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THE COST OF EUROPEAN ENERGY TRANSITIONS

8th European Energy Forum - Paris, 11-12 June 2019

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La Revue de l'Énergie

Depuis soixante-dix ans, *La Revue de l'Énergie* est l'un des lieux de débat sur les questions énergétiques, en France et dans le monde, à l'interface des milieux académiques, politiques et industriels. Éditée depuis fin 2017 grâce à l'engagement du Conseil Français de l'Énergie, la revue est au cœur des transitions énergétiques. Elle ouvre ses pages aux points de vue d'auteurs venus d'horizons divers, représentant toutes les énergies, toutes les technologies et tous les acteurs. L'ambition de la revue est de contribuer à une meilleure compréhension des enjeux et des opportunités dans le domaine de l'énergie et de partager les meilleures stratégies et politiques pour favoriser la transition énergétique vers des systèmes énergétiques plus durables.

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Éditorial

Voici le premier hors-série de *La Revue de l'Énergie* édité par le Conseil Français de l'Énergie. Il propose une synthèse du 8e Forum Européen de l'Énergie consacré au coût des transitions énergétiques en Europe. Le Forum, qui s'est tenu à Paris en juin dernier, a réuni des participants venus de différents pays d'Europe : c'est pour cela que ce numéro est exceptionnellement publié en anglais.

La transition énergétique a pris, en Europe, des formes différentes selon les pays qui s'y sont engagés et les priorités qu'ils se donnent : changement climatique, baisse de l'intensité énergétique, désengagement des énergies fossiles, développement des énergies renouvelables, sortie du nucléaire, aspiration citoyenne au développement des territoires, sobriété énergétique, compétitivité économique, pouvoir d'achat… Ces objectifs, parfois difficiles à concilier, ont un coût.

Poser la question des coûts de façon spécifique, c'est poser une question inhabituelle mais pourtant cruciale dans l'évaluation des transitions énergétiques et des conséquences de toute accélération du changement. Poser la question des coûts, c'est s'obliger à caractériser les transitions énergétiques et réfléchir, si cela a un sens, à ce qu'aurait été une «absence de transition». Le Forum s'est particulièrement intéressé à trois enjeux majeurs : le logement, la production d'électricité et le transport. Poser la question des coûts, c'est aussi poser la question incontournable : «Qui va payer?», et donc celles du partage de l'effort et de la faisabilité sociale des transitions. Poser la question des coûts, c'est, pour un objectif très souvent lié au climat, rechercher les trajectoires les moins coûteuses et préciser les outils et les politiques pour s'y engager.

J'espère que vous trouverez, dans les différentes contributions, des éléments de réponses à ces questions qui permettront la réussite des transitions énergétiques que nous vivons.

Le Conseil Français de l'Énergie travaille d'ores et déjà à la préparation du 9e Forum Européen de l'Énergie qui aura lieu à Paris, au printemps 2020.

Bonne lecture!

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The Cost of European Energy Transitions

8th European Energy Forum - Paris, 11-12 June 2019

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INTRODUCTORY REMARKS

Jean Eudes Moncomble
Secretary General, Conseil Français de l'Énergie

On behalf of the Conseil Français de l'Énergie, I am pleased to welcome you to the 8th European Energy Forum, devoted this year to the cost of energy transition in Europe. We will begin with a session on the concept and pace of the energy transition, followed by three sectoral sessions on the electricity mix, the housing sector, and the transport sector. That will be followed by two sessions on Day 2 concerned with who will pay for the energy transition and reducing the costs of that energy transition.

We are very honoured to welcome Jean-Bernard Lévy to open this meeting. He is both Chairman of the Conseil Français de l'Énergie and Chairman and CEO of EDF, France's electricity utility company.

OPENING SPEECH

Jean-Bernard Lévy
Chairman, Conseil Français de l'Énergie, Chairman and CEO, EDF – France

Good morning, Ladies and Gentlemen. As Chairman of the* Conseil Français de l'Énergie*, it is an honour to open this event, the 8th European Energy Forum. It has become an annual tradition to bring together representatives from industry, academia and government, from various countries around Europe. The aim is to engage in discussions on key issues, with the perspective of one country to another, and of one energy system to another. That diversity of points of view is what makes this Forum so enriching. It takes us beyond our narrow national points of view and allows us to see matters from a new perspective.

I. The Global Context

The topic of this year's meeting is the cost of European energy transitions, which is a key topic for us all. In 2018, global CO_2 emissions did not decline; in fact, they increased by 1.7% to reach over 33 billion tonnes of CO_2 emitted in the world. The level of emissions in Europe decreased by 1.3%, which is encouraging. However, that reduction will not be sufficient to enable us to achieve the objectives of an 80% reduction by 2050. Nor will it allow us to reach the target of carbon neutrality by 2050.

At the international level, the objective is to grow our ambitions with respect to current trends on emissions. That is the aim of the Paris Agreement. However, we have seen the impact of movements such as France's *Gilets Jaunes*, which go against our intentions with respect to climate change. The idea of a just transition is therefore emerging, and it is imperative that the transition is a just one that leaves no-one behind.

The theme of this year's Forum is the cost of the energy transition in Europe, which is particularly pertinent to us all. Discussions over the next two days will focus on how to better take into account all the relevant factors, and how to ensure that there are no losers in this transition. On behalf of the *Conseil Français de l'Énergie*, I would like to thank all of our speakers and participants for having accepted our invitation to share their expertise and points of view on these critical topics. Thanks to your participation, I know that we can expect very fruitful discussions indeed.

II. Keeping Costs Under Control

I will now continue with a few words in my capacity as Chairman and CEO of EDF, where I will try to shed further light on the issues on which this Forum will focus. In my role as Chairman and CEO of EDF, I pay careful attention to what our economists have to say. They are very clear in explaining that, if carried out

properly, the cost of the transition should remain within our control. That was the message of the Stern Report of 2006. The Report was widely criticised when it was released, but its conclusions appear to have been vindicated with time.

The Stern Report provided that, with effective policies, the cost of the energy transition could be controlled, reaching 1-2% of global GDP by 2050. That limited level of cost would allow us to take rapid and determined action in order to reduce greenhouse gas emissions, compared to the costs associated with climate change. Those costs are potentially significantly greater in the long term, reaching up to 20% of global GDP. That is, by investing 1-2% of GDP we can avoid having to spend 20% at a later time.

Since the publication of the Stern Report 13 years ago, our estimates of the potential damage due to climate change have increased even further, as demonstrated in the most recent IPCC report. That Report refers to the rise in sea levels, the increased frequency of extreme weather events such as storms, floods and heatwaves. There is also the impact on biodiversity and the impact on human health to consider, all of which indicates that the impacts of climate changes are potentially both more severe and more rapid than originally thought.

Since 2003, EDF has spent several hundreds of million euros in adapting our own infrastructures and installations to climate change. The decarbonisation of our economies is more than ever necessary today. The IEA has demonstrated that, taking into account current projects, our carbon budget for reaching the 2°C target, has virtually been reached. We must therefore rapidly find room to manoeuvre through the decarbonisation of our electricity generation by replacing fossil fuels with low carbon electricity in transport, building and construction, and industry. To achieve that, it is necessary to have an efficient regulatory framework. Otherwise, the potential losses in GNP will be much greater.

III. The Right Course of Action

Have we embarked on the right course of action? In answering that question, we can see that the glass is half-empty, or half-full, depending on our perspective. Nevertheless, I am not sure that we have reason to be too optimistic today. At the international level, emissions continue to grow. In spite of the considerable increase in the use of renewable energies, the share of fossil fuels in our global energy mix has not changed since the adoption of the Kyoto Protocol; we are still close to 80% of fossil fuels in our energy mix. In the United States, competition from gas – principally shale gas – has led to the closure of nuclear power plants. However, maintaining those nuclear power plants in operation is the most cost-effective ways in which we can produce decarbonised electricity. In the developed world, the share of nuclear energy is growing. Without nuclear energy, the decarbonisation of electricity will be virtually unattainable.

According to figures provided by the French government, European emissions have been reduced by 22% in the past 25 years. However, a non-negligible proportion of that decrease is due to a reduction in Europe's industrial ecosystem — namely the closure of many industries and factories on our continent. If we consider Europe's carbon footprint — taking into account emissions generated by our imports — the reduction in CO_2 emissions falls from 22% to approximately 14%.

Europe spends €50 billion per year in direct subsidies for renewable energy. However, as highlighted recently by European network operators, Europe's security of electricity supply is at risk due to the lack of a long-term return on investment. When it comes to electricity consumption, it is necessary to move twice as fast as we are doing today. The GIEC has advised that, in order to reach the 2°C target, the share of electricity in the energy mix should double at the international level, from approximately 19% today to over 38% in 2050. That requires a growth of 2% per year compared to the current pace of 1% per year.

A number of different factors explain this situation. Standards for energy performance are often expressed in terms of primary energy, resulting in a re-carbonisation of some buildings. Tax is another factor at play here. Given that electricity in France is largely decarbonised, it would not be illogical for this to be reflected in the amount of taxes payable on electricity as compared to other energy sources. The amount of tax payable should reflect the number of tonnes of CO_2 emitted. When it comes to subsidies, these should be expressed in terms of the avoided tonnes of CO_2. That would allow us to see more clearly in a field that is rather approximative today.

IV. Key Success Factors

My comments are aimed are demonstrating that we are still very far from the conditions called for by economists in order to succeed in the energy transition. What do we need to do to move closer to success? I see four key success factors here.

- First, we need a systematic evaluation of public policies in terms of euros per tonne of CO_2 emitted. That is an indispensable tool for controlling the cost of the energy transition, in particular in an environment where public policies tend to take the form of standards and norms, rather than an effective carbon price.

- Second, we must strengthen the overall approach to decarbonisation, so as to better take into account the global impacts of policies. Germany provides an excellent example here in its development of networks for renewable energies. We can also consider the impact on consumption of various technologies and on the consequences for our carbon sinks, such as our forests or agricultural lands.

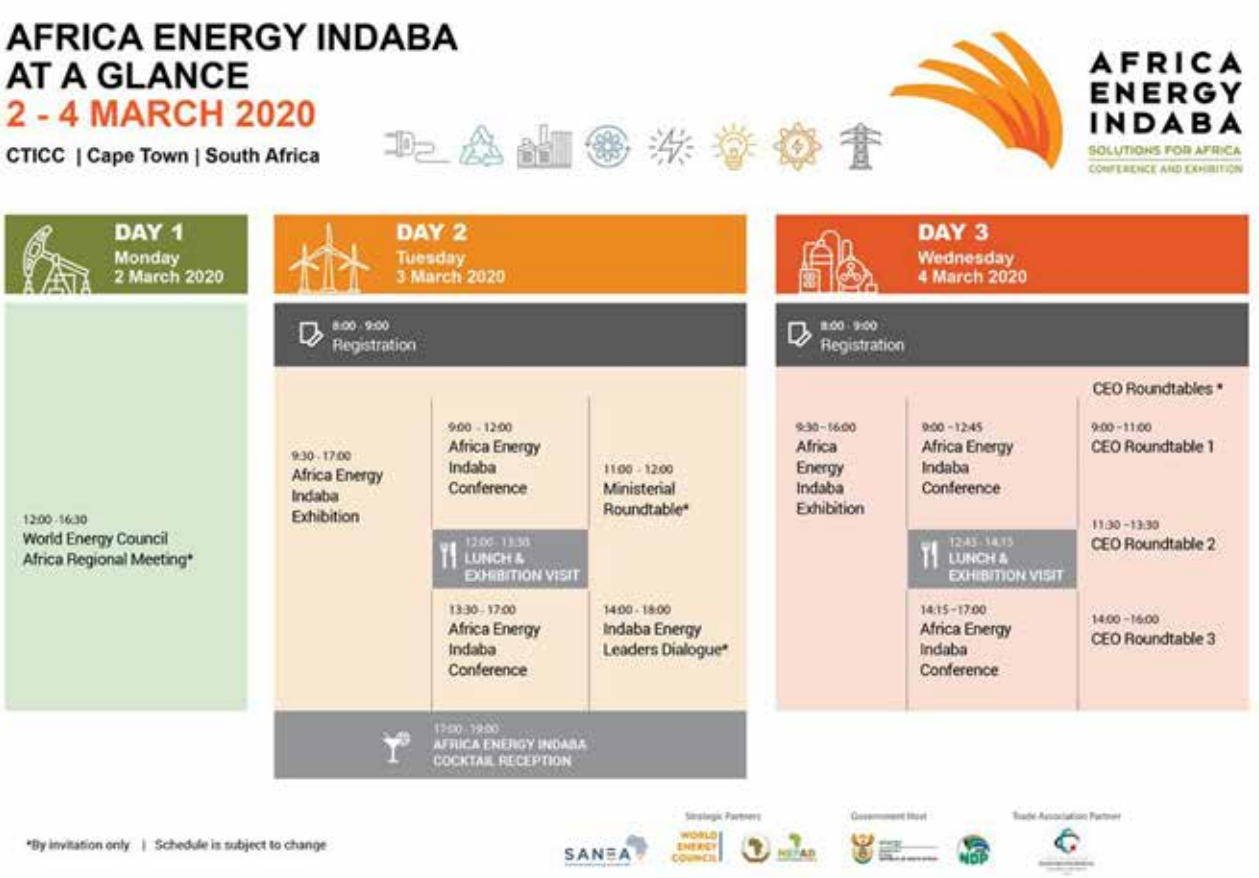
- Third, we must ensure security of supply, notably with respect to electricity. The energy transition is first and foremost an investment challenge: over €2,000 billion in Europe, in the next 20 years, for electricity production alone. Today's markets do not enable adequate returns for such investments. According to the IEA, the European market will only provide 50% of the sums that are required to fund power investments by 2035. It therefore seems to be imperative that long-term schemes are implemented in order to remunerate the generation plants. That appears to be crucial in order to protect the security of supply.

- Fourth, we need to reinforce the industrial policies of the European Union. The energy transition involves many political and financial challenges. However, the industrial challenge should perhaps be more highlighted. It requires significant investments, as well as the complete transformation of our entire infrastructure from electricity networks, gas networks, oil networks, and investments required in hydrogen and perhaps for carbon capture and storage in the future. All these investments will be backed by investments in the industrial ecosystems of our countries: factories for the production of wind turbines, solar panels, batteries, electric vehicles, or heat pumps. We also require investments in extraction, refining, recycling, and production of materials that are necessary for the energy transition to improve the performance of existing technologies and develop future technologies as well as the digitalization of the supply chain will necessitate a whole ecosystem that brings together industries, universities and laboratories.

The importance of this industrial dimension of the energy transition has particularly been highlighted in a number of recent developments. They have reminded us that the energy transition will not succeed unless it is a just transition, if people receive concrete and tangible dividends, first and foremost employment, purchasing power and growth. This means more industrial development in France and in Europe. This also means taking back control on the way things go, at the individual or collective level. In the current restless geopolitical situation, we cannot simply shift from a dependence on fossil fuels to a new dependence on imported technologies.

Ladies and Gentlemen, these are the elements that I wanted to highlight for you today. I hope that your discussions over these two days will go into all of these elements in greater detail. I wish you all a very rich and fruitful two days of discussions.

Thank you very much.



SESSION 1

The Different Paths of Energy Transition and their Costs

Moderator: Jean Eudes Moncomble
Secretary General, Conseil Français de l'Énergie

I would like to launch this session by sharing several ideas developed by Dominique Finon and myself while preparing this Forum. To determine the cost of the energy transition, it is first necessary to define what exactly is meant by the energy transition. Another approach would be to determine the cost of not pursuing the energy transition. This first session will therefore look at the cost of the energy transition in its different dimensions. In terms of historical background, we can ask whether this transition is different to past transitions. Is it being undertaken at a different pace to the transitions of the past?

I. Reflections on Energy Transitions Past and Present

Gerald Davis, Executive Chair of World Energy Scenarios, World Energy Council – United Kingdom

What can we learn, if anything, from history to help us face the challenges and tasks that lie before us?

There is much debate among analysts as to what the term "energy transition" means. It is not just about a change in the dominant primary energy source. It is also about the development of new infrastructures, and complementary technologies or devices. It is about the long-term transformation of the prevailing energy ecosystem. It is sufficiently dramatic that it has the potential to fundamentally reshape our economies, societies and politics as a whole. It is these broader issues that we must keep in mind in exploring the "energy transition".

1. World Energy Transitions

We have had a fairly limited number of world energy transitions in the past, and we need to take care in drawing conclusions from a small number of cases: the movement from traditional wind, water and biomass to coal; from coal to crude oil; and from crude oil to natural gas. We are now embarking on a new and unique transition. Coal met 50% of the world's energy needs in 1900. Crude oil took 40 years to go from 5% to 25% of global energy supply, and peaked at close to 40% in the 1970s. Coal and oil still amount to approximately 30% each of the overall global energy supply.

What can we learn from previous energy transitions? First of all, they are all linked to a specific phase of the Industrial Revolution. We also know that the world energy transition is shaped not just by the change in dominant

energy supply but also by micro-transitions. Overall, transitions are of long duration, taking about 75 to 100 years to be fully achieved. Energy transitions are often accompanied by a large increase in energy consumption.

Social and political developments shape transitions and are themselves shaped by those transitions. Fundamentally, an energy transition requires new infrastructures and investments.

Lastly, each transition brings with it large-scale changes in regulations, tariffs, and pricing regimes. There is no reason to believe that any future transition would not lead to such changes.

2. National Energy Transitions

There are a number of interesting examples of national energy transitions. Denmark is one of the countries that has been hardest at work in enabling energy transitions. Denmark was 95% dependent on oil at the time of the first oil shock, and then shifted to 95% dependence on coal. More recently, wind electricity rose from 12% of total demand to well over 40% today.

In France, the rapid development of the nuclear programme after the first oil shock led to the construction of some 56 reactors between 1974 and 1989. That is a remarkable development over only one decade and a half.

The Netherlands saw a rapid change in its energy system towards natural gas, which grew from 5% of the energy mix in 1965 to 50% in 1971.

Sweden had a very large government-led programme with respect to its lighting systems.

The most extensive programme of energy transition is perhaps to be found in China, where 186 million cooking stoves were introduced in only 15 years, touching some half a billion people. In Indonesia, LPG was introduced in order to reduce pollution from kerosene. Finally, Brazil transformed its car fleets to flex fuels in a handful of years.

These examples show that much is possible under certain circumstances, notably in the presence of strong planning and regulatory stability in a period of rapid change. That must be reinforced by political will, stakeholder involvement, public support, and the ability to handle the community issues associated with radical change.

National transitions have also taught us that none of this is certain, and the transition is influenced by many different external factors and shocks.

3. Looking Forward

We need to have a sense of the radical nature of the transformation on which we have embarked. The Shell Sky scenario is of value here. Today's energy system is dominated by oil, particularly when it comes to transport. This system has to be completely transformed by 2070 if the 2°C target is to be reached. That will also require the development of a hydrogen economy, and massive growth in solar and wind supply.

What does this mean and how much will it cost? IPCC's P3 middle of the road world scenario assumes that emissions reductions are primarily achieved by changing the way in which energy and products are produced, rather than by reductions in demand. To achieve the desired reduction in CO_2 emissions it is first necessary to re-direct investments from fossil fuels to

low-carbon and efficiency solutions. Second, the power sector has to be decarbonised, with a phasing out of coal. Third, it is necessary to have a carbon neutral economy. Fourth, it is necessary to compensate residual emissions and compensate for carbon budget overshoot.

When determining the costs of the transition, we tend to look at capital costs. However, it is also important to consider the operating costs of the new systems. We also have to take into account two very challenging risks: (a) physical risks (arising from climate and weather-related events), and (b) transition risks (arising from the process of adjustment towards a low-carbon economy). These financial risks are relevant to a wide range of businesses, sectors, and geographies. Their full impact on financial systems may therefore be greater than for other types of risks.

4. Conclusion

Europe amounts to only 15% of the world's energy use, a figure that will fall to 10% by 2050/2060. The cost of the European energy transition is therefore estimated at €160-200 billion per year (compared to a figure of $1.2-1.5 trillion at the global level). It will be necessary to restructure all transport, industry and building stocks. The additional costs of afforestation, bioenergy and agriculture must also be considered, as does the revaluation of stranded assets and resources. Finally, who pays? Citizens, consumers? The answer to that question raises multiple issues of justice and fairness.

II. Where Does Path Dependence Lead?

Patrice Geoffron, Professor of Economics, University Paris Dauphine PSL – France

The questions we are dealing with today are quite different from the transitions of the past. Historically, we were more in a process of "addition" (biomass + coal + oil + gas + …) than of "transition" from a specific energy source to

another (for example, more coal is consumed today than ever). Thus, we have to admit that the low carbon energy transition differs drastically from the energy evolutions of the past and that, thus, the challenges we are dealing with are quite different.

Between now and 2050, a huge reduction in CO_2 emissions is required if we are to reach the 1.5°C or 2°C targets, in order to implement the Paris Agreement: it would be necessary in 2050 to go back to the same emissions levels as the 1950s, with a GDP that would be 10 times higher and a world population 3.5 times greater. Reaching those targets therefore logically appears to be quite improbable: we have never to date seen, at World level, an uncoupling of GDP growth from the volume of CO_2 emissions for two centuries… Inventing a new macroeconomic model in a decade is therefore much more than a challenge, it is a Copernican revolution, and there is no indication at this stage that such revolution is underway. And, at the "breaking point", turbulence will be inevitable because this changeover does not only mean a modification in the energy system, but also a profound change in the organisation of all sectors of activity, without exception, and of the whole society, in reality.

1. Understanding Path Dependence

Considering the footprint of the changes to be implemented, understanding the inertia of our socio-economic organization is key,

inertia likely to induce a phenomenon of path dependence.

First, the typical lifetime of energy-related capital stock is very long (ex: thermal power plants) and therefore, mechanically, the implementation of the Paris Agreement would lead to stranded assets, probably on a massive scale.

Second, the Paris Agreement does not necessarily require significantly higher investment volumes, but massive reallocations (roughly form coal and oil to renewables and efficiency) but, without effective systems of carbon pricing and/or regulations, such reallocations will take time.

Third, the social organisation also leads to inertia: for example, if we compare Atlanta to Barcelona, both cities of approximately 5 million inhabitants, we observe that Atlanta has 7.5 tonnes of CO_2 emissions per person compared to 0.7 tonnes per person for Barcelona. This leads to observe that the transition is not limited to the energy system, *stricto sensu*, but involves profound transformations in the organization of societies.

Fourth, the geopolitical dimension of the transition must be considered. Fossil fuels exporting countries such as Saudi Arabia or Russia, and others, have much to lose here, which could lead to potential conflicts and unrest.

2. Future Scenarios

While providing probabilities regarding our perception is that the possible futures mainly depend on two variables — the "intensity of climate change" and the "stability of the international economic environment":

- The climate, depending on efforts to implement the Paris Agreement, could be relatively close to the one we are currently experiencing, or could be significantly modified, with warming in excess of 2°C by 2050.
- Regarding the international context, the beginning of a change of model can lead to greater stability... or not, depending on cooperation efforts.

Thus, depending on whether the climate is stable or not and whether the international economic context is stable or not, we believe four types of possible futures seem to emerge.

Scenario 1: The regulated emergence of a post-carbon world

- The Paris Agreement is being implemented in a proactive way so that the CO_2 emissions curve is reversed at the beginning of the 2020s and decreases steadily thereafter.
- Leading countries in the emergence of a post-carbon economy (Europe, China, United States...) are accelerating the deployment of "low-carbon" innovations (renewable energies, energy efficiency, electric vehicles, smart cities, sustainable agriculture...).
- By disseminating these innovations, hydrocarbon exporting economies are gradually adapting, as are countries lagging behind in terms of access to energy — particularly Africa — whose development is accelerating.
- This "virtuous circle" paves the way for entry into the post-carbon world without recurrent economic and/or geopolitical crises.

Scenario 2: The chaotic emergence of a post-carbon world

- As in Scenario 1, the Paris Agreement is being implemented in a proactive way so that the CO_2 emissions curve is reversed in the early 2020s.
- But this entry into the post-carbon world is very unstable because nations and companies dependent on the carbon model are severely disrupted, their economic base is eroding rapidly, even collapsing, with the process accelerated by an increase in their risks assessment by financiers.
- This instability is a source of economic and geopolitical crises, delaying the creation of a virtuous circle in the distribution of low-carbon innovations, unlike Scenario 1.
- This instability leads to regional downturns, fragments globalisation and reduces visibility on long-term investments.

Scenario 3: The regulated persistence of a carbon-intensive world

- The Paris Agreement is being implemented insufficiently or late.
- Despite the concurrent increase in the costs of climate change, the carbon model persists during this first part of the century.
- The richest countries are making adaptation efforts and reducing their emissions, but without ripple effects on the rest of the world.
- In the least developed part of the world — Africa in particular — economic catch-up remains based on access to fossil fuels and not on the accelerated adoption of low-carbon technologies (e.g. solar).

Scenario 4: The chaotic persistence of a carbon-intensive world

- As in Scenario 3, the Paris Agreement is implemented insufficiently or late.
- But, unlike Scenario 3, the effects of climate change are not contained, so that economic and/or geopolitical crises are more frequent, with a form of instability that extends the one that emerged with the crisis of the late 2000s.
- The succession of shocks both weakens the richest nations and hinders the development of the least developed nations.
- This international environment is conducive to regional or even national downturns, promoting fragmentation of globalisation.

http://wec-france.org/DocumentsPDF/Evenements/8-Forum-Europeen-Energie/Patrice-Geoffron.pdf

III. Insights from the UK's Conversion from Manufactured Gas to North Sea Gas, 1966-1977

Peter Pearson, Honorary Professor, Imperial College, London – United Kingdom

I will be focusing on one episode in the history of the gas industry in the UK: the conversion from manufactured gas to natural gas in the 1960s and 1970s.

1. Decarbonising the Gas Industry 2008-2050

The UK's climate change targets require an 80% decarbonisation, with a major change to occur in heating where most gas is used. The pathways to that decarbonisation include (a) replacing natural gas with non-carbon renewable gases such as hydrogen, bio-methane or decarbonised bio-synthetic natural gas, (b) decarbonising natural gas through carbon capture and storage, (c) switching to non-carbon electricity, (d) developing decentralised non-carbon local options, or (e) reducing heat demand. All of these options pose technical, economic, cultural and regulatory challenges for the gas industry.

In 1945, the Labour government nationalised and re-organised the gas industry, accepting the need for a response on both the supply and the demand sides. In the period 1960-1965, gas sales grew by one-third. In 1965, the discovery of gas in the North Sea led to a decision to convert the entire system and appliances to natural gas. Terminals were built to bring the gas onshore, and a national gas grid was constructed. In 1967-1977, the national appliance conversion programme was carried out, requiring the training of a new workforce to modify 35 million appliances in 13 million homes and 440,000 commercial and industrial premises. During this period, sales went up by almost 400% and prices came down by 16%. The conversion to larger combustion chambers and taller flame port orifices was completed by 1977/1978.

During this process, the gas industry was re-organised and carried out extensive R&D. Industry worked closely with government, and managed the risks of this natural gas conversion. Monopoly state ownership and government support for the transition to natural gas meant that it was possible to coordinate and control all actors in order to achieve a change desired by government and industry. Consumers were initially reluctant but responded well to the fact that natural gas was cheaper than the town gas it was replacing.

2. Decarbonising the Industry 2008-2050

The pathways to move from natural gas to low-carbon heat and transport resonate with the transition that was made with respect to natural gas. It will also involve the disruptive conversion or replacement of appliances. It will also require public acceptance of the alternative fuels, and developments in transmission or distribution networks and storage mechanisms. Finally, it will involve the additional challenge that energy services may initially cost more than the system they are replacing.

All in all, then, market forces and fiscal incentives alone are unlikely to ensure decarbonisation by hydrogen at the desired scale and speed.

In the 1960s, the UK gas industry was a vertically integrated, state-owned monopoly. Today's industry is no longer integrated, but is made up of many privately-owned, national and international companies. There are no logical leaders to steer this transition. The relationship between industry and government is fundamentally different from that of the 1960s. Although all political parties supported the 2008 Climate Change Act, recent governments have given a somewhat confused message on reaching the targets.

3. Conclusion

Governments and industry in the UK have not yet created a transformative, attractive vision of a low-carbon gas industry of the future. The natural gas transition shows that, while rapid, planned transitions are achievable, they may require complex, demanding forms of steering and governance that could be difficult to achieve in today's context. As such, the natural gas transition cannot be used as a blueprint for the UK's low carbon transition although it can help to highlight the challenges. The natural gas transition could help in the development of hybrid forms of governance in a very different sociotechnical context. It therefore seems likely that the UK government will have to play a more assertive, active role in steering the heat transition.

http://wec-france.org/DocumentsPDF/Evenements/8-Forum-Europeen-Energie/Peter-Pearson.pdf

IV. Path Costs and Uncertainties

Marc Bussiéras, Head of Corporate Strategy, EDF – France

I will focus on 3 topics: the preparedness of Western European countries for the energy transition; the sectoral nature of the transition; and the specific case of the construction industry.

1. The Situation in Western Europe

Are Western European countries in a position today to use the available technologies to achieve the energy transition? Electricity currently represents one-quarter of all energy consumed, and that is expected to double by 2050. Electricity is rather easy to decarbonize, but what about the other 50% in 2050?

- The most recent report of the Climate Change Committee shows that the UK counts on large amounts of low carbon hydrogen coming from natural gas and carbon capture and storage technologies. However, there are some doubts as to the maturity of that technology and its deployment at the large scale.

- In France, the ADEME has shown that achieving 100% green gas is only possible through hydrogen, synthetic methan and biomass including a lot of pyrogasification at a rather high cost.

- In Germany, a recent study referred to the 95% decarbonisation target, showing that this could only be reached with the contribution of large imports of power to X from outside the European Union.

These three examples demonstrate that there is no common view nor solution of the technologies which will enable the energy transition. It raises questions about technical feasibility, cost and convergence, and therefore raises doubts as to the projections and scenarios that have been announced in various quarters.

2. A Sectoral Transition

The transition will occur on a sector-by-sector basis. In the mobility sector, for example, the cost of batteries is already going down rapidly, and the volume of car sharing is on the rise. E-mobility will not have a significant impact on the electricity supply system as such, and a recent RTE report in France confirms that there are no major risks here. The real risks are to be found on the industrial side. We tend to focus our attention on the electricity system alone but the transition that we face is much broader in nature. This transition will completely transform the way that tens of millions of consumers use energy.

3. The Construction Sector

The construction sector is where urgent action is needed. The renovation of our existing building stock is necessary but not sufficient. This is a very broad subject that also includes the issue of consumer acceptance, which has to be managed very carefully and well in advance of the relevant changes being implemented, one of the key points will be to avoid stranded costs which would harm the consumers.

4. Conclusion

In spite of the uncertainties involved in this transition, it is necessary to get the public onboard as soon as possible. It is assumed that there will be a rapid acceleration in decarbonisation after 2030 in order to reach the 2050 targets. However, on the basis of what we know today, that assumption has to be revised. Hydrogen technologies might open up the future, as might carbon capture and storage, but we have to reduce the levels of uncertainty about the potential of these technologies as soon as possible.

V. Questions & Answers

From the floor

How can we calculate the additional investments that will be required in the energy transition?

Patrice Geoffron

The figure of €2000 billion in investments per year has been put forward. However, it does not include the value of stranded assets which is clearly considerable, and not only for industrial companies, but also for households. I myself bought a diesel car 4 years ago, and will not be able to use it in Paris in some years' time (considering the new city regulations). That type of issue applies in many different sectors, obviously at a much greater scale.

From the floor

How are these costs evaluated given the very different situations that exist in countries around the world?

Gerald Davis

The difference between localisation versus global development is inherent in the Paris Agreement in the form of nationally determined contributions. That is a complex, ongoing geopolitical process. Given the increasing urbanisation of our countries, cities are the ultimate path dependent entities. As such, the new urban developments in Chinese cities will provide very good ideas for addressing climate change. However, it is not simply a matter of replacing thermal vehicles by electric vehicles. The development of electric vehicles will require a radical re-thinking of our public systems, and will require consideration on a more systemic approach to policy development. However, today, many of these developments are occurring in fits and starts. We need an approach that is aware of the need for change to public policies, not just at the national level but also at urban and community levels.

Jan-Horst Keppler, Paris Dauphine

I share the scepticism that was expressed with respect to the 2050 targets. The transition will have much more impact on our institutions and markets than supposed. What role can we therefore expect institutions to play in this process?

Marc Bussiéras

Between now and 2050, we can expect many changes to have emerged that we are unable to anticipate today. Some changes will take much longer to achieve, and should be triggered as of today. Second, it is also necessary to consider consumer behaviour and consumer acceptance. That may be even more important than questions of technological maturity or systemic change.

Peter Pearson

Markets and institutions do have to change. We are familiar with what a high-carbon world looks like. We are much less familiar with what a low-carbon or even no-carbon world would look like. To that end, it is necessary to acknowledge the need for change, and it is important that governments develop visions of what the future will look like. One of the lessons learned in the UK natural gas transition was that the gas industry recognised and acknowledged the need for change.

Patrice Geoffron

We have a diverse range of technical solutions possible, some of which are more mature than others. Our real challenge lies in the lack of time at our disposal for the transition.

Gerald Davis

The World Economic Forum's research on fostering the energy transition includes a ranking of countries by their ability to address the energy transition. Countries such as Finland, Denmark, Norway and Sweden come out on top here. The ranking is not only on technical issues that need to be addressed in the transition but also the social and political issues requiring resolution. I would therefore suggest taking a close look at the institutional frameworks of these countries, and their apparent increased capacity to take action.

Dominique Finon

I believe we are being quite idealistic with respect to the technological feasibility of the transition. We are therefore losing sight of the reality of issues such as the cost for consumers and the cost for governments. The technology has made the transition possible, but the intermittence of renewable energy sources creates huge problems. We also tend to forget the fact that we will be reliant on China for batteries or that we will need to overhaul our heating systems. We also have to deal with the high level of inertia in our systems.

We therefore need to be much more realistic and avoid unnecessary idealism. It is also imperative that we take a long-term approach, and that we provide for both public and private funding of the energy transition. I would say we have a duty of absolute realism rather than making groundless assertions.

Marc Bussiéras

The *Gilets Jaunes* movement has shown that consumers will simply not put up with an unjust transition. It is therefore necessary to develop a concept of energy transition where everyone stands to gain or at least does not lose. Even the commitments of the COP21 would not have been possible without the deep reduction in the cost of renewables, we go on as soon as the transition become sufficiently affordable.

Peter Pearson

We are long overdue for a thorough re-evaluation of the role of markets. We also need to re-evaluate the roles played by government and the roles played by private citizens. When the gas and electricity industries were nationalised in the UK, the underlying legislation was silent on matters such as long-term energy security and environmental responsibility — they were simply not on anyone's agendas. Our old models are therefore very overdue for further questioning.

Patrice Geoffron

We are aware of the issues associated with leaving these matters to resolution by market mechanisms. However, it is also necessary to consider the geopolitical aspects of the energy transition. For example, Russia relies heavily on oil and gas exports; if those exports suddenly drop, we can envisage major geopolitical upheavals. I therefore agree on the necessity to remain realistic and build all of these elements into the analyses made. That has not been done sufficiently to date.

Jean Eudes Moncomble

On the one hand, we have climate specialists calling for rapid change. On the other hand, we have heard of the difficulties associated with change: the inertia of the system, the massive cost of investments. How can we reconcile these two contradictory requirements?

Gerald Davis

The current world energy transition is a unique challenge for which we have no historical experience at the global level. We have a new set of values framing our concerns, but these have not necessarily obtained global consensus. No single technology provides an answer to the issues faced. We need double subsidiarity: from the global level to the nation state, and from the nation state to the local area. There are likely to be very substantial winners and losers in this transition. That makes it extremely difficult to build a consensus for

change. It also makes it difficult to see how markets alone will be able to do everything.

Jean Eudes Moncomble

I would like to ask our panellists to provide a key takeaway message from our discussions.

Marc Bussiéras

We need to continue to challenge our ideas and, most importantly, we need to understand the necessity for change.

Peter Pearson

I chose the example of the transition to natural gas as a positive example of how rapid change can be well-managed. It is also a very good illustration of how disruptive such change can be. That is, such transitions can be both disruptive and positive at the same time.

Patrice Geoffron

We need to understand that we are part of a historical process. Our GDP is 100 times higher than in 1800, and we have moved from almost zero net CO_2 emissions to a volume of over 30 billion tonnes. We are now seeing the tangible consequences of those 2 centuries of history.

Gerald Davis

What we need across all sectors is serious prototyping. We need to solve problems at the level of the city and not just at the level of the vehicle. Finally, we need a "Club of Leaders" who will accept the challenge and who will want to make a difference.

SESSION 2

Decarbonisation of the Electricity Mix – The Overcosts of Technology-Oriented Policies

Moderator: Bérénice Crabs
Secretary General, World Energy Council – Belgium

Given the enormous challenges faced with respect to climate change, decarbonisation is an issue for all economic actors in Europe. It is necessary to completely re-think the management of our energy systems in order to integrate more and more renewable energy into the electricity mix, and in order to position the customer at the heart of our energy system.

The European Commission recently published its strategic long-term vision for achieving a low carbon or carbon neutral economy by 2050* – A Clean Planet for All. *To that end, joint action is required in 7 strategic areas: energy efficiency; the deployment of renewables; clean, safe and connected mobility; competitive industry and the circular economy; infrastructure and interconnections; bio-economy and natural carbon sinks; and carbon capture and storage to address remaining emissions. In addition, it will be necessary to develop new technologies. That will not be easy for the energy sector: disruptive technologies will require significant capital and very long-term investments. At the same time, it will be necessary to address the issue of stranded assets.

I. The Costs of Decarbonisation: Insights from a New Study of the OECD Nuclear Energy Agency

Jan-Horst Keppler, Professor of Economics, University Paris Dauphine – France

I will be presenting a study from the OECD's Nuclear Energy Agency on the costs of various systems to reach the targets of the Paris Agreement. Those targets imply an objective of 50 gm of CO_2 per kWh. Today, renewables remain the principal method for reaching decarbonisation objectives, and the Agency considered the relative costs of doing so by using various levels of nuclear and renewables in the mix.

1. Background to the Study

Costs can be measured in various ways. First, plant-level production costs at market prices (LCOE). Second, system costs at the level of the electricity system (grid level). Third, full costs including the external and social costs of atmospheric pollution, climate change, security of supply, and so on.

The Paris Agreement aims to limit the increase in global average temperatures to well

below 2°C. That requires a reduction in annual CO_2 emissions by 43% at the global level and by 61% at the OECD level. Annual emissions from electricity generation will have to be reduced by 73% at the global level and 85% at the OECD level. In other words, emissions in OECD countries for electricity generation will have to fall from 430 gm of CO_2 per kWh today to 50 gm of CO_2 per kWh by 2050.

2. Assessing the Total Costs of Electricity Systems

The total costs of electricity systems include both the plant level generation costs and the grid level systems costs. These system costs will depend on the individual characteristics of each country's energy mix. They will also depend on the penetration of renewables and the availability of systems providing storage and flexibility.

A high share of variable renewables in the energy mix de-structures the remainder of the system. With 75% of renewables in the mix, the residual demand becomes more volatile and unpredictable, resulting in significantly greater capacity needs — considerable excess capacity is required to meet demand. Due to carbon constraints, coal is no longer included in the scenarios. Flexibility is therefore provided through gas and through battery storage but only at high levels of renewable penetration.

As the share of renewables increases, therefore, system costs also increase. The bulk of these costs are represented by profile costs especially when the share of renewables is particularly high. When renewables reach 75% of the energy mix, an additional cost of €50 per MWh must be added to the LCOE costs of renewable plants.

It should be noted that the decreased load and volatile electricity prices associated with renewables discourage the necessary investments. This secondary effect was not modelised in the Report.

The increase in the use of renewables also leads to a decline in nuclear capacity. This poses the question of sector coupling — that is, combining electricity generation with the production of another "storable" product such as heat or hydrogen.

The Study therefore concluded that the market-based introduction of renewables is intrinsically difficult. Renewables earn less than average market prices due to auto-correlation during production hours. This effect increases as their share in the energy mix rises, and is greater for solar PV. Nevertheless, the cost of renewables is expected to decline in the future, by up to 60% for solar PV, by up to 50% for offshore wind, and by up to 33% for onshore wind. This will allow self-entry into the market, subject to local conditions.

3. Conclusion

As a result of its analysis, the OECD has made five complementary policy recommendations for a cost-effective decarbonisation of electricity to 50 gm of CO_2 per kWh. That decarbonisation should be based on policies for the rapid deployment of all low-carbon technologies.

- Carbon pricing is the most efficient way of decarbonising electricity supply, and should be implemented.
- New investment in all low-carbon technologies should be encouraged by providing stability for investors.
- Competitive short-term markets for the cost-efficient dispatch of available technologies should be promoted.

- Adequate levels of capacity and flexibility, as well as transmission and distribution infrastructure, must be ensured.
- System costs should be recognised and fairly allocated to the technologies that are responsible for those costs.

http://wec-france.org/DocumentsPDF/Evenements/8-Forum-Europeen-Energie/Jan-Horst-Keppler.pdf

II. Evaluating the Costs and Benefits of the German Energiewende

Dimitri Pescia, Senior Associate, Agora Energiewende – Germany

I will present work on quantifying the costs — and benefits — of the energy transition in Germany. Agora is a German think tank made up of about 40 independent and non-partisan experts whose mission is to make the energy transition in Germany and around the world a success story. It is responsible for analysing, discussing and putting forward proposals in this area.

1. The German Energiewende

What does the energy transition mean in the German context? It is a long-term strategy aimed at phasing out nuclear and coal power and significantly reducing greenhouse gas emissions. It has a number of primary targets, including reducing greenhouse gas emissions by 80-95% before 2050 and the shut-down of all coal-fired power plants by 2038. It also has a number of secondary targets related primarily to increasing energy efficiency and increasing the share of renewable energy in the energy mix.

In order to reach its 2030 climate target, Germany must reduce its CO_2 emissions by 25 million tonnes per year. If Germany remains on its current trajectory, it will have to pay €30-60 billion to other EU states in the form of carbon allowances.

After a significant drop in the costs of production, solar PV and wind energy are now competitive with fossil fuels in many countries around the world. As a result, production costs for solar PV and wind are now lower than those of thermal power stations run on fossil fuels.

2. A Meta-Analysis

An objective definition of costs for the energy transition is likely to be impossible. Costs depend on the scope of the analysis and on the reference points used. In terms of scope, it is possible to look at different system boundaries. Starting from the direct cost of electricity, one can also take into account the external costs of electricity, the impact on the economy, or even the impact on foreign policy.

Consumer spending provides an indication of historic costs for the supply and consumption of energy. In Germany, that spending has been relatively stable since 2011, at a level of approximately €200 billion per year for all consumer spending on power, heat and transport. In 2016, for example, consumer spending on energy accounted for approximately 6% of GDP.

The additional costs of the energy transition in Germany have been analysed in five comprehensive studies carried out between 2014 and 2017. Despite their different assumptions, the five studies came to several similar conclusions.

- The energy transition requires considerable added investment but that remains manageable.
- If climate related damage is valued at €50-60 per tonne of CO_2, or if the price of fossil fuels increases, the energy transition will be cheaper than a scenario without energy transition.
  - o A system based on a 95% share of renewables will reduce CO_2 emissions by 96%. A renewables-based energy transition can therefore be considered as an efficient climate policy (as the costs associated with climate change are estimated to be much higher than €50-60/tCO_2).
- Overall, the energy transition has a slightly positive effect on the economy.
  - o It is estimated that the German energy transition will lead to a GDP increase of 0.1-2.7% in 2030, and an increase of 1.1-4.4% in 2050 (compared to a reference scenario).
- Additional positive effects could be expected from the exports of Energiewende technologies.
- The cost of capital has a massive effect on the total expense of the energy transition.
- Financial commitments already made for the launch of renewables will put a strain on consumers until 2022-2023.

3. The Additional Costs of Accelerated Phase Out of Nuclear and Coal

The accelerated phase out of nuclear in Germany will lead to additional costs of approximately €16 billion between 2008 and 2025.

It is estimated that the phase out of coal in Germany will cost the federal budget about 70 to 90 Mds€. This is €3.5-5 billion per year or 1-1.4% of the total federal budget. This includes the support to mining regions that represent about half of the total costs. It covers also the compensation to power producers for the early retirement of coal power plants, which is estimated at €5-10 billion, and the compensation to be paid for the early retirement of employees of coal companies which is estimated at €4-7 billion.

4. The Distribution of Costs

The distribution of costs varies greatly between different economic players: households, industry, and energy-intensive industry. Consumer prices have increased over the years primarily due to the increase in grid charges and the EEG levy (renewable energy surcharge). As a result, German households and small industrial consumers pay one of the highest retail prices in the EU. However, the German energy-intensive industries pay one of the lowest, as they benefit from numerous exemptions in order to preserve their international competitiveness.

In the coming years, consumers will still face a moderate increase of their bill. However, by the middle of the 2020s, the burden carried by consumers to support renewables will decline, as new renewables are much cheaper. By 2030, the share of renewable electricity should reach about 60%, while the burden to consumer will be lower than today (for a share of only 35% renewable electricity). The real political challenge therefore lies in addressing that "cost hill".

5. The integration costs of renewables

The system costs of renewable electricity are larger than generation costs. Integration costs are generally considered to include grid costs, balancing costs, and the cost effects on conventional power plants — the so-called "profile costs" or "cost of reduced utilisation". Experts disagree on whether or not the cost effects of interactions with other power plants should be considered as integration costs. A more appropriate approach therefore lies in comparing the total system costs of different scenarios. That would avoid the controversial issue of attributing system effects to specific technologies.

http://wec-france.org/DocumentsPDF/Evenements/8-Forum-Europeen-Energie/Dimitri-Pescia.pdf

III. The Importance of Macroeconomic Assessment for the Energy Transition

Richard Lavergne, Permanent Member of the High Council for the Economy, Ministry for Economy and Finance – France

1. The Rationale for Macroeconomic Assessment

Innovation for the energy transition is financially risky in the short-term, as demonstrated in the example of the solar road opened in Normandy in 2016. 1 km of PV panels were installed along a length of road at a cost of €5 million in subsidies. The concept proved unsatisfactory, with lower production than expected, an issue with noise, and the need for constant repairs. Of course it does not mean that experimentation is bad but an ex-ante evaluation would have save cost in adjusting the size of the project.

It is estimated that the French authorities will spend more than €5 billion on electric renewables in 2019. That will rise to €10 billion by 2023. It is therefore of value to evaluate the impact of that spending, including its macroeconomic impact.

Macroeconomic assessments consider the global dimensions of an economy: GDP, investment, consumption, unemployment, inflation, greenhouse gas emissions, and so on. Some of these dimensions — for example, well-being or social cohesion — are difficult to quantify. Others — for example, net job creations — are difficult to project. Macroeconomic assessment of a given policy aims to measure the impact of that policy on those global dimensions.

Various models have been developed in France for the macroeconomic assessment of national energy policies. They rely on different sets of assumptions and different reference scenarios, and their results are not at all convergent, making comparisons difficult.

2. The CGE Project

In 2017, the CGE (*Conseil général de l'économie*, within the French Ministry of economy and finance) decided to address the macroeconomic impact of the French energy transition. The assessment concerned electricity only to a time horizon of 2030, and focused on 3 factors:

- CO_2 emissions from the electricity sector
- Total costs of power generation (CAPEX, OPEX and dismantling)
- Foreign trade balance.

The study used open data from RTE for the period 2013-2016, and the EU reference energy scenario for France as published by the European Commission in 2016. The study was based on a number of assumptions. First, that the safety of nuclear plants in France is correctly verified by the ASN. Second, that the US dollar was equivalent to €0.90, that coal was priced at $77 per tonne, oil at $52 per barrel, gas at $3.1 MBtu, and that the EU ETS scheme was based on €5 per tonne of CO_2.

18 scenarios of different energy mixes were tested with various figures for the EU ETS and for fossil fuels prices. In order to move from the electricity transition to the energy transition, it was shown that priority should be given to a number of key sectors and actions. This would help maximise CO_2 reductions with limited

public spending. It would also limit the external trade deficit.

3. Main Results

Without counter-measures, increasing the share of renewables in the electricity mix in France to 40% could lead to a significant reduction in the nuclear fleet, and an increase in gas consumption to support the use of intermittent renewables. As a result, CO_2 emissions could rise, as could the total cost of power generation. At the same time, the external trade balance could deteriorate by up to €13 billion between 2017 and 2030. It would also be necessary to calculate the socio-economic impact of the transition, for example employment or GDP, factors that were not assessed by the CGE study.

4. Conclusion

Thanks to nuclear and hydro, power generation in France is already 90% carbon free. The current electricity mix is reliable and relatively inexpensive. Therefore, decarbonising the French economy requires a focus on a certain number of other priorities: research and innovation, the carbon footprint of goods and services, and the use of fossil fuels in housing, transport and agricultural sectors.

http://wec-france.org/DocumentsPDF/Evenements/8-Forum-Europeen-Energie/Richard-Lavergne.pdf

IV. Questions & Answers

From the floor

First, do you take into consideration "grey" CO_2 emissions — emissions generated by the production of materials required for wind turbines? Second, why will the investment in renewables peak in Germany in 2022?

Dimitri Pescia

Investments in renewables will peak in Germany in 2022 due to the decline in costs. For example, installing a solar panel costs three times less today than it did in 2008. As to grey emissions, they are generally not taken into account for nuclear power plants or for wind turbines.

Richard Lavergne

The need to calculate grey emissions is clearly one of the conclusions we made with respect to the overall carbon footprint.

Jacques Leger

Should Germany succeed in withdrawing from coal and nuclear by 2038, how will it deal with the issue of renewables intermittence? Second, reference has been made to pressurised water reactors in the nuclear domain. However China and the US are working on the development of fusion reactors. I believe that China will have developed this technology by 2035.

Jan-Horst Keppler

Germany will continue to use gas to address the issue of intermittence, even if it no longer has recourse to coal or nuclear. With respect to nuclear, all developments are being closely monitored. However, I am very sceptical as to the likelihood of China or the US developing fusion batteries in the short- to medium-term.

Dimitri Pescia

The variability of renewables is dealt by various flexibility options. Currently, in Germany most of the flexibility is provided by coal and gas power plants and cross-border trade with neighbours. Given its costs structure, gas power plants are a good match for renewables, unlike new nuclear which is too expensive to be used only to provide flexibility. In the German energy transition, the aim is also to reduce the use of gas that is mostly consumed currently in the heating sector.

Richard Lavergne

I agree that external trade for electricity and cross-border exchanges between EU members also have to be taken into account in our assessments.

From the floor

If Germany is to use a combination of renewables and gas, how is it planning to deal with the issue of the greenhouse gas emissions associated with gas?

Dimitri Pescia

This has not yet been determined in details. Green gas and biogas should gradually replace natural gas. Renewables-based green gas could come from the North Sea or North Africa, where sun and wind conditions are excellent. Biogas may also have a role to play but probably more limited.

From the floor

Have you taken into account the transport and network costs associated with the energy transition? Second, one study has shown that Germany does not have sufficient land area to install all the wind turbines it needs to meet its objectives. What are your views on these physical constraints? Third, a number of assessments have been carried out on the potential impact on employment. What are your views on that potential impact?

Jan-Horst Keppler

When it comes to costs, we have to decide who is responsible for system costs and who is responsible for integration costs.

Dimitri Pescia

The production costs of electricity will drop with the energy transition. However, network costs are likely to rise. Those two effects should offset each other. When it comes to land area for the installation of wind turbines, the question of physical constraints is indeed becoming a critical one for Germany. It is also linked to the question of public acceptance.

Richard Lavergne

When we consider the number of jobs created by the renewables industry, it is important to remember that some of that job creation will be shifted abroad.

Dominique Finon

With respect to subsidies, is Germany's withdrawal from coal and nuclear an issue?

Dimitri Pescia

Not really. Compensation are provided to minimize the economic impact of the coal phase-out. Preserving the competitiveness of relevant

economic sectors, while accompanying the restructuring of other sectors, is usually understood and accepted by the population.

Bérénice Crabs

I would like to ask our speakers to conclude with a key takeaway message.

Jan-Horst Keppler

We absolutely need to adopt a systems-based approach rather than a technology by technology approach. In addition, we need to understand that a higher cost for CO_2 emissions will resolve many of the economic issues we face.

Dimitri Pescia

The climate and environment agenda gained new momentum, as highlighted for example by the "Fridays for Future" movement. Surveys shows also that the Green party could become soon a ruling party at federal level in Germany. This context calls for more ambitious policies.

Richard Lavergne

I would hope that our citizens will have access to objective information on the policies being implemented. That would allow them to make an informed judgment on the various scenarios that have been put forward. However a good understanding of what is at stake needs various technical expertise and the way to converge towards decisions of general interest is quite difficult.

The Role of Technology

Jean-Marie Dauger
Co-Chair, World Energy Council – France

Ladies and Gentlemen, on behalf of the World Energy Council, I send you our best wishes for the Forum. The World Energy Council is an international network, with national and regional committees and members. My presentation today will therefore have more of an international perspective than a European one.

I congratulate the French Committee of the World Energy Council for having organised this Forum on the cost of energy transition. There is still much confusion and misunderstanding as to the true objectives of energy policies (climate, economic growth, security) and the means used to attain them (technology, sectorial approach). That confusion is evident in the public discussions on these subjects. An approach limited to the means and not the sources of energy is doomed to move us away from the best path forward, and could even prevent us from reaching our targets. In other words, the comparative advantages of each of the energy vectors will not be sufficient alone to succeed in the energy transition. There are many different reasons for this, including the need for changes in behaviour or the need for social acceptability.

I am therefore delighted that we are exploring the economic aspects of the transition, which are not limited to the costs of solutions but also include the costs for investors and customers. They also include a consideration of the benefits for society, and the acceptability of different options from a social and political point of view.

I therefore congratulate our French colleagues, in particular to Jean Eudes Moncomble, for their continuing efforts in this now well-established European Energy Forum.

I. A Global Transformation

The energy transition refers to a global transformation in the production and use of energy. We begin with a variety of fossil fuels sources that are unevenly distributed around the world. We then have the diverse promise of abundance in solutions, most particularly of renewable energy — wind, solar PV, wave, biomass. However, this transformation is not occurring in a vacuum. Rather, it reacts and interacts at a higher level with the Grand Transition that is now underway — a Grand Transition that is leading to new ways of living, learning, relating, and communicating which are creating new energy needs and usages. This "Grand Transition" also has an impact on where decision-making powers will be located today and in the future.

This is why a successful global energy transition is an unprecedented challenge affecting the lives and livelihood of billions of people.

II. The Energy Transition

I would now like to make a few non-exhaustive remarks on the energy transition.

1. Climate Change

First, one of the pressing concerns (but not the only one) of this energy transition is the need to avoid catastrophic climate change by reducing energy-related greenhouse gas emissions. To address this concern, the cost of carbon is pivotal in managing a successful global transition. However, it will not be sufficient.

All options for decarbonisation need to be considered. There are many national or local options for developing affordable zero carbon energy pathways. However, many of these cannot be considered if an ideology of zero-carbon energy sources is used to strictly limit our transition thinking.

Innovation is also critical, not only for new and converging solutions but also with respect to traditional sources or usages, some of which are here to stay for a long period of time.

Successful decarbonisation also remains heavily dependent on leveraging global cooperation — global carbon prices, climate policies, coordination, investment in carbon capture and geoengineering options.

2. The Role of Renewables

Second, there is much excitement concerning the dramatic fall in the cost of renewables, notably solar PV, although the costs of offshore wind have not declined as expected, at least in Europe. However, we need to be wary of the danger of over-relying on technology cost curves in the fundamental shifts in society, industry, business and policies that are unfolding as part of the Grand Transition.

For example, while there is no doubt that solar and wind, as well as other technologies, will grow in importance, we cannot ignore the fact that we are still in an early stage of this exponential surge. As a result, even small changes in signals today can shift predictions by a considerable and unpredictable order of magnitude.

Despite the promise of abundant zero marginal cost renewables, their prices do not reflect entire system costs — meeting the new challenges of intermittency, storage, maintaining existing or delivering new grids, and so on. That also cannot simply be ignored.

Last but not least, resilience is not only a question related to intermittency, but is also a matter of material scarcity, geographic and geopolitical constraints, sector saturation and social acceptability. Geopolitics will continue to matter and may even broaden in scope to include social licence.

3. An Economic Vision

Third, we also need a new economic vision of the entire energy system transition.

Historically, energy transition has always created winners and losers, although there are not many losers in the initial stage. In a new era of digital transparency and data empowered consumers and citizens, the concept of success implies a more inclusive and socially "just" transition in both developed and developing economies.

Who will benefit? Who will really pay for a successful system transition? These questions are rising up on the political agendas not only of Europe, and they require an economic approach. All countries are facing — or will have to face — the common challenges of improving access, accelerating decarbonisation, and achieving a fairer sharing of new opportunities and cost. That is also one of the reasons why, due to regional diversity, promoting the sharing of knowledge and best practices is a greater necessity than ever in this transition. The transition will involve huge costs and risks burdens and, hopefully, many new opportunities.

It must be recognised that understanding and addressing the true costs and benefits of the transition in the entire energy system transition in an era of decentralised technology innovation, social atomisation, political fragmentation, and new and shifting geopolitics is becoming more and more challenging.

4. The World Energy Council

Fourth, the World Energy Council is a truly global network of members. As a neutral but not passive platform, we promote the entire energy system thinking and respect for regional diversity. We do that in order to help our members co-define what is meant by a successful global energy transition, and help them cooperate on what can be done to move towards that transition.

Several tools, instruments and platforms have been developed to favour these analyses and dialogues with members and other stakeholders, including governments or international organisations. The world may not be short on technology or ideas but requires more shared vision and practical experiences of new and different energy solutions.

III. Conclusion

Our next triennial World Energy Congress will be held in Abu Dhabi on 9-12 September 2019. Under the banner of "Energy Prosperity for All", it will address various aspects of the energy transition. Day 1 will concentrate on a new vision for the energy future. Day 2 will focus on the business opportunities of change, and Day 3 on new policy imperatives. The final day will consider innovation as a pathway to prosperity. More than 200 speakers, dozens of ministers and, I hope, most of you will actively participate in the Congress.

Thank you for your attention. I wish you all a fruitful and constructive continuation of the Forum programme.

Jean Eudes Moncomble

This is perhaps the ideal moment to wish you all the best for your next three years as Chair of the World Energy Council.

SESSION 3

Energy Efficiency in Housing – The Cost-Efficiency of Domestic Energy

Moderator: Einari Kisel
Regional Manager for Europe, World Energy Council – Estonia

There is much confusion in the market with respect to the energy sector. In this session, we will try to address the issue of the energy efficiency of housing which is, to a large extent, the elephant in the room. I would ask participants to raise their hands if they live in a dwelling that fulfils the criteria of zero net energy consumption, or even of level A in terms of energy efficiency.

[No hands are raised!]

We therefore have much room for improvement, as will hopefully become clear during our session.

I. Energy Efficiency Benefits and Costs: A Global Perspective

Kathleen Gaffney, Senior Programme Manager, International Energy Agency – France

1. Global Trends

The IEA tracking report, the *Global Energy and CO_2 Status Report*, shows a higher demand for fossil fuels globally, driving up CO_2 emissions for the second consecutive year after a brief hiatus. That increase in demand was driven by an exceptional level of global economic growth, with energy use in China, India and the US accounting for 85% of the net increase in emissions. In the same period, energy-related emissions in Europe declined for Germany, France and the UK. Germany's emissions decreased by 4.5%, and the UK's emissions fell for the 6th consecutive year. In France, emissions decreased significantly thanks to the use of hydroelectric and nuclear sources.

Energy efficiency can play a role in curbing CO_2 emissions. It is a key curb on emissions growth, and was the largest source of abatement of CO_2 emissions in the global energy sector in 2018. That trend will hopefully continue. However, that is more difficult than it seems. The annual rate of improvement in primary energy intensity has been slowing down in recent years, falling from a high of almost 3% in 2015 to 1.9% in 2017 and 1.3% in 2018. In addition, the global figures hide significant disparities at the regional level.

When it comes to energy efficiency policies, coverage is high in EU countries with most end uses covered by mandatory regulations. About one-third of all energy use around the world is subject to a mandatory energy efficiency requirement. The remaining two-thirds are not covered.

2. European Trends: Residential Sector

The energy efficiency of the residential sector in Europe is showing steady improvement. The increase in building floor space and appliance ownership is being offset by efficiency changes and weather impacts that have reduced the need for heating. A similar trend is underway in other advanced economies such as the North America, East Asia and the Pacific. However, the impact of weather on energy use is more apparent in Europe.

Most of the savings in the residential building sector have come from space heating.

3. The IEA's Efficient World Strategy

The IEA's *Energy Efficiency 2018 Report* provides a modelling for an "efficient world scenario": what would the world look like by 2040 if all the economically viable energy efficiency potential was realised around the world? It shows that, through energy efficiency measures alone, it would be possible to halve the world's energy-related greenhouse gas emissions by 2040. However, only one-third of those potential energy savings from efficiency gains are captured by current policies.

As to the costs involved, energy efficiency investments in buildings are levelling off. These investments totalled $140 billion in 2017, with Europe representing the largest market at $56 billion. In global terms, that investment must double by 2030 and then double again by 2040 if the efficient world scenario is to be reached. That is both a massive challenge and a massive opportunity. Europe already invests more in proportional terms, but it also needs to double its level of investment by 2040.

II. Costs, Opportunities, Risks and Rewards of Housing Retrofits

Gavin Killip, Senior Researcher, Environmental Change Institute, University of Oxford – United Kingdom

1. Retrofit Defined

There are 2 basic approaches to retrofit: (a) the hare approach, which is based on undertaking one big, global renovation project, or (b) the tortoise approach, which is based on a phased retrofit undertaken over a number of years.

Determining the costs of retrofit will depend on our definition of retrofit. If we aim for more than a 50-70% reduction in CO_2 emissions, the cost curve begins to rise steeply. The most appropriate standard for a retrofit therefore probably lies at a 50-70% reduction. That raises the question of whether we should aim for a 90% or even 100% reduction, in which case where does the responsibility for building end and where does the responsibility for the energy system start?

There are a number of tensions between our technical potential and our market potential. A 60% reduction is less technically difficult and more affordable than a 90% reduction. There are more market opportunities but it may be difficult to ensure quality. A 90% reduction is more technically difficult and is much more expensive. It assumes a "once and for all" approach that may be difficult to scale up.

2. Repair, Maintenance and Improvement

The construction industry operates at the right scale but not with the right quality. That is due to various factors including skills

and labour shortages, a limited capacity to innovate, a high rate of low-skilled jobs, a low demand for training, and a reduced appeal for skilled workers. All of this means that the risks are high for poor quality retrofits that lead to poor energy performance and even moisture damage to buildings over time.

However, the rewards are high if we are able to do this properly. For occupants, a good retrofit offers the possibility of comfort, well-being and improved health. For retrofit businesses, it is an opportunity for upselling larger projects, and establishing loyal customers.

Access to capital is another important factor. Funding is needed for retrofit costs, and it is important to fund work when costs are marginal. Delays in funding can bring projects to a halt. This is, however, an opportunity to develop new business models. In the UK and France we have seen SMEs come together in cooperatives to provide a full range of retrofit services. We have also seen the emergence of off-site construction techniques, for example, the Dutch *Energiesprong* concept. However, this may not work for all existing buildings, and may be better suited to new constructions only.

Experience has shown that having a project manager to coordinate retrofit projects makes the job easier and cheaper. That person needs some technical understanding, must be a good team manager, and have a practical sense. This raises the question of cross-disciplinary education, which is still lacking in most of our countries.

3. Conclusion

Retrofit is not only an energy problem. It requires much more serious policy engagement with the construction sector. Access to capital is also an issue, although it is important to avoid a narrow focus on costs.

Effective retrofit policies must focus on skills, knowledge and new business models. Innovation is also required, not only in products but also in processes and practices. In this area, coordinated field trials may be a way forward. They would help expand performance standards, and allow innovations to be tested in a real world setting. Such field trials would require a broad partnership between industry, policy and research, and would cost approximately €10 million to get off the ground in France.

http://wec-france.org/DocumentsPDF/Evenements/8-Forum-Europeen-Energie/Gavin-Killip.pdf

III. Low-Energy Buildings in Sweden – Costs and Benefits

Paula Hallonsten, Head of Policy Analysis Unit, Swedish Energy Agency – Sweden

1. Nearly Zero-Energy Buildings

The Swedish Energy Agency (SEA) is the national authority for energy policy issues. It carries out statistical research, policy analysis, and market surveillance. I will present the work of the SEA and the National Board of Housing, Building and Planning, which carried out an evaluation of low-energy buildings in Sweden.

The EU Energy Performance of Buildings Directive provides that, by 2020, all new buildings should be nearly zero-energy buildings (NZEBs). As there was no consensus as to what constitutes a nearly zero energy building, the 2 agencies involved in the assessment came up with different conclusions and different recommendations.

In 2014, the 2 agencies launched a joint project. A metering project on 3 buildings was carried out in 2014-2015 but faced a number of methodological and practical challenges. A second metering project was carried out in 2016-2018 on 31 buildings, including a case study on 16 buildings that involved a private economic assessment and a socio-economic assessment. Metering will continue in 2019-2020 by the Energy Agency.

2. Case Study

An economic and socio-economic assessment was made of 16 buildings. The economic assessment considered the additional construction costs required as well as the savings in energy costs achieved. In addition to that, the socio-economic assessment considered the value of avoided air pollution, the value of avoided CO_2 emissions, and the value of an improved indoor environment.

The study found that both economic efficiency and socio-economic efficiency were achieved in 2 out of 4 single family houses, in 6 out of 6 apartment buildings, and in 3 out of 6 commercial buildings. The similarity in results between the economic and socio-economic calculations is due to the fact that energy use in the residential and service sector is very low in CO_2 emissions. It is based on district heating, electricity and biomass. Electricity in turn is dominated by hydro- and nuclear power.

IV. Questions & Answers

Gerald Davis
What are the best approaches to enforcement in the construction sector? What is the best way to guarantee quality?

Gavin Killip
Compliance checking is a major issue. We tend to think of compliance checking on its own when we should think of it in conjunction with training and standards. There is also the question of who is responsible for compliance checking. I believe that it should be the responsibility of local government. In the UK, however, it has been privatised.

Kathleen Gaffney
I agree that responsibility for compliance checking should be shared with local government. Too often the burden of the entire checking process falls on the body that is also responsible for energy efficiency. Ideally, we should move towards a system based on performance codes and standards.

Paula Hallonsten
I also agree that local governments should be involved in compliance checking. However, that would make it necessary for local government to have the relevant competencies.

From the floor
Would you comment on the returns on investment for retrofit projects?

Gavin Killip
The return on investment lies in the comfort and well-being of occupants, which is difficult to monetise. The cost of energy retrofit represents approximately 15-20% of the total project, which is equivalent to the VAT payable. That means that fiscal and financial incentives could be envisaged in this area.

Einari Kisel
Depending on the underlying conditions, the return on investment can range from 3 to 15 years.

Jean-Marie Dauger

In the Swedish example, you referred to the evaluation of the value of avoided air pollution. How was that assessed?

Paula Hallonsten

We carried out an evaluation of the indoor environment. That involved both the measurement of air flows and personal surveys of occupants. The results showed that there was no deterioration in the indoor climate as a result of a reduction in energy consumption.

From the floor

What are your views on the rebound effect? Increasing one's well-being often means using more energy. Has that been factored in?

Gavin Killip

There is also the pre-bound effect, which is related to the fact that our models of energy use in buildings are not very accurate. We think we know how much energy people should be using but people behave quite differently. When it comes to the rebound effect, there is a general consensus that this amounts to approximately 30% across a number of sectors. As such, the rebound effect should not prevent us from pursuing energy efficiency measures.

Kathleen Gaffney

It is important to identify the objective of the policy. If your measures are aimed at improving living conditions for a targeted group of people, your definition of a positive outcome will be different from measures that are aimed to address energy poverty or economic development.

Bérénice Crabs

Energy poverty is often an issue in rental houses: tenants who pay for inefficient heating systems are not able to make decisions on retrofitting. What can be done to address this issue?

Kathleen Gaffney

The question of rental housing is challenging, both for low income and higher income homes. That is why a range of different policies are required, each targeting a specific issue.

Gavin Killip

Regulation is the obvious answer here. We require a system based on a minimum standard together with financial incentives and an information programme or energy label for buildings.

Paula Hallonsten
In Sweden, heating is usually included in the rent paid for housing.

Einari Kisel
That does not provide an incentive for the renter to save energy.

From the floor
We have been talking about the costs of heating. However, due to global warming, we are seeing an increased demand for air conditioning in warmer countries. To what extent are regulations being developed in that direction?

Kathleen Gaffney
The increased demand for air conditioning is currently a blind spot for the IEA. It represents a significant growth in energy demand. The simplest answer here is the introduction of minimum energy performance standards for air conditioning appliances.

Gavin Killip
We can learn much from vernacular architecture — the design of buildings at a time before the intensive use of fossil fuels. There are many passive ways to design buildings to be comfortable in very hot climates. Having tall steel buildings clad in glass in hot climates is a thermal disaster. I assume they will eventually have to be taken down.

Gerald Davis
I am interested in the effect of decisions to install solar panels. What do we know about the behaviour of people once they install solar panels? Do they tend to use more energy because it is cheaper?

Gavin Killip
It depends on the tariff systems in place. People change their use of certain appliances to make use of the sunshine.

Dominique Finon
A recurring problem for retrofit projects is the question of funding. In contrast to German banks which provide both funding and technical advice on retrofitting, French banks are not able to provide technical advice. Second, what is the situation in the UK with respect to condominiums?

Gavin Killip
Access to capital is indeed an important part of this story. Retrofit projects are seen as risky investments, and improving the quality and performance of the construction industry would contribute to abating those risks. Second, the UK does not have a high proportion of condominiums. I understand that they pose a major problem in France.

Kathleen Gaffney
I agree that funding comes down to questions of risk management and scale. There is no appetite within banks for small projects. That could be improved through the use of de-risking measures and greater standardisation of such projects.

Dominique Auverlot
There are 2 objectives in both retrofitting and new builds: reducing greenhouse gas emissions and increasing energy efficiency. How can we reconcile these 2 goals?

Kathleen Gaffney
I believe that retrofitting has huge potential to help us achieve both objectives.

Gavin Killip
We should, of course, measure greenhouse gas emissions. However, when it comes to buildings, the real metric we are interested in is energy. If we trade-off one against the other, we will clearly not be able to achieve our goals.

Dominique Auverlot
However, the primary goal for 2050 is not zero energy but carbon neutrality. There is therefore a conflict of priorities between the 2 goals.

Gavin Killip
This results from a confusion between means and ends. The primary goal is zero carbon. However, in the building sector, the way

to achieve carbon neutrality is through energy efficiency.

Kathleen Gaffney

I agree. There is a growing demand for energy in buildings. If we only consider the question of CO_2, we would continue to grow the number of buildings and the energy consumed. By focusing on energy efficiency first, we can reduce the burden on the energy system and reduce the costs of the energy transition.

Gavin Killip

We should beware of trade-offs that look attractive superficially but that take us away from our objectives.

Einari Kisel

Many houses in Estonia still use firewood. If retrofitted, they will use natural gas. Those types of trade-offs have to be taken into account.

I would ask our panellists to provide their takeaway messages from this session.

Paula Hallonsten

I am pleased to see that we have discussed practical action rather than just theoretical policies.

Gavin Killip

My key message is not to think only about energy systems or energy industries. It is also necessary to engage with the construction industry.

Kathleen Gaffney

We already have the technology we need to achieve the energy efficiency outcomes we want. It is complicated, but less complicated than other supply side options that require significant investments. Energy efficiency is therefore a low-hanging fruit that we should take advantage of.

The Cost Advantages of the Transition to Low-Carbon Urban Mobility

Moderator: Francis Duseux
President, Union Française des Industries Pétrolières (UFIP) – France

This morning will be devoted to urban mobility from a broad perspective that includes a range of issues from air quality to purchasing power. This was particularly highlighted in France with the* Gilets Jaunes *movement but is evident throughout all European countries.

Electric vehicles appear to be a silver bullet solution here, but I remain sceptical concerning their capacity to resolve all the issues we face. Electric vehicles are still more expensive than thermal cars, and we do not have enough charging points in our countries. The capacity to charge such a large number of cars will also require a change to electricity networks. We also have to consider the source of the electricity used, and the issue of batteries.

I. The Costs and Advantages of the Transition to Electric Mobility

Dominique Auverlot, Project Manager, Ministry for an Ecological and Inclusive Transition – France

I will consider the question of electromobility from seven different perspectives: greenhouse gases, technological, microeconomic, environmental, electricity system, macroeconomic, and industrial.

1. Seven Perspectives on Electromobility

First, the perspective of greenhouse gas emissions which is a rather scary prospect and where a transition, if not a revolution, is clearly necessary. We are currently tracking towards a temperature rise of about 3 to 4°C by 2100. To reach only 2°C, it is necessary to further decrease world emissions by 30% compared to those which result from the pledges of the different countries after the Paris agreement. At the same time, it is necessary to avoid overshoot and reliance on the future large-scale deployment of CO_2 removal. That can only be done by starting to reduce global CO_2 emissions well before 2030. If that is not achieved, our world will surpass the 3.5°C - 4°C mark and, as a result:

- the tropical regions will be virtually uninhabitable;
- the plankton will disappear from the sea, as well as the larger sea life;
- the vast majority of humanity will migrate to high-latitude areas, Canada, Siberia, Scandinavia in the northern hemisphere,
- Saharan deserts will expand into southern and central Europe.

It would be a world of increased migrations in which democracies would be threatened. In short, a 4°C world would be another world.

In that context, a transition to 1.5°C is preferable to a transition to 2°C. But, to achieve it, we must undertake much more drastic reductions in greenhouse gas emissions and, in the longer term, 2050, maybe 2070, reach a carbon neutral world. Given that transport represents 20% of global greenhouse gas emissions, we must choose energies with no GHG emissions, or with no hydrocarbons, which is a huge challenge. In this context, electromobility may be an ideal candidate for helping us reach our objectives.

Second, the perspective of technology. Great progress has been made during the last twenty years. In the middle of the nineties, a battery of about 0,2 tons gave you an autonomy of about 40 kilometres. At the end of the 2000's, the same weight of Li-Ion batteries provided you with an autonomy of about 170 km: electric vehicles were doomed to daily travels and hybrids cars were necessary for long travels. Nowadays, that same battery of about 0.2 tons gives you an autonomy of about 280 km and passenger vehicles with a battery capacity of 60 to 80 kWh can travel long distances. Moreover, another wave of progress expected to take place in the next decade will increase once more the energetic density of batteries from 280 Wh/kg today to 350 Wh/kg by 2025. That will open up the possibility of electromobility to heavy-duty vehicles: according to IEA, electrical heavy trucks with an autonomy of less than 500 km (which is sufficient for most of the regional trucks) should become profitable. According to Roland Berge's experts, but I have second thoughts on that, even electric aircraft could be seen: in their view, the first hybrid airplanes could make fare-paying flights between Paris and London in 2032.

Third, the microeconomic perspective. From 2010 to 2025, it is estimated that the kWh cost of a Li-Battery cell will have been reduced by ten, representing a significant contribution to the reduction in the cost of electric vehicles. As a result, with a carbon tax of €150 per tonne of CO_2 and a battery costing €125 per kWh, the costs of thermal and electric vehicles will be roughly equivalent.

The cost difference between the two kinds of vehicles is mainly determined by four factors:

(a) Battery costs that have seen a sharp decline for several years,

(b) Production costs that will decrease under the influence of mass production and of the competition between the carmakers,

(c) Carbon taxes which enable to reduce the fuel consumption but which is not the main factor,

(d) Diesel prices that may vary a lot!

Fourth, the environmental perspective. For that, it is necessary to consider the cost of urban atmospheric pollution (see for instance: France Stratégie's report on the *Cost benefit assessments of public investments*). When the polluting costs of diesel are taken into account, the average diesel vehicle (cars, Euro 2 or 3, not equipped with a particle filter) is already more expensive than the electric vehicle in dense urban towns. However, it should be noted that some new diesel vehicles are much less polluting.

Fifth, the perspective of the electricity system. It is necessary to rethink the interconnection between automobiles and electricity systems. The production, transmission and distribution of electricity, and the electric vehicles themselves, will all form part of a single system in

the future. That is, batteries will not be passive objects like car fuel tanks. Rather they will be used to regulate energy supply in grids. They could even be used to supply energy to the grid or to homes during periods of peak demand. As a result, the cost of electricity used to charge them will be reduced, as well as the invoice for an electric vehicle user.

The annual total costs for the State and the citizens (so without any tax) of 15.6 million thermal or electric vehicles in 2035 were globally calculated by the French national grid (RTE). The annual total costs of electric and thermal vehicles are roughly the same, about 50 billion euros per year and RTE has estimated that, in the most expensive scenario, the additional costs for electric vehicles amount to €5 billion, primarily the cost of charging stations. However, that would save 20 million tons of CO_2 per year, which at €250 per ton, also amounts to €5 billion. So, according to their calculations, even in a pessimistic scenario, the total cost of 15.5 million electric vehicles would be equivalent to a thermal scenario, probably a bit inferior.

Sixth, the macroeconomic perspective, where we can see a wide range of impacts on employment. Most studies forecast a small increase in GDP but a number of major uncertainties remain, including oil prices, the future of the European automotive industry, and the location of battery production.

Seventh, the industrial perspective that is perhaps the most important point of all for our economy. The European automotive industry represents approximately 12 million jobs today, and this industry faces an unprecedented revolution. There is no consensus among economists but it would appear that the European automotive industry could lose in some cases a significant number of jobs, due to the development of the electric vehicle. The important aim for our jobs and our economy is in fact the market share and the value added that French and European car industries and firms in Europe will be able to achieve. It will also depend on the existence of industrial policies to promote R&D and to promote support for electric vehicle demand. So whatever the electric vehicles sales in 2040 may be, we must develop right now electric vehicles, for three reasons:

- to be able to withdraw the competition with Korean and Chinese automakers,
- to keep our industry,
- and to reduce our GHG emissions.

2. Conclusion

A new era of mobility, with long ranged electric cars and electric trucks, will be possible due to technological progress and a sharp decline in battery prices. Electric vehicles represent an industrial opportunity for France and Europe that we should not miss. To that end, it is necessary to develop electric mobility right now and, for the State, to implement the following three measures: a significant carbon tax in Europe, a European industrial policy, especially for the production of batteries, and the deployment of common infrastructures around Europe.

I will finish this presentation by noting that if, in the long run, electromobility may be an opportunity, in the short run, a hard Brexit will have a disastrous impact on the European automotive industry. On average, only 41% of car parts assembled in the UK are produced in the UK, and assembly of a Mini car requires three crossings of the Channel for completion (four if the car is sold on the continent).

http://wec-france.org/DocumentsPDF/Evenements/8-Forum-Europeen-Energie/Dominique-Auverlot.pdf

Francis Duseux

There are two key points that need to be considered. First, the carbon footprint of the electric vehicle throughout its lifecycle as compared to a thermal car. Second, 40% of electric vehicles around the world will use electricity that is generated by coal.

Dominique Auverlot

That is exactly the situation in which China finds itself: a higher level of CO_2 emissions generated by its coal-fired power plants and its

electric vehicles than by its thermal vehicles. Nevertheless, electric vehicles contribute to a reduction of pollution in cities. In Europe, we must bear attention to the location of future batteries production factories: better putting them in countries where electricity is already almost decarbonized than in countries where electricity is generated by coal-fired power stations!

II. The Costs of the Transition to Low-Carbon Mobility in France: A CEA-IFPEN Study

Jean-Guy Devezeaux de Lavergne, Manager, I-Tésé, CEA – France

I will present a CEA-IFPEN study on the costs of achieving a low-carbon world by 2040, with a focus on the electric vehicle. The study involved the use of a technological foresight, a consideration of the strategies of the main actors, and an examination of the infrastructure needed for electric and hydrogen mobility.

The vehicles considered in the study included thermal vehicles, hybrid electric vehicles, plug-in hybrid electric vehicles, battery only electric vehicles, and hydrogen fuel cell electric vehicles.

The following 3 scenarios were considered:

- Median: based on reduced costs for batteries and fuel cells, and an increased carbon tax.
- Pro-batteries: based on accelerated R&D on batteries leading to a further 50% cost reduction by 2030.
- Pro-hydrogen: an additional reduction in the price of fuel cells.

1. Main Results

Who are the winners and losers? The study was designed with a relatively neutral impact for households, thanks to different systems of subsidies and decrease in taxes (no additional taxes on vehicles or electricity). On the basis of the ambitious but realistic assumptions made, the total ownership costs of the different vehicles would fall for households, contributing to their social acceptability. Subsidies can help reduce the total cost of ownership of electric vehicles and thus increase the speed of the transition. Ultimately, therefore, it is the state and local authorities that will bear the cost of that transition.

Decarbonisation will require the progressive electrification of the French fleet, with the development of hydrogen vehicles witnessed post 2030 in all cases and made significant in the Pro-Hydrogen scenario when several conditions (subsidies, cost of electricity, fuel cell price reduction) are met.

There are a number of benefits of the transition to low-carbon mobility in France. The main benefits include the reduction in CO_2 emissions and a better balance of trade. Other benefits include a reduction in urban pollution (NO_x, SO_x and particles). There will also be an impact on the French car industry and associated services.

As to the costs of the transition, we first considered the costs of the infrastructures (primarily charging points) required for electric vehicles which could amount to between €40 billion and €100 billion as a whole.

The taxation regime is also a key component of any mobility transition, and France's *Gilets Jaunes* movement has highlighted the fact that fuel taxes are not redistributive in nature. In this, the need to adopt a fair tax regime must be taken into account. In this study, the level of carbon tax is equivalent to 1 euro/liter in 2040.

However, there will also be a €20 billion/year loss in tax revenues from fuel sales, and those tax revenues will have to be replaced, perhaps by a tax on low carbon vehicles.

Given the current situation, we know that we have about 10 years ahead of us for setting up all of these measures.

2. Total Costs

On average, the total impact on households is quite neutral (see above), although there is some issue regarding the burden sharing between cities and rural areas.

For the French state, costs will amount to approximately €40 billion per year up to 2040.

For foreign countries and oil producers, there will be a loss in the range of €40-60 billion per year, depending on international oil prices. Thus, the energy independence/security and trade balance will be very significantly improved with such a policy.

3. Conclusion

The deployment of low carbon electric vehicles appears to be feasible by 2040, provided that the assumptions as to the cost and performance of those vehicles hold. The main benefits are quite significant both in terms of a reduction in CO_2 emissions and a more favourable balance of trade. The total cost for the state (and in a very lesser extent households) would amount to roughly €500 billion to 2040 with a significant loss in government revenues from fuel taxes after 2030. But that leaves us with at least 10 years to prepare for this new era.

Of course, many caveats apply to these types of studies. It is necessary to use macroeconomic models to take into account the combination of technical, fiscal and trade impacts. In addition, the technology can be expected to evolve as we go forward.

http://wec-france.org/DocumentsPDF/Evenements/8-Forum-Europeen-Energie/Jean-Guy-Devezeaux.pdf

Francis Duseux

With respect to CO_2 emissions, all the studies show that it is necessary to consider the carbon footprint for the entire lifecycle of the car. I also believe that it is highly unlikely that the carbon tax will be increased in France.

Jean-Guy Devezeaux de Lavergne

The decarbonisation of electricity will occur in France and Europe, notably through the use of renewables and, possibly, nuclear energy. It is also necessary to continue efforts to produce cleaner and more efficient vehicles.

Francis Duseux

However, the production of batteries is also responsible for emitting significant volumes of greenhouse gases.

III. Fuelling Europe's Future – How the Transition from Oil Strengthens the Economy

Jon Stenning, Associate Director, Cambridge Econometrics – United Kingdom

1. Study Details

I will be presenting our work which is based on macroeconomic models. I will focus on cars but many of the same implications also apply to heavy-duty vehicles.

The study was commissioned by the European Climate Foundation. Rather than working in an ivory tower, stakeholders were consulted throughout the project, including representatives of the automotive sector, the battery sector, the energy sector, trade unions, consumer organisations and NGOs. The aim was to ensure that we reflected the most up-to-date information, used the most realistic scenarios, and that our overall picture was sensible and deliverable.

A two-stage modelling approach was taken: stock models allow us to understand the implications of new vehicle technologies, including the different consumer spending profiles. That provided the inputs to the macroeconomic models that allow us to understand what this means for GDP, employment and investment across Europe as a whole. We assumed that thermal vehicles (ICEs) and hybrid vehicles would be phased out of new sales by 2035.

There are 3 key macroeconomic impacts. First, trade: EU spending on imported oil is reduced in favour of more domestic activity. As less diesel and gasoline are used, the amount of capital leaving the EU economy to buy oil is reduced. Second, more will be spent on vehicles, and that should mostly be captured by European companies. However, some uncertainties remain with respect to the location of battery cell production. Third, overall, less will be spent on mobility as low carbon technologies are more efficient.

2. Impacts on the Economy

What does this mean for the economy at large?

The net impact for the European economy is positive, with a small net increase in GDP (0.1-0.2%).

The net impact on employment is also small but positive. By 2030, 206,000 jobs will be created although the jobs impact will vary by economic sector. There will be a slight increase in employment in the automotive sector, but that should decline after 2030 reflecting the switch to simpler battery electric vehicles which are less labour intensive. There will also be a decline in employment in the fuel sector, reflecting reduced demand for fossil fuels. There will be an increase in employment in the electricity and hydrogen generation sectors, which are Europe based. New value chains will be created, notably in the electrical components that are required for electric vehicles and fuel cell vehicles. A proportion of these will be based in Europe. The service sector has the most to gain in terms of employment. The modelling shows that 50% of the increase in net employment concerns service jobs.

The net impact on fuel duties is a loss of €55 billion by 2030. However, this will be offset by compensatory taxes, and by increased income tax revenues and VAT resulting from a net increase in consumer spending, GDP and employment. As such, government finances will not be significantly affected by the loss of fuel duties, and this is therefore a manageable transition.

In terms of the implications of unmanaged charging on the electricity network, it was found that an increase in generating capacity was required. However, investing in smart charging will allow charging to be spread over periods of low demand. The study showed that the investment costs of smart charging will therefore be cost effective.

Overall, then, we can see that the transition can be achieved without imposing significant macroeconomic costs. In addition, air quality will be dramatically improved.

3. Conclusion

The transition to low-carbon mobility is technologically feasible. It is also both economically and ecologically desirable. This is therefore a win-win transition.

Nevertheless, a number of challenges must be overcome. First, it is necessary to support

the deployment of sufficient infrastructures to inspire consumer confidence. Second, electric vehicles must be integrated into the grid through smart charging technologies. Third, the impact of job losses in traditional automotive and petrol refining industries must be mitigated through re-skilling and development programmes. We must ensure that those who will lose from the transition are not left behind in the post-industrial landscape but are offered alternative solutions.

http://wec-france.org/DocumentsPDF/Evenements/8-Forum-Europeen-Energie/Jon-Stenning.pdf

Francis Duseux

You have demonstrated that the transition will lead to a significant improvement in air quality in our cities. The potential increase in sales taxes could be an issue for public acceptability. You stated that the net impact on employment is positive but that remains questionable. Finally, while Europe will spend less on oil, that means that oil exporting countries will buy fewer European products and services.

Jon Stenning

The study does indeed analyse those trade effects in both directions. The modelling takes into account global macroeconomic effects — which is to say that lower foreign purchases of European goods and services as a result of lower demand for oil is taken into account. The modelling presents one potential method for balancing government incomes (through increased sales taxes) but alternative measures (such as road charging) are a more likely replacement for the reduced fuel duty revenues, since they also address the issue of congestion.

IV. Questions & Answers

Gerald Davis

On the automotive side, what will happen in spatial terms: electric vehicles will not be built in the same factories and locations as thermal vehicles were built. That will have an impact on redistribution issues. Second, recycling is a major issue for batteries. It is difficult to envisage a world where we fully commit to climate change resolution but not to other aspects of sustainability. What plans does the French state have for the recycling of batteries?

Jean-Guy Devezeaux de Lavergne

Action is underway in the European Commission to promote the construction of giga factories for batteries in Europe.

Jon Stenning

Today, batteries are bought from China because the level of domestic demand is still relatively weak. Going forward, battery production should shift to Europe but this will probably be focused on Eastern Europe. As to recycling, this is a key part of the puzzle, and the European Commission is looking at this very carefully.

Francis Duseux

It is estimated that establishing a battery manufacturing capacity in Europe would cost €70 billion. To date, Germany has announced that it is ready to spend €1.2 billion and France is ready to spend €0.8 billion. Some therefore argue that it will be impossible to manufacture batteries in Europe.

Jon Stenning

There is also the question of who is doing the investing: will it be European companies?

Dominique Auverlot

The real question is whether European-produced batteries will be competitive with those produced in China and Japan.

Jean-Guy Devezeaux de Lavergne

How quickly will we be able to build these factories in Europe? It takes much more time to build a factory in Europe than in Asia, for example.

From the floor

It would also be possible to reduce greenhouse gas emissions by developing more efficient thermal cars. What is being done with respect to greenhouse gas emissions in maritime transport and aviation?

Jean-Guy Devezeaux de Lavergne

Building more efficient thermal cars is indeed something that should be further explored. With respect to aviation, we are beginning to look at the use of biofuels, and that should become increasingly feasible in the coming decades.

Dominique Auverlot

The cost of the electric vehicle will have a major impact on the take-up of this technology. That cost should be reduced rapidly as we go forward, especially if we have the right standards and regulations in place.

Einari Kisel

We have not spoken about the potential of electric vehicles to support the electricity system. Today, car manufacturers are not producing cars that can "speak" to the electricity system. It may be necessary to provide the appropriate incentives to ensure interconnectedness between the vehicle and the grid.

Dominique Auverlot

An RTE study released 2 months ago addressed this very point for France. The study also showed that consumers can reduce their electricity bills by returning electricity to the network via their electric vehicles.

Jon Stenning

This is a technological issue: vehicle to grid integration could reduce the effective life of the battery.

From the floor

A major advantage of electric vehicles is that they could potentially be used as a storage solution for intermittent renewable energies.

Dominique Auverlot

I agree that storing electricity is a major issue in the further development of renewables that has to be resolved.

Jean-Guy Devezeaux de Lavergne

A great deal of work has been done by RTE and other analysts, showing that this should not be an issue by 2030-2035 for France at least.

Francis Duseux

It is clearly necessary to reduce greenhouse gas emissions and improve air quality. However, I remain sceptical about the timeline for this transition and about its costs. If this is not done progressively, it will not succeed. In addition, 40% of the world's electricity generation is still coal-based. If that electricity is not decarbonised, we will not be able to meet our climate objectives.

SESSION 5

Who Will Pay? Burden Sharing and Social Feasibility of Different Transition Policies

Moderator: Jean Eudes Moncomble
Secretary General, Conseil Français de l'Énergie

The preceding 3 sessions of our Forum focused on sector based issues. We will now move to a more general discussion on burden sharing and social acceptability. You will all be familiar with the* Gilets Jaunes *movement in France, which was initially triggered by a fuel tax linked to the energy transition. It is a perfect illustration of the fact that the question of costs is clearly associated with the question of social acceptability.

I. Costs in the UK's Energy Transition

Mike Hemsley, Senior Power Analyst, Committee on Climate Change – United Kingdom

I will be focusing on the costs of the UK's energy transition. The Committee on Climate Change advises the government on long-term climate targets, in particular with respect reducing emissions in the UK's electricity system at the lowest cost. A similar body has just been set up in France: the *Haut Conseil pour le Climat*.

1. The UK Climate Change Act 2008

The UK Climate Change Act 2008, the first of its kind in the world, set up the Committee on Climate Change (CCC) and committed the UK to an 80% reduction of greenhouse gas emissions by 2050 based on 1990 levels. That was consistent with the global 2°C temperature target. A measure is being introduced to UK Parliament today to raise that target to 100%.

The Climate Change Act 2008 also set a pathway to reach that target: carbon budgets which break up the period from 2018 to 2050 into 5-year periods. The government then has to put into place a plan and policies to meet those carbon budgets.

The UK has now set 5 legislated carbon budgets that are stepping stones to the 2050 80% target. The latest budget covers the period 2028-2032, and commits the UK to a 60% reduction in emissions by 2032. Today, the country is halfway to its target largely through the decarbonisation of electricity generation, a shift in industrial processes, and the reduction of emissions from waste. However, the second half of that journey will be much more difficult – especially given that the target has now been raised to 100%.

The CCC has shown that, since 2004, the increase in low-carbon policy costs on household bills has been more than offset by the savings achieved through energy efficiency. Without energy efficiency, the price changes since 2008 would have pushed annual household energy bills to £1,460. However, reduced consumption since 2008 has helped cut bills to £1,160. Those savings are primarily the result of higher

UK and European appliance standards. For example, energy-efficient lighting represented 10% of lighting stock in the UK in 2008. It now represents over 50%. A-rated fridges have gone from 10% of stock in 2004 to approximately 70% in 2015.

Going forward, low-carbon costs are expected to rise to 2030 in order to meet the 5th carbon budget. However, future opportunities for energy efficiency are expected to more than offset the impact of those low-carbon policies.

2. Net Zero Target

In May, the CCC recommended that the UK should legislate as soon as possible to reach net zero greenhouse gas emissions by 2050. That target should cover all sectors of the economy, including international aviation and shipping. It should also be met through domestic efforts in the UK, without relying on international carbon units or credits. This is one of the most ambitious targets to be set by a country in the developed world, and it will put the UK ahead of the pack for meeting the Paris Agreement.

The CCC has called for government policies to support the target. The net zero target is only credible if the government ramps up its policies to reduce emissions. The overall costs of this are manageable, representing 1-2% of GDP per year up to 2050. That is, we will be paying £20-40 billion per year more today than we would in a high-carbon world. By 2050, we would be paying £40-80 billion per year more. That is, the UK will be as rich by September 2050 as it would have been by January 2050. Nevertheless, the costs must be fairly distributed, and the CCC has recommended a Treasury review of how the transition will be funded and where the costs will fall.

In order to reach net zero emissions in the UK, efforts will be required with respect to energy supply, energy use, and land use. Today, about 50% of the UK's electricity supply is low carbon, compared to 25% ten years ago. It is also necessary to decarbonise energy use across the economy: homes, businesses, transport and industry. That will require a doubling of the electricity system compared to today. Electrification cannot cover all uses, and that is where hydrogen will play a role. The UK currently produces 27 TWh of hydrogen per year but not in a low carbon manner. We would have to increase that production by a factor of 10, and do so in a low carbon manner. That would require building a hydrogen production infrastructure similar to that of electricity production.

Some industries, such as cement, cannot be electrified or switched to hydrogen. Carbon capture and storage would therefore be required for those sectors. Finally, net zero can only be reached with a reduction in the growth of aviation and agricultural activities. Those residual emissions can be addressed through reforestation programmes and through bioenergy.

3. Conclusion

The switch to low-carbon heating (heat pumps and hydrogen) has a cost, but that can be offset by the reduction in costs for zero-carbon power and transport, and by the savings achieved by energy efficiency. Those costs will have to be managed to ensure a fair distribution, and we have recommended a Treasury review of the costs to see how they can best be allocated.

http://wec-france.org/DocumentsPDF/Evenements/8-Forum-Europeen-Energie/Mike-Hemsley.pdf

II. Incentives and Solutions – Combining CO_2 Taxes and Energy Policy in Sweden

Tea Alopaeus, Climate Analyst, Swedish Environmental Protection Agency – Sweden

Sweden has had a carbon tax in operation for almost 30 years, and I will show how we have combined that with our energy policy.

In the period from 1990 to 2016, Sweden reduced greenhouse gas emissions by 26%. In the household and service sector, the reductions reached 90%, compared to only 16% for the domestic transport sector.

1. Sweden's Regulatory Framework

Sweden has a population of 10 million living mostly in urban areas. It has a very open economy, with exports representing 46% of the economy. It relies heavily on forestry, and the iron and engineering industries. Electricity production is dominated by nuclear and hydro power. In terms of culture, Swedish people have a high level of trust in society.

In 1998, the government started a program focusing on renewables and energy efficiency with the objective to phase out nuclear power. The Climate Strategy was launched in 2001, and a combined energy and climate bill was released in 2009. More recently a climate framework was launched in 2017, similar to the UK climate framework. A tax reform in 1991 introduced the CO_2 tax. Soft policy measures included the creation in 1998 of municipal advisory services for SMEs and households. A major information campaign on climate change was launched in 2002-2003.

The CO_2 tax was introduced in 1991, providing a basic level of tax (then €0.02 per kg of carbon, now at the level €0.12 per kg of carbon) for households, services and the transportation sector. This took the form of a tax shift: the energy tax was reduced and the carbon tax was introduced. A further shift occurred in

2000: labour taxes were reduced, and the carbon tax was raised. A reduced tax applies to agriculture and industry in the EU ETS. Industry outside EU ETS has since 2018 the full basic level of carbon tax.

The Swedish Environmental Protection Agency advocates packages of policies combining the carbon tax with other policy instruments. For example, the package for households and services includes carbon and energy taxes as well as measures for technology development and deployment. At the same time, energy efficiency policies were deployed in the form of building codes, technology procurement, and government funded municipal energy advisory services. Public awareness of climate change rose dramatically, and CO_2 taxes and oil prices increased. When the carbon tax was increased and cost of heating rose a subsidy was given in 2006-2007 for the switch from oil heating to district heating and heat pumps. Since switching was so cost effective the subsidy was taken away after only two years.

2. Who Pays?

Generally speaking, it is households that pay. Total energy expenditure for households (including cars) as a proportion of total expenditure has increased, but only in a very limited manner. Approximately 80% of households pay 2-4% of their income for energy. Approximately 10% of households pay 20% or more on heating, electricity and petrol.

While households have paid, this occurred at a time of increasing disposable income. Households adapted to that by shifting from the consumption of fossil fuels. The number of jobs in the building sector has also increased. Jobs are protected and carbon leakage has been avoided by a reduced tax for industry. That is not fully cost-effective but it contributes to acceptability. The CO_2 tax generates approximately 2% of government revenues, but the energy budget represents approximately 0.3% of expenditures.

3. Conclusion

In order to make policies effective and acceptable in Sweden, CO_2 taxes have been part of a larger tax reform that also includes a reduction in energy and labour taxes. Public understanding of the problem has been crucial to acceptability of the measures, and attractive alternatives to fossil fuels have been made possible by policy packages.

Sweden's new climate policy framework entered into force on 1 January 2018. It requires the government to produce annual climate reports for Parliament as part of the budget bill. A climate action plan must be launched every 4 years, describing how the climate goals are to be achieved. The long-term goal is to reach net zero emissions by 2045, with intermediary goals set for 2030 and 2040. The most challenging element here is the 70% reduction target for emissions from domestic transport from 2010 to 2030. The Climate Policy Council is responsible for assessing whether all government's policies are compatible with Sweden's climate goals. It released its first report in March 2019.

http://wec-france.org/DocumentsPDF/Evenements/8-Forum-Europeen-Energie/Tea-Alopaeus.pdf

III. The Socio-Political Drivers of Energy Transitions

Solange Martin, Sociologist, ADEME – France

I will present work carried out by ADEME on the expectations of French citizens with respect to climate change. The figures probably reflect the general situation in Europe as well.

1. Do People Care about Climate Change?

What are the environmental issues that people care most about? An ADEME study on a range of environmental issues showed that climate change and biodiversity were the 2 environmental issues about which the French cared most. Interest in these issues varies over time depending on levels of media and public awareness.

What are the consequences of climate change? People are increasingly concerned that climate change will lead to extremely difficult living conditions.

Will it be necessary to adapt to climate change? 82% believe that changes will be necessary at the local level, and only 13% believe that adaptation will not be necessary.

Will climate change remain at acceptable levels to the end of the century? 58% believe that that will not be the case.

2. Whose Is Responsible for Actions Against Climate Change?

Is it necessary to act to prevent climate change? Only 1 out of 2 French people think a lifestyle change is necessary. For the first time, people feeling that it is all too late and nothing can now be done to avoid climate change reach 17% of the population.

Who is best positioned to resolve the problem of climate change? The majority of people believe that governments, international authorities and local authorities are best placed to respond to climate change.

Who should take concrete action? The majority of people feel that companies should take action, followed by governments and individuals. 89% of people believe that companies should be obliged to be more responsible in their production processes.

Almost one-quarter of people (23.7%) are unwilling to act at all. Of these, 64% are men aged between 35 and 59 years of age. They tend to be shopkeepers, agricultural workers, factory workers or unemployed, and were overly represented in the *Gilets Jaunes* movement. They are clearly not on board for the energy transition.

3. Political aspects of the transition

59% of people believe there is consensus on climate change among scientists. 37% believe there is no consensus at all. 66% trust in scientists to correctly evaluate the risks of climate change, and 29% believe that scientists are overly pessimistic.

When it comes to trust in public institutions, the institutions that obtain over 50% of trust include hospitals, schools, and SMEs. In contrast, government institutions, political parties, media, trade unions, and banks obtain a score below 50%.

When it comes to political institutions, none obtain more than 50% trust apart from local authorities.

When it comes to equity in the transition, 91% of the French think that products are deliberately designed to wear out or break down rapidly. 74% believe that government favours the lucky few, and only 23% believe that government works for the greater good of all.

4. Impact of a Carbon Tax

In terms of a willingness to change one's lifestyle, 77% of the French would be willing to change provided that the impact is fairly shared among all members of society. Equity and fairness were the key factors here, followed by the need for collective decision-making.

In terms of the impact of a carbon tax on household revenues, the global energy bill reaches €2,200 per year for the poorest 10% of households compared to €3,600 for the richest 10% of households. However, the impact of the carbon tax is in inverse proportion to the level of revenues, amounting to 1.8% for the lowest income households and only 0.4% for the highest.

A degressive redistribution of the carbon tax would make it possible to reduce those social inequalities.

5. Conclusion

Leaving the transition to individual behaviours only is unrealistic and would be considered illegitimate by citizens. The demand for equity requires action from all types of actors (individuals, companies, public authorities, and so on). Those actions will depend on the impacts on each actor, and on their own capacity to act.

Barriers to a change in behaviour are less related to the transition itself than to the context of a mistrust in those who hold power, whether it be scientific, economic or political in nature. Finally, for the transition to be socially acceptable, the whole of society has to become fairer and more inclusive.

http://wec-france.org/DocumentsPDF/Evenements/8-Forum-Europeen-Energie/Solange-Martin.pdf

IV. Questions & Answers

Francis Duseux

We have seen that the French are generally in favour of the energy transition but only 20% of the population is actually prepared to pay – and they are mostly retirees. Second, Sweden began by lowering fuel taxes before introducing the carbon tax. France has done the opposite, raising tax after tax. Is petrol cheaper today in Sweden than in France?

Solange Martin

30% of people do not want to pay the additional costs of 5% for green electricity. They are generally low income earners or are hostile to the arguments of environmentalists.

Tea Alopaeus

I do not have the figures for oil prices in Sweden versus France. We did indeed reduce energy taxes before introducing the carbon tax. However, we still face a huge challenge in the transport sector as to whether or not to increase taxes. A 2018 study showed that approximately 50% of the population was in favour of paying higher prices for products that are seen as damaging to the climate.

From the floor

How much intermittent electricity is produced in Sweden? Second, why was no reference made to nuclear when presenting the UK electricity system?

Tea Alopaeus

The Swedish electricity system has changed considerably since 1990. In 2003, we introduced a system of renewable electricity certificates, and we increased combined heat and power (CHP) and wind power. Approximately 10% of Sweden's electricity now comes from intermittent sources. 2 nuclear plants were shut down in 2000 and 2002, but Sweden's overall nuclear capacity has increased. There will, however, probably be a phase out of 1 or 2 older stations in the near future.

Mike Hemsley

We believe that nuclear can be part of the solution in the UK, but renewable sources are much cheaper: we can buy renewables for £40-60 per MWh compared to £90 per MWh for Hinkley Point. We also see a role for gas in providing support for intermittent renewable sources.

Dominique Auverlot

If we were to decarbonise French industry, would we need to introduce a carbon border tax, for people or for industry?

Mike Hemsley

If industry is required to pay all the costs of decarbonisation, certain industries would clearly close. Other industries are able to pass on the costs of a carbon tax to consumers. Today, the UK compensates industry for the taxes it pays on electricity prices and on the ETS. Border carbon adjustments are being explored in the UK — they are very difficult to implement for certain products where the supply chain travels through many different countries.

Tea Alopaeus

The bulk of Swedish industry is part of the ETS system. Industries that are outside the ETS and now face a carbon tax have to an extent already shifted from oil to natural gas or electricity. That transition has occurred quite smoothly to date. Investment grants to climate change actions may have played a role.

From the floor

When it comes to hydrogen production, how do the costs compare to fossil fuels?

Mike Hemsley

The cheapest way to produce hydrogen is through natural gas. It should be possible to capture and store the CO_2 released by that process, and that would cost approximately twice as much as natural gas. Biomass would be 2-3 times more expensive than producing it via gas but may, nevertheless, be worth doing.

Gerald Davis

How do we best serve poorer households which tend to have older and less efficient housing, appliances and cars?

Tea Alopaeus

We have a threefold strategy for the transport sector in Sweden: efficient use of transport systems, efficient vehicles including EVs, and a quota system (renewable energy obligations) for the use of renewable fuels. During the transition period, people will continue to use their old cars but there will be more renewable energy mixed into the petrol used. That is probably the most effective solution for people living in rural areas.

Solange Martin

We saw that different social strata react in different ways to energy policies. The rich are able to invest in new appliances and so on, making them more efficient. A redistributive system is necessary to increase purchasing power among the lowest income earners, and provide them with economic incentives.

Jacques Maire

What is the relationship between taxes and standards? Second, how will Brexit impact on the UK energy system?

Mike Hemsley

Brexit should not affect energy in the UK in a significant manner. The UK is likely to continue to reflect European standards and norms in its own laws. When it comes to electricity trading, it is more efficient to maintain the current arrangements. Finally, the UK will probably not be allowed to continue to participate in the EU ETS. Creating a new scheme within UK would be a huge administrative burden.

Jean Eudes Moncomble

Dominique Auverlot showed that Brexit would have a major impact.

Solange Martin

The ADEME believes that we need public instruments, no matter how unpopular they are. Taxes work well but can have a negative impact on incomes. That means that accompanying measures are required. The advantage of using regulations is that the end user does not have to bear the brunt of the impact.

Jean Eudes Moncomble

I would like to ask our panellists on the factors, apart from cost, that are most important in achieving social acceptability.

Solange Martin

Trust, equity, social justice and a real sense of meaning for the proposed changes. What really matters to people is knowing that a change is not meaningless.

Tea Alopaeus

Public awareness of climate change is key to acceptability. The challenge lies in the fact that we have so much to do in such a short period of time. Finally, the cost of inaction also has to be considered: Sweden has recently suffered from bush fires and water shortages, leading to greater public awareness of climate change.

Mike Hemsley

The biggest challenge lies in convincing people that we can achieve a low-carbon future. People are concerned about climate change but they are not at all optimistic that anything can be done to turn the situation around.

SESSION 6

How to Reduce the Cost of Transition to a Low Carbon Objective?

Moderator: Olivier Appert
Advisor, IFRI Energy Centre – France

It is a great pleasure to be here today. The energy transition involves moving towards an energy system that is sustainable in the long-term, as defined in 1987 by former Norwegian Prime Minister Gro Harlem Brundtland. She highlighted three distinct dimensions of sustainable development: the environmental, economic, and social aspects. We are all aware of the environmental aspects, but we often forget the economic and social aspects, as illustrated in the French "solar road" project which cost €5 million for 1 km of solar road and was withdrawn after only 2 years in operation.

The costs involved in the energy transition are substantial, and regularly estimated in hundreds of billions of euros. It is therefore imperative to reduce those costs, and that is precisely the subject of this final session of the Forum.

I. A Clean Planet for All: Financial and Economic Impacts

Lukasz Kolinski, Head of Unit for Economic Analysis and Financial Instruments, DG Energy, European Commission – Belgium

I will present the European Commission's 2050 strategy — *A Clean Planet for All* — and the accompanying in-depth analysis focusing on the economic aspects.

1. Key Aspects of the Strategy

The strategy was prepared in order to bring the EU in line with the commitments made under the Paris Agreement to keep the temperature increase to well below 2°C, and to pursue efforts to limit it to 1.5°C. The first objective would require the EU to reduce its emissions by at least 80% by 2050 and then reach climate neutrality. The second one – 1.5°C – is compatible with the net-zero GHG emissions by 2050. That is why – although the Commission's vision proposes to achieve climate-neutrality by 2050 for a number of reasons – in the in-depth analysis we look at a reduction in the range of 80% to 100% in net terms by 2050.

What will it take to bring the EU from the level of 24% in emissions reductions today to these levels of emission reductions in 2050? Energy plays a central role in the Strategy, but the Strategy goes beyond that to consider energy, transport, industry, buildings and so on. It identified 7 building blocks in the energy transition:

- Energy efficiency
- Deployment of renewables
- Clean, safe and connected mobility
- Competitive industry and the circular economy
- Infrastructure and inter-connections
- Bio-economy and natural carbon sinks
- Remaining emissions will be tackled with carbon capture and storage.

The Strategy was underpinned by 400 pages of analysis based on a suite of models covering economics, energy, and land use and agriculture. 8 different long-term scenarios were analysed. The first 5 scenarios are based on an 80% reduction in emissions: electrification, hydrogen, synthetic gases, energy efficiency, circular economy. They were combined in a 6th scenario to reach a 90% reduction in emissions. The 2 final scenarios are based on a net zero climate neutrality: one scenario achieves this through technology only, and the other assumes behaviour changes.

2. Macroeconomic Effects

The various models converge on the broad economic impacts of the energy transition. The impact on output could be slightly positive at best (+2.2%) or slightly negative at worst (– 1.3%). At the sectoral level, however, the impacts are more contrasted. Certain sectors such as the fossil fuel industries will shrink markedly (up to –50%). Other sectors, such as electricity supply or construction, are expected to grow significantly. Smaller net changes but a deep restructuring is expected in energy-intensive industries, manufacturing, and transport.

3. Investment Needs and System Costs

All of these changes require very significant investments for a sustained period of time. Excluding transport, the 80% scenarios imply annual investments of €468 billion on average in 2031-2050. That is equivalent to 2.4% of GDP. The 1.5°C scenarios imply annual investments of €547 billion or 2.8% of GDP. Today, the level of spending is at approximately 2% of GDP.

The highest investments are required in residential buildings (€230 billion per year for the net zero scenarios). Very high investments are also required in the power grid and in power plants (€180 billion per year for the net zero scenarios). Relatively high investments are required in industry with the development of new technologies to replace fossil fuels.

Additional investments over the baseline are also required. In the period 2031-2050, those additional investments represent 0.6% of GDP in the 80% scenarios and 0.8% in the 1.5°C scenarios. By far, the lowest additional investments are found in the circular economy scenario: €60 billion. Behavioural change also has significant potential to reduce the cost of the energy transition. As to the timing of the investments, the additional investments peak in 2040 at 2% of GDP in total.

Energy system costs are growing in absolute terms, peaking in 2030, with energy efficiency driving the reduction in costs. Energy related expenses for industry should represent 12-14% of industry value added by 2050. Household expenses increase up to 2030, after which energy efficiency effects reduce expenses as a percentage of household income.

4. Conclusion

For the energy transition to occur with the lowest costs possible, an enabling framework of policies going beyond energy and climate is required e.g. in the fields of competition,

taxation, industrial strategy and so on. Due to the deep changes ensuing from the energy transition, the social dimension is also critical at the EU, national, regional and local levels.

Olivier Appert

Both the IPCC and the IEA have highlighted the fact that nuclear and CCS are fundamental to any solution proposed. The Kyoto Protocol referred to both mitigation and adaptation. Does the EU strategy also cover adaptation?

Lukasz Kolinski

The focus of the strategy was on mitigation. However, even if the strategy is fully implemented, it will still be necessary to take adaptation measures. The strategy therefore includes an entire chapter on adaptation.

II. Containing the Costs of the Transition – Regulatory and Market Approaches to Minimising Financing Costs

Fabien Roques, Executive Vice President, Compass Lexecon – France

I will focus on the question of financing costs, in particular the need for a regulatory and market framework that will enable us to attract the financing needed for the energy transition. I will also explore the need to minimise the costs of that financing. The energy transition will require a great deal of capital, with very steep costs during the construction phase, followed by lower operating costs.

1. Trends in Energy Investment: Greater State Involvement

The IEA's *World Investment Outlook 2018* shows that the share of government-backed energy investment is on the rise. That trend is even more pronounced for the power sector, where government policies in the form of regulation or state-backed contracts are increasingly playing a major role.

These trends have emerged due to the changing cost structure resulting from the more capital-intensive nature of "clean" technologies. The industry cost base is moving from Opex to Capex, and investment decisions are increasingly based on some sort of long-term contract or regulation.

2. Efficient Risk Allocation

The greater involvement of governments is not a silver bullet for the reduction in costs. It simply shifts risks from one player to another. It is therefore necessary to ask which market design and regulatory framework would best promote an efficient risk allocation. A range of approaches are available to allocate risk, from the investor to the end user, and it is necessary to determine who is in the better position to assume those risks.

Economic theory suggests that risks should be allocated to those parties best able to manage them. The risks include planning and licensing risks, construction risks, operating risks, market risks, and policy and regulatory risks. Some of these risks should be borne by the public authorities.

Coordination mechanisms are also required for decarbonisation investments. Investments must be coordinated across networks and generation, and across subsidised generation and merchant generation. Today, the interface between public and market investments is far from optimal. As a result, a number of hybrid

power markets are emerging around the world, combining state intervention and competition.

3. The Cost of Capital

The drivers of the cost of capital include technology, grid connection, public acceptance, regulation, and policy risks. The perception of market and technology risks affects the cost of debt and equity for different technologies. As such, it also affects the cost of capital. We can reduce those costs by spreading the burden of risk, but that has not yet been achieved in Europe.

A DieCore study of the impact of risks in renewable energy investments showed that the most important risk for investors was policy design risk, closely followed by administrative risk, and market design risk. Those risks therefore have to be addressed in order to minimise the cost of finance. For example, having a contract for difference (CfD) in which the price of electricity is guaranteed can lead to a 0.3-0.9% reduction in the weighted average cost of capital (WACC). The reduction in WACC associated with infrastructure type regulations can reach 3%.

A recent report by the BBC showed that EDF is looking to reduce financing costs by adopting a new financing model: users will pay upfront in the form of a surcharge on their annual energy bills, and developers can borrow against that guaranteed stream of income. Analysts have stated that financing costs could thereby be reduced from 9% at Hinkley Point to 4-5%. However, critics argue that this new model shifts risk to consumers.

4. Conclusion

There is an ongoing trend towards greater state involvement in support of financing in capital-intensive energy technologies. This is particularly seen in the power sector, where public sector involvement in the backing of long-term contracts has emerged in many countries.

Public intervention can either hamper the functioning of markets or supplement it in a constructive manner. If properly designed, state backing and long-term contracts can reduce the cost of financing.

An efficient allocation of risk is essential to underpin the investment framework for the decarbonisation of the power sector. In this, there is a critical role to be played by risk-sharing mechanisms such as long-term contracts.

I will conclude with an appeal for further work on market design and the interface with financing costs and investment constraints.

http://wec-france.org/DocumentsPDF/Evenements/8-Forum-Europeen-Energie/Fabien-Roques.pdf

Olivier Appert
The market only provides very short-term signals to investors. Could the European Commission's Winter Package help here?

Fabien Roques
On the one hand, the Winter Package contains a number of elements on market design and the integration of renewables. On the other hand, the Package has not contributed to providing the more long-term signals required.

III. On Paradigm Shifts for European Climate and Energy Policy

Marc-Oliver Bettzüge, Director, Institute of Energy Economics EWI, University of Cologne – Germany

The first presentation took a central planning perspective on the energy transition: in which technologies should we invest and how much would those investments cost? The second presentation showed that the investments and behaviour changes required will be undertaken by private companies and individuals. Therefore, the relation between the central planning approach and what happens in the real world plays a significant role in the energy transition.

1. Preliminary Remarks

European targets for the reduction in greenhouse gas emissions have been set without a proper evaluation of Europe's interdependence with the rest of the world. Nor have they taken into account geopolitical risks, or the implementation and distributional challenges of those targets.

Furthermore, the costs of the transition have been systematically under-estimated due to the optimistic bias in the modelling approach, and the optimistic bias in the assumptions made. Similarly, the willingness of European consumers to pay for a marginal unit of fossil fuels in 2030 is not known.

2. Comparison of Central Planning Scenarios

I will compare 2 central planning scenarios or pathways within a consistent framework.

The Dena-Leitstudie considers the German energy sector (electricity, transport, and heating), assuming there will be no nuclear or CCS as that is the official position of most political parties in Germany. The main source of energy is therefore wind and solar, and the underlying assumption is an 80-95% reduction in greenhouse gas emissions relative to 1990. We can see that onshore wind and biomass in Germany will be exploited to their full potential by 2050, and the country has a limited amount of electricity potentially available.

A major increase in energy efficiency is therefore required to reach the country's emissions reduction targets. Primary energy consumption would have to decrease by 1.6-1.9% year on year over the next 30 years. In addition, the share of renewables in the final electricity mix will reach 50%. As such, the 95% target would be extremely difficult to reach and would require significant imports of zero-carbon fuels.

Near carbon neutrality will be difficult to achieve under either the aggressive electrification scenario or the technology neutral scenario. In terms of cost efficiency, it is necessary to decarbonise the electricity sector first before electrifying new applications. If we choose to aggressively electrify transportation and heating, more electricity will be required and this will be generated by gas or PtX. However, it would be preferable to use that gas or PtX directly in the transport and heating sectors.

Aggressively electrifying the economy is very expensive. The accumulated total additional costs amount to over €500 billion, driven by capital costs, electricity/gas infrastructure costs, and PtX import costs.

3. Conclusion

The electricity system is central to the energy transition, providing the opportunity for the lowest costs of decarbonisation. However, in Germany, that electricity is generated on an intermittent and distributed basis. This results in a temporal and geographical mismatch leading to the emergence of bottlenecks at all levels of the electricity system. It also means that flexibility is a key lever in reducing total system costs. Significant and sustained investment is therefore needed across all sectors of the economy.

There are 2 principal challenges for policy makers: they must provide useful short-term price signals, and they must promote efficient and effective levels of investment. What is relevant here is not the wholesale market level but the end consumer level where taxes, levies and grid fees are critical.

A new paradigm is required for European energy markets. The current paradigms date from the 1990s when all the necessary investments had already been made. The challenges we face for 2020 and beyond are quite different, and national policies are already deviating from the current paradigm.

I will conclude with a few questions for discussion. Can EU climate policy have an impact at the global level without reciprocity? Can Europe manage the transition on the basis of volume targets rather than carbon prices? Can member states deliver national energy transitions with all the distributional challenges that entails? How will that square with EU market integration and state aid? Can the liberal paradigm enable the investments that are needed at the level required without state intervention to reduce policy risks?

Olivier Appert

We have seen that the issues are much more difficult than we may have anticipated. It would seem that we are now at the edge of a cliff where there is no alternative but to move forward. In Germany, the equilibrium of the electricity market in 2050 can only be achieved through imports, and the ADEME reached the same conclusion for France. What will be the impact of energy policy on German industry and employment? Second, can we envisage a change in German policy following the European elections?

Marc-Oliver Bettzüge

To date, industry has been exempt from energy policy. This will, however, be undermined by the exit from coal which will lead to higher wholesale prices and the need for compensation for energy-intensive industries. This will therefore depend on whether Germany can continue to exempt industry from the burden of the policy. Second, it will be necessary to wait until next week's announcement by the Chancellor of what are expected to be relatively bold propositions on climate change.

IV. An Economic Assessment of Decarbonisation Pathways for Central and Western Europe

Pierre-Laurent Lucille, Chief Economist, ENGIE – France

I will provide a relatively technical comparison of a number of different pathways to full decarbonisation of the European energy system by 2050. The energy transition will be driven by energy efficiency, decarbonisation, and electrification. We analysed 2 different scenarios: (a) the massive electrification scenario, which includes the electrification of transport and heating, and (b) the multi-energy carriers scenario, which is based on a 50% electrification rate; heating is provided by electricity and green gas. We also compared those 2 scenarios to the business as usual scenario.

1. Pathways to Full Decarbonisation

The study found that sufficient renewable resources were available in Europe to support further electrification under both scenarios. However, the resources for biomethane are significant but not sufficient for the multi-energy carriers scenario, leading to a need for alternatives. Various sources are available for Europe to import green gas mainly from Northern Africa (synthetic methane) and Ukraine/Russia, with an import price of €60-75 per MWh in 2050.

Biomethane resources are fully exploited in both scenarios. Natural gas will continue to be essential during the transition period. By 2050, 500 TWh of hydrogen and 90 TWh of domestic synthetic gas would be needed, in the multi-energy carriers scenario.

It will be necessary to undertake a major shift in the pace of development of renewables. Under the massive electrification scenario, investments of 63 GW per year are required in solar PV and wind in order to reach renewable production of 3,540 TWh in 2050. Under the multi-energy carriers scenario, investments of 44 GW per year are required in solar PV and wind in order to reach renewable production of 2,660 TWh in 2050. Decarbonisation will also lead to a major shift from oil expenditures towards electricity and hydrogen. The global additional costs associated to the massive electrification scenario represent €650.

2. Conclusion

It is necessary to have a global vision of the energy system, including all its different interactions and interfaces. The Study has shown that there is a considerable difference in costs between the 2 scenarios. It also shows that the electricity mix should be based on technological diversity. Above and beyond the economic aspects, we have to address the question of risks which is also linked to the question of acceptability.

We saw that the multi-energy carriers scenario limits the costs and optimises the investments required. The global costs of this scenario are €650 billion lower than the massive electrification scenario. It requires fewer investments and will lead to lower volatility in energy prices.

The multi-energy carriers scenario also limits the risks involved. The use of natural gas in the transition phases will ensure security of supply, and there is a lower risk of failure for the energy transition. In the massive electrification scenario, the annual capacities of solar PV and wind installations must be doubled during the 30-year period, compared to the highest levels observed today.

I will conclude by saying that we have now reached a point in time where we cannot afford to make any mistakes.

http://wec-france.org/DocumentsPDF/Evenements/8-Forum-Europeen-Energie/Pierre-Laurent-Lucille.pdf

Olivier Appert

I was struck by the fact that no mention has been made of the network issues surrounding electrification and intermittence. It may be necessary to develop our networks within Europe, but that raises a question of acceptability.

Pierre-Laurent Lucille

I agree that this is a very sensitive subject. The priority should be on using existing networks such as gas infrastructures as much as we possibly can before we begin thinking about building new ones.

V. Questions & Answers

Didier Beutier

It is clear that we need to limit risk as perceived by investors. For example, with respect to UK investments in nuclear, it has been shown that the sharing of risk between taxpayers and project leaders can help to significantly reduce risks and thus costs.

Fabien Roques

Europe is subsidy-free but does have support mechanisms in place. Wind turbines have reached a level of competitiveness today, but that required significant investments in the past. It is necessary to introduce risk-transfer mechanisms, for example through a contractual arrangement.

Marc-Oliver Bettzüge

We tend to focus on the wholesale market and ignore the consumer level. In Germany, the electricity sector is already highly penetrated by wind power. Adding more wind in the same

meteorological region leads to a reduction in price, which makes the return on investments in the wholesale market even more difficult. That would not happen if the heating sector were able to pick up excess electricity during periods of high wind.

Salaheddine Soummane, CIRED

First, we have to consider European efforts towards the energy transition in their global context. If Europe succeeds in reducing its CO_2 emissions but other regions of the world do not, there will be no positive impact on climate change. Second, what are the consequences of the fact that Europe imports substantial quantities of Russian gas?

Lukasz Kolinski

The question of Europe acting in a global context is an important issue. There are existing international tools to fight climate change, notably the Paris Agreement. We have tried to model the macroeconomic impacts for the EU in a situation where the commitments of the Paris Agreement are met but also in a situation of fragmented action around the world. Comparison did not show significant differences for EU's GDP between the 2 options. Also, the European Climate Policy includes tools that target those industries that are exposed to international competition. This issue is closely monitored, and built into the work of the European Commission.

Marc-Oliver Bettzüge

Nothing in the Paris Agreement precludes the EU from having an NDC that includes pricing reciprocity and border tax adjustments. The quantity based approach is not enshrined in the Paris Agreement.

Dominique Auverlot

Several speakers have expressed doubts about the capacity of the electricity markets to attract the investments need. How can we ensure that those investments are indeed made?

Lukasz Kolinski

The European Commission is very aware of the fact that investors need policy framework predictability. This was an objective of the new electricity market design. However, during a transition period, it is difficult to ensure full predictability from the point of view of investors. That is inherent to all transitions.

François Dassa

Either the EU moves forward in an orderly manner so as to guarantee security of supply, or member states will move forward in an unorderly manner. Given the hundreds of billions in investment needed for the energy transition, how can Europe ensure that it does not lose out vis-à-vis Asia?

Lukasz Kolinski

The price of energy is higher in Europe than in the US or Asia. However, European industry has been addressing this issue for many years. The European industry is much more energy efficient, which means that the cost of energy is lower in Europe. For example, for the automotive industry, energy accounts for 2% of total production costs. Of course, an increase in the cost of energy may have an impact on competitiveness. Therefore, we will continue to closely monitor the situation.

Fabien Roques

I am sceptical as to whether there is a will to subsidise established technologies in Europe. Today's technologies will not suffice to bring about the energy transition, and it is therefore necessary to focus on the technologies of the future. States are back in the energy field. As a result, buyers will be able to negotiate contracts that include, for example, requirements for local European content.

Olivier Appert

We have not heard much about security of supply. I remind you a recent book by Austrian writer Marc Elsberg, *Blackout*, which is a technological thriller showing the major consequences of a black out induced by two cyber-attacks.

Francis Duseux

How high can costs be expected to climb in Germany in terms of what consumers will accept and in terms of what will make German industry non-competitive?

Fabien Roques

If we consider that the energy transition is a public good, its costs should be shared between industry and taxpayers.

Marc-Oliver Bettzüge

The German government is asking the whole of society — industry, business, taxpayers — to participate in the energy transition but the government itself is not contributing to it.

Olivier Appert

I would ask our panellists to provide their key messages from the session.

Pierre-Laurent Lucille

First, we need to consider the system in all its entirety – we cannot consider gas, electricity, renewables as separate systems. Second, we have to encourage investment – that is a key factor in this entire debate.

Marc-Oliver Bettzüge

First, the European policy landscape needs to clarify how it will reconcile its long-term pledges with its potential to change policies in the short-term. Second, Europe is not an island but part of a global battle against climate change. The geopolitical ramifications of all that we do cannot be ignored.

Fabien Roques

Our discussions have highlighted the interdependencies that exist among our countries. As a result, we need to define a European policy for the energy transition. We also need a framework for state aid, both by member states and the European Commission.

Lukasz Kolinski

We have the European *Clean Energy for All Europeans Package* but we also need more granularity on that at the national level. To that end, member states are preparing their national energy and climate plans for the period to 2030. Those finalised plans are to be issued by the end of this year. That is an extremely important step in translating the European policy framework into new policies and financing tools at the member state level.

CONCLUDING REMARKS

Jean Eudes Moncomble
Secretary General, Conseil Français de l'Énergie

I will not try and sum up the discussions of the past two days, but will go back over some of the ideas that emerged during our Forum.

I. Discussion Topics

We began by looking at the concept of the energy transition. We tried to understand what the transition is all about, and how it is different to previous transitions. We found that it was in fact quite original in nature, with a number of changes occurring in different sectors and a number of different pathways to be followed. We also considered the pace of the transition. We know that we must move quickly but, if we move too quickly, transition will be costly and then will slow down. We must implement the transition as quickly as possible but without crash. We therefore face a dilemma: we must implement the transition as quickly as possible but without crash.

We also carried out the interesting exercise of looking at the situation from a historical point of view. It is always very useful to look back to the past; that raises many valuable questions and considerations. If we go back to 1990, we can see that certain questions were on the agenda that no longer exist today, and *vice versa*. For example, we talked about technological revolutions back in 1990, a time when there was no internet and no smartphones. Is the technological revolution we are going through today more significant than the one from 30 years ago or the one we will face in 30 years' time? The answer to that question still has to be provided.

I was unsettled by the idea of objectives. When we talk about the energy transition, we are not necessarily talking about climate transitions. However, we have objectives that are often very diverse and even contradictory. We are not yet sufficiently clear about these objectives, for example with respect to biodiversity or the withdrawal from nuclear. To quote Seneca, "*ignoranti quem portum petat, nullus suus ventus est*" or a strong wind is of no use to those who do not know where they are going!

We then discussed the need to take a balanced approach to these issues. The environment is clearly a priority, but there are also other priorities to be considered: security supply, equity. We also talked about the need to see the energy transition as part of a global approach. That is a very important aspect that we should not lose sight of.

Another matter that emerged was the lack of consensus on definitions. For example, when it comes to overall costs, should network costs be included or not? As professionals in the energy sector, we cannot be ambiguous or equivocal. While this can be a complex subject leading to much confusion, we need to be more demanding and more precise in terms of our definitions. We need to have very concise ideas, and very clear definitions in order to properly and accurately express those ideas. For example, if

we talk about an avoided tonne of CO_2, we all need to be very clear on what that means.

Several times, we heard that positive synergies can be generated by coupling together several sectors. That became very clear when we discussed the housing sector or the transport sector, for example. And our discussions confirmed that this is an important feature of the "*Grande Transition*" we are going through.

We also heard about the need for systemic approaches. Looking at only one specific link in the chain will not help us progress. Rather, we need a much more systemic and global approach to move ahead in the right direction. One example is clean technologies, which are often indeed "locally clean" but can be "dirty globally" if a more systemic approach is taken.

II. Key Takeaway Messages

In terms of takeaway messages, there are four key ideas I would like to share with you.

- First, we face an investment wall. However we do things, however we look at them, we are going to have to obtain investment. That is an unavoidable condition for achieving our objectives, but there is no certainty that we will be able to implement these investments. A great deal of thought will be required as to how and where to find that financing. We live in a world where decisions are made at several levels: at the European level, at the national level, at the local level. We have to think about those decisions and how they are interrelated at these very different levels.

- Second, there can be no energy transition without public acceptance and indeed without public empowerment. We have seen the example of the *Gilets Jaunes* movement in France, which has highlighted the need for a just and fair transition. It means the cost of the transition must be shared more fairly throughout the whole of society. That will also involve awareness-raising among consumers and among the various actors involved. We must provide citizens with the relevant information to address their concerns, and allow them the opportunity to express their views and perspectives. In other words, we have to empower our citizens in this process.

- Third, it is important to see the energy transition as a major opportunity for industry. By having effective industrial strategies in Europe, we can help grow our economies and create jobs. The energy transition will help us improve both competitiveness and purchasing power. The Americans and the Chinese are very pragmatic in this regard, and it now falls on Europe to be pragmatic as well by setting up a genuine innovation policy and a genuine industrial policy.

- Fourth, we have the issue of governance, in particular at what level will the right decisions be made? Some decisions are best made at the European level, others at the local level. We need to understand that certain decisions are more appropriate at certain levels, and we need to ensure that we are making the right decision at the right level. Thinking about a "new" subsidiarity is an important deal for the energy transition.

I will conclude by thanking a certain number of people, starting with our presenters. I would also like to thank the members of the audience for their questions and comments, and I would like to thank you all for your patience and your interest.

I would also like to thank my partner in organising this Forum, Dominique Finon, who is responsible for its success. The report of the meeting will be posted in a special edition of our review, *La Revue de l'Énergie*. Finally, I would like to thank the CFE team for their wonderful work in organising the Forum.

I will close by saying thank you very much and see you next year!

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