types of innovation that would be most useful? Before identifying a need for technological innovation, around the world there are best practices that, if adopted, would substantially help. For example, using the best available air conditioners, or more fuel-efficient transportation methods, heat pumps or waste disposal can happen before there are more technological

The starting point for our thoughts should be the physical infrastructure. We need to consider where all the materials such as wood and steel with which we want to create the world would come from? How are we going to build cities in a sustainable and durable way? While on the one hand, we need to think how sustainable cities can be built given resource constraints, on the other hand, I believe that people are incredibly innovative – every time the design community faces a technological challenge, it comes up with a very creative solution.

Chris Luebkeman, Director, Global Foresight and Innovation, Arup Group, USA; Global Agenda Council on Design Innovation

breakthroughs. Such improvements would, for example, require innovation in the way we decide what to use, the business and policy models that shape those decisions, and the way information flows to help us.

Komiyama's *Vision 2050: Roadmap for a Sustainable Earth* largely makes the case for progress using existing science and technology, rather than by inventing new technical solutions. Of course we need to find and broadcast more examples of specific and promising actions that contribute to spreading change and that can fit into the development of a movement towards a new architecture, while benefiting from a new policy framework and encouraging technological innovation. Some examples, many of which emerge from the narrative above, include:

- Promoting air travel that would not require fossil fuels
- Increasing urban planning in megacities
- Dealing with very large supply side payoffs such as cleaner coal
- Emphasizing carbon capture and storage and nuclear safety
- Finding ways to proliferate the use of today's best technologies in various activities that use energy
- Advancing mass transit
- Finding ways to involve more people in energy policy-making

13 Yergin, Daniel, The Quest: Energy Security and the Remaking of the Modern World, Penguin Books, 2011, p. 717.

– Speeding up energy access projects in least developed countries
– Improving the energy efficiency of methods used to recycle materials
– Designing products so that recycling is easier
– Framing the debate to emphasize enjoyment rather than energy use or consumption.

In terms of technology, the innovations that emerged from the question "How do you hope people will live in 2050?" include:

> **My children and grandchildren have all flown on long-haul solar powered planes. Energy storage has finally reached the point of being able to store intermittent sources on the grid.**

Rosie Pidcock, Partner Specialist, China Greentech Initiative, People's Republic of China

> **In Japan, we have an index that measures the environmental value of buildings. This index is not used at the international level since it is too complicated to measure the environmental value of buildings globally. What I find interesting about this index is that it shows that buildings built with advanced technology are not necessarily more environmentally friendly. A lot of measurements today show that the more advanced technology you have, the better it is. However, sometimes it is not true. Maybe people should start thinking about how to use different measurement systems.**

Reina Otsuka, CEO, Ecotwaza Co., Japan; Global Shaper, World Economic Forum

And perhaps there will be innovations that result from changing demographics that today are harder to predict:

> **Technology will make a huge difference…and I think I will be surprised by the older generation…the elderly are more active and more respected … technology and the behaviour of older people may make this shift less pessimistic.**

Khalid Koser, Deputy Director, Geneva Centre for Security Policy, Switzerland; Member, Global Agenda Council on Migration

> **Technology is tremendously important. Technological advancements can allow us to overcome the issue of resource constraints. Developments in this area would lead to substantial decreases in renewable energy prices. They would also enable us to better manage our economy. Technological improvements would therefore allow us to diversify the use of energy resources, which would reduce our dependence on oil from the Middle East. Thus, technology will be playing a key role in supporting our lifestyle and increasing our living standards in the future.**

Lin Boqiang, Director, China Centre for Energy Economics Research, Xiamen University, People's Republic of China; Member, Global Agenda Council on Energy Security

No one can claim to have the last word on how people want to live in 2050 and how energy can support the combination of individual visions that can be articulated. In the quotations above there is a collection of suggestions about future innovations that different people and organizations will follow. 2050 may seem distant, but because of long lead times, there is a need to focus on what can be done in the next one to five years to enable a future state of which everyone can be proud. Fortunately, envisaging and developing a **new energy architecture** is a job that does not only have to be left to today's leaders.

Conclusion

The **new energy architecture for 2050** will be most shaped by how people in non-OECD countries are able to develop. If they are to enjoy many of the benefits of progress that OECD citizens have long enjoyed, then everyone needs to work together to ensure that growth in population and affluence does not lead to proportionate increases in energy consumption as they have in the past. Moreover, the energy architecture must serve the billions of people that it does not reach today.

Achieving this will be very difficult, but it will be easier if there is a focus on the energy that people want to enjoy, rather than on what they consume. Today people consume and pay for far more energy than they use, and they use far more energy than they enjoy. Finding solutions that are affordable and realistic, especially where they are most needed in fast-growing cities in the non-OECD world, is difficult. Implementing them is even more so.

The best solutions will have their greatest chance of being implemented if more people support them; and that support is most likely to come as a result of greater energy literacy and much greater involvement in energy decision-making by more people, especially the young. There are many leaders and powerful entities in the energy industry who continue to contribute greatly to energy architecture; their experience and knowledge must be connected directly to the aspirations of a far greater number of people.

Appendix

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