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Synthesis on energy and climate change

This synthesis might be submitted to the principal countries of the world for comment, approval or disapproval.

It draws together key considerations on energy, technological progress and climate change.

I. Energy in terms of demographic and economic considerations

1/ Along with food and drink, clothing and shelter, health and education, mobility and communication, energy is a fundamental human need. **However, it is unique in that it contributes to satisfying these other needs:** food, mobility, health, production of industrial goods, communication, etc.

Energy therefore allows humans to **adapt their environment to make their life longer or more comfortable.** And this will be a bitter realization if they run out of energy.

2/ Ever since humans mastered fire, they have used more and more energy. Even today, **the level of energy consumption is one of the indicators - although a fairly crude one - of development** in different regions of the world.

3/ The Earth's population was nearing **half a billion** individuals at the beginning of the common era. It reached the fatal **billion** around the middle of the 19th century before an incredible acceleration in demographic growth saw the population rise to its current figure of **7 billion** in just 160 years, having reached **3 billion in 1960** and **6 billion in 2000.**

The global population is now growing by 90 million individuals each year, and we will doubtless reach 9 billion by the middle of this century. Improved nutrition and healthcare in particular is contributing to this demographic expansion.

4/ **Individual consumption is characterized by a constantly growing demand for goods and services**, balanced in part by an improvement in energy efficiency due to technical progress, which makes it possible to obtain equivalent services while using less primary energy.

5/ **In many cases, this improvement is due to a greater use of electricity,** because of better efficiency of electric equipment**.** Furthermore **17% of**

electricity consumption in developed countries is already associated to the use of personal computers, televisions and mobile phones.

6/ **Currently, every person on earth consumes an average of 1.9 toe per year, which results in an annual cumulative consumption of primary energy of more than 13 billion toe (13 Gtoe/year) when all energy sources are included.**

This average of 1.9 toe/year per person hides a huge regional disparity that reflects the north-south divide in terms of development: while an American consumes 8 toe each year, a European uses 4 toe and a Japanese person 3, while someone from India has to survive with just 0.4 toe per year.

7/ After biomass, in the form of food and fire, humans used the muscular energy of animals or other humans. Then, fairly early, they mastered hydro and wind energies in certain applications (windmills, sailing boats) and, of course, solar energy in its passive form. The beginnings of industrialization greatly increased the demand for wood to produce charcoal, and its replacement with coal narrowly saved Western Europe from total deforestation. Later, oil and gas were extracted and used. In the second half of the 20th century, nuclear energy was added to the global energy mix, while the rise of electricity enabled a far greater use of “renewable” energies such as hydroelectricity, wind and solar, by making it possible to physically separate energy production and use without significant expense.

8/ In spite of vital efforts to improve energy efficiency, **the needs of emerging countries are such that energy consumption (without concerted effort) would probably at least increase at the same speed as population itself.**

This is even more true given that the populations of OECD and former-USSR countries have stabilized and the 3 billion people who will doubtless increase the global population in this century will be in emerging countries (China, India, Brazil, etc.) or developing countries (Africa in particular).

Until now growth of the energy demand has always been higher than 1% per year.

9/ In particular, energy consumption for transport by road, sea or air tends to grow at least as fast as the economy because of the important use of emerging economies. It has also been predicted that **by 2030-2040, there will be twice as many cars and air traffic will be increasing at a far greater rate than the economy.**

Increase of goods transport through globalization and economic development is parallel to the economic growth.

10/ Like all human activities, the production and consumption of energy are not without drawbacks: the depletion of local resources, accidents, and air and water pollution, not to mention social and societal impacts.

We know that since the 1950s, this consumption has reached a level that has consequences on a planetary scale, via the greenhouse gas emissions caused by burning coal, oil and gas.

To keep this threat to the climate at a level that would allow humanity to adapt without catastrophe, scientists have recommended to world leaders that global CO_2 emissions should be at least reduced by a factor of 2,5 before 2050, even though energy demand risks almost doubling by this point if we want to see economic growth continue at the current rate.

11/ Fossil fuels, oil, petrol and gas, account for 92% of the primary energy used on the planet.

Access to oil reserves is a geopolitical issue as much as an economic one, and this has already been the case for 50 years.

This issue should not be demonized, but should not be unknown or under-estimated.

12/ Excluding traditional biomass and hydroelectric power, **so-called renewable energy sources provide barely 1% of the total.**

The figures speak for themselves: **there is no chance that new renewable energies alone could cover the increases in needs.**

Nuclear power will be necessary as well as carbon sequestration or CO_2 recycling if we want to face up the climate change challenge.

13/ The US energy revolution (shale gas yesterday, tight oil today and tomorrow) changes the energy picture throughout the world.

In the short term, combined with prospects in Iran, Nigeria, Libya, it can relax the tension on prices for oil.

14/ In the long term, beyond 2020, the key question is much more to know if we can stabilize the oil price at a level really lower than 150 $/barrel.

We could reach at that time a plateau in conventional oil production and can relax the market with the use of biofuels, shale oil, extra-heavy oil, but it has naturally limits.

15/ The fear of a rapid exhaustion of global fossil fuel resources has vanished at least for fifty years to come, since technological progress and rising prices have allowed the exploitation of new resources.

In the November 2013 issue of the World Energy Outlook, the IEA estimates that recoverable oil, natural gas, and coal resources amount to 178 years, 233 years, and 30 centuries of current production respectively (and still to an impressive 54 years, 61 years and 142 years for proven reserves), provided, that is, that considerable investments are made, but it is clear from these figures that the core of the matter is not resources, but emissions.

As well as for conventional oil as for non conventional gas, key long term problem is less linked to quantities available than to environmental impact of use.

16/ We can already speak for oil about a peak demand in OECD countries and a budgetary floor price for many producing countries and mainly OPEC countries.

17/ Biofuels prospects have now taken off and could be followed by CO_2 recycling, with much fundamental research on the latter taking place around the world.

Completion for using biomass (heat, biofuels or biogas) is already a reality.

18/ **Between 2000 and 2013, it was coal use that grew quickest:** it is on the point of catching up with oil in terms of global consumption.

This coal "explosion" is seriously aggravating the climate threat.

China will change its policy in connection with this consideration, and aim at the use of the cleanest technologies in this field.

19/ The Fukushima-Daiichi accident **set back the nuclear "renaissance"** that began in 2005 by several years.

Yet this "renaissance" **is vital** if we are to achieve our goal of stabilizing the atmospheric concentration of CO_2.

20/ It is no accident that electricity occupies a growing share of energy consumption in all developed countries, and that all forecasts confirm this trend. Indeed, compared with other forms of energy, **electricity has specific and often unique advantages:**

Electricity is an important crossover point for converting one form of energy to another. Could we imagine transforming mechanical energy into chemical or light energy without going via electricity?

Replacing other forms of primary energy with electricity can often significantly improve the yield, and therefore the energy efficiency of processes.

Electricity makes it possible to separate energy production and consumption, thereby providing the average citizen with a host of mechanical and electronic servants that would have been inconceivable in the past.

Electricity is the preferred, if not only, vector of information and communication (even the photon traveling through an optic fiber is produced and modulated by electrons…).

Electricity is a clean energy during the transport, distribution and final use phases: producing no pollution and no greenhouse gases (with the exception of ozone). In the case of nuclear, hydroelectric, solar or wind power, or fossil fuels with CCS, it is also clean during the production phase.

21/ Aside from this list of advantages, however, electricity has a considerable weakness: **it is practically impossible to store**, except in small quantities and at a high cost. It can be stored indirectly (pumping stations, flywheels), but this remains marginal.

This weakness explains the still minimal role that electricity plays in the road transport sector, despite the fact that the first car to reach 100 km/h was an electric car (the "Jamais Contente" driven by Jenatzy in April 1899). A battery does not last as long as a tank of petrol, and is "refilled" at a much slower rate…

22/ Another consequence of the electricity storage issue is that if a network is supplied by an intermittent and random source, which is the case for a lot of new renewable energies, another source of conventional generation capacity must be kept ready to supplement it if necessary.

For most countries, this remains a minor issue given that renewable energies represent only a small part of electricity production.

However, if the hoped-for increase in renewable energy share takes place, this will become a more serious issue.

II. Technological perspectives

Electricity and transport currently represent 70% of global CO_2 emissions. And we certainly do not lack ways to reduce these carbon levels while continuing to maintain economic growth.

23/ Let us take the example of **electricity** to start with:

- Emissions from **coal-fired plants** could be reduced by 50% in relation to technologies used 10 years ago, but they would cost around 50% more; the same is true of gas-fired plants.

- **Nuclear plants** represent a considerable opportunity for all countries able to set up fully competent safety authorities.

- **Hydroelectric resources** could be further developed in certain countries where water resources are plentiful.

- **Renewable energies** - on-shore wind, off-shore wind, solar - could be developed on a large scale but will always be limited by the intermittence of these resources (almost nowhere has wind every day, the sun does not shine at night).

All these technologies could be developed. Within the G20, they could reduce emissions from electricity to less than **100g of CO_2/KWh**. Note that some countries are today close to this level already.

24/ For **transport**, a distinction should be made between different means of transport:

- Traditional **cars** with internal combustion engines could now see their emissions halved and rechargeable hybrid vehicles could as an initial estimation also halve consumption, while electric vehicles for urban-only use could bring about an even greater reduction in emissions if the electricity used is low-carbon.

- **Transport by electric train or by long-distance truck on an electric highway** could largely stabilize emissions from the transport of goods.

- For **short-distance truck transport**, either electric trucks or trucks powered by fuel cells (i.e. hydrogen produced by water electrolysis) could be chosen.

- Finally, **planes** could not only make progress in their overall design but also be fuelled by what are known as “second-generation” biofuels, which are produced from biomass and hydrogen from water electrolysis. Electricity can also contribute.

Electricity is involved in most of these elements.

25/ These issues become even more important when we take on board the fact that, regardless of its cost, **carbon capture and storage** is only possible for carbon released in large amounts and geologically impossible in two-thirds of the world. As we are not going to transport the CO_2 thousands of miles, it is likely that we will also begin to study CO_2 transformation into methanol, petrol or kerosene.

From this perspective, **cement works** located on the coast could represent a major resource for CO_2 recycling.

There are **three other areas** that account for the majority of remaining CO_2 production: industry, construction and water.

26/ When considering industry, it is important to differentiate between different **requirements**:

- where there is a need for heat greater than 1200°C,
- where there is a need for heat between 300 and 600°C,
- and the rest.

In the first case, needs may be continuous and must therefore be provided for by electricity. Where needs are occasional, plasma torches can be highly effective.

Where heat requirements fall chiefly in the range of 300 and 600°C, we cannot ignore the value of high temperature nuclear reactors, which can provide electricity, heat and hydrogen to industrial zones.

These measures alone provide scope for largely supplying industry needs with **carbon-free energy**. This is also vital if we wish to overcome the climate challenge.

27/ The issue of construction is more complex on a worldwide scale, as climates differ hugely and there is often confusion over what can be done for new and old buildings.

However, it remains that:

- We could of course improve the insulation of old buildings, but this would represent significantly less than 10% of global energy demands. It would help, but would not be a panacea. It will have secondary benefits such as reduction of fuel poverty.

- We could supply heat everywhere, through geothermic energy, solar water heaters, or wood-fired heating, or by heat pump to complement electric heating.

- It would make a lot of sense to integrate industrial waste heat and waste heat from thermal power generation with residential demands.

- Positive energy buildings are possible but it would take a long time to substitute them for old buildings.

- Truly effective smart meters could help make progress with energy use by private individuals.

If they were linked up, all these sources of technical progress could **stabilize CO_2 emissions despite the growing population.**

28/ In this technological landscape, we should not finish without mentioning water needs, and particularly the desalination of sea water. Water requirements are increasing across approximately 20% of the planet, and to deal with this we once again need electricity. Renewables are useful in this regard as water is easier to store than electricity.

28/ To conclude: **we can overcome the climate challenge while maintaining economic growth if we reduce the carbon emissions of electricity, transport and industry and manage the issue of buildings more effectively. However, without major developments in electricity, and more specifically carbon-free electricity, there is no way this can be done.**

III. Overcoming the climate challenge

30/ It is not easy for us as individuals to appreciate the scale of climate change. We can all see that the climate is already changing. We are getting by in a haphazard way, and find it difficult to imagine what could happen if the average temperature on earth really rose by 4 or 5°C in comparison to the pre-industrial era. Yet if we fail to change global energy policies and such a threshold were reached, many parts of the globe would suffer from either a lack of water or too much water, and hundreds of millions of people would starve or be forced to migrate. Far from being merely an economic problem, climate change would become a geopolitical problem on a scale never before seen.

31/ It is strictly impossible to reconcile economic growth, prices and saving the planet unless we make serious developments in low-carbon electricity, double the share of electricity in the next 40 years and successfully **reduce CO_2 emissions to below 100g CO_2/KWh within the G20 countries.**

32/ If the industry and transport themselves do not call directly or indirectly for low-carbon electricity, or even manufacturing processes using hydrogen, the challenge will be impossible to overcome.

33/ The creation of **car fleets that emit less than 70g CO_2/Km** can be achieved by 2025-2030, at least in the G20 countries.

34/ Even if we are optimistic, **carbon capture and storage will never reduce global CO_2 emission by more than 15%. In spite of this, it should not be neglected.** We should not, however, delude ourselves into thinking that CO_2 could economically be transported across millions of miles or placed into deep sea-bed storage.

35/ Each major country must specify what it can expect from the **use of biomass for energy.**

36/ All the studies carried out to date show that the fight against climate change could be compatible with sustained economic growth and cost less than 1.5% of global GDP.

37/ If no agreement is found inside the G20 countries it would be very unlikely to define a system that could be appropriate for the world.