

Experts & Stakeholders workshops

Synthesis report of the German
scenario workshops

Project: ENCI-LowCarb
Engaging Civil Society in Low-carbon Scenarios



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1. Expert Workshop about the German Transport Sector

Summary by Brigitte Knopf¹

1.1 Introduction

The EU aims at achieving 80-95% emission reduction in 2050 compared to 1990 levels. So far, the electricity sector has attracted the most attention in model analyses. As most models show, a complete decarbonization of the electricity sector by 2050 is feasible. The decarbonization of the transport sector, however, is a much more difficult task and most models rely still on diesel and gasoline for passenger transport in 2050.² Also in the new Energy Roadmap 2050 of the EU Commission the transport sector increases until 2020 and is responsible for about 25% of the total emissions in 2050 (see Figure 1). Therefore the motivation for the expert workshop on the German transport sector was to learn about the visions and ideas for possible emission reductions in the transport sector and secondly to get a detailed response from experts on technical parameters implemented in the model.

Figure 1: EU GHG emissions towards an 80% domestic reduction (100% =1990)

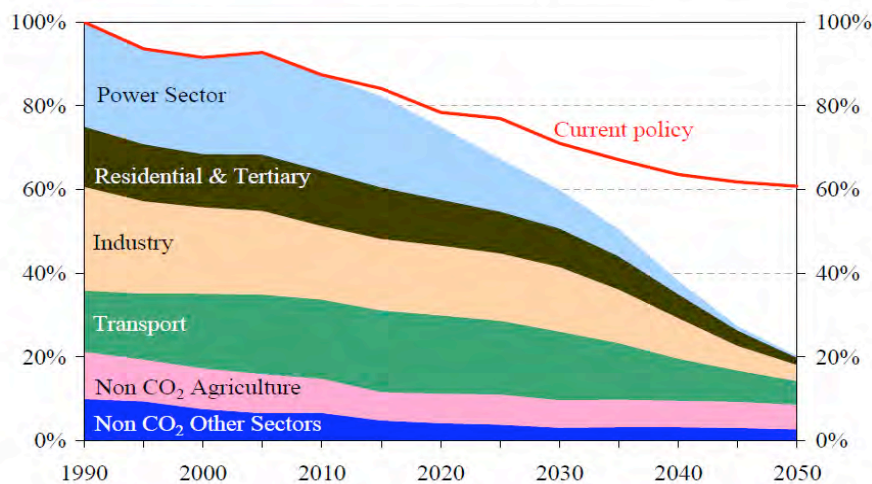


Figure 1: EU GHG emissions towards an 80% domestic reduction (100% =1990). Reference: A Roadmap for moving to a competitive low carbon economy in 2050, EU Commission March 2011³.

The expert workshop within the ENCI project about the German transport sector took place at PIK on 17th March, 2011. The participants came from various backgrounds, such as research institutions, interest groups, car manufacturing and the public transport sector. The workshop was divided into two sections: The first part dealt with technical issues within the model REMIND-D⁴, whereas the second part concentrated on visions about possible future trajectories. Both sessions were opened with a short presentation and continued with a general discussion.

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² (see e.g. Luderer et al. 2011).

³ http://ec.europa.eu/clima/documentation/roadmap/docs/com_2011_112_en.pdf

⁴ Eva Schmid, Brigitte Knopf and Nico Bauer (2011). REMIND-D documentation. Available online at <http://www.pik-potsdam.de/research/research-domains/sustainable-solutions/groups/esm-group/remind-d-model-description>

1. Part I: Technical Issues

1.1 Presentation: The Transport Sector in the Model REMIND-D

In order to provide a technical background for the subsequent discussion, the session started with a presentation of the model REMIND-D by Eva Schmid (PIK), including its basic structure and main results with a special focus on the transport sector. It already became obvious in this part of the workshop that the experts could make valuable contributions to the theoretical setting by incorporating their practical experience. An important point to be made was, for example, the drawback of a purely national perspective in REMIND-D that excludes relevant international transport. Especially freight transport is rarely limited to national boundaries in reality. Another problem concerning freight transport arose because its capacity is determined internally in the model and appeared to decline over time. However, there is a positive correlation between freight kilometers with trucks and GDP, so the corresponding relationship in the model has to be adapted to avoid disproportionate GDP losses. Besides, many technologies used in the model rely on critical resources, e.g. car batteries when an electrification of the transport sector is pursued. Therefore, the need for enriched resource constraints including other rare materials was mentioned, too.

1.2 Discussion

The general discussion focused on several technical questions prepared by PIK. One of the most intensely discussed issues was the future of car engines and which technology will prevail. There was a wide consensus that hybrid engines are supposed to be only a temporal phenomenon to bridge the gap until pure electric cars, hydrogen fuel cell cars or second generation biofuels are beyond their infancy. In general, the provision of the respective infrastructure is crucial. The role of hydrogen, though, is primarily seen as a storage medium within a decentralized energy system rather than a combustible on a grand scale. Second generation biofuels are mostly perceived as a long-term option since both synthetic biomass and lignocellulosis are still lacking cost-effectiveness. Moreover, optimization strategies for different means of transport were analyzed. With respect to trucks, the potential for further efficiency increases is limited. German rail transport is also performing efficiently already: 90% of transport services are provided electrically today, aiming at a completely CO₂-free railway system in 2050. The existing capacities allow for a doubling of the current rail traffic; a greater increase requires an expansion of hubs.

2. Part II: Visions for the Future of the Transport Sector

2.1 Presentation: The “50/50-2050” scenario

Manfred Treber (Germanwatch) presented a vision for the passenger transportation sector in 2050 with only 50% of motorized individual transport (as opposed to currently 80%) and the remaining 50% being covered by public transport, bike, etc. He emphasized that such a transformation was feasible and required a rise of public transport use by only 2% per year. However, the transition has to be supported politically and depends on public investment.

2.2 Discussion

When asked for their own visions of the transport sector, the experts revealed a lack of ideas. They argued that the transport sector was much more complex than other sectors, like electricity, as in contrast to electricity, transport is not a homogeneous good, but requirements are very different e.g. for rural areas, cities, freight transport, short distance, long distance etc.

They also pointed out that the sustainable restructuring of transport was significantly more difficult and more expensive as it would require intensive investments into new infrastructure.

Therefore, changes were not market-driven, but would only occur due to political demands. Because of the complexity, decision processes are also very tough. From the individual point of view, three main drivers of passenger transportation were identified: first, economic development, second, demography and structure of the work force, and third, settlement patterns, with the latter being the major starting point for political intervention. One expert pointed out that the highest potential for decarbonization is associated with transport in cities, where smart concepts are already being developed. For a transition like the one proposed by the speaker, cost estimates play a crucial role. Yet there are no robust prognoses so far. It can be assumed with some certainty that investments in infrastructure will constitute the largest share. A general consensus was reached on the fact that the transport sector can only be decarbonized by combining the use of renewable energy sources with further efficiency increases. However, the concentration on passenger transport, like in the “50/50-2050” scenario, provides only a limited perspective as the major part of emissions originates from freight transport.

4.1 Conclusions

The workshop yielded useful insights for the modelers at PIK as the experts came up with important considerations for making the model more realistic. Especially in the first session, a gap between theory and practice as well as between normative and positive scenarios became evident. From the modeler’s perspective an upper bound for CO₂ emissions is set and then evaluated what kind of transformation this would imply for the transport sector, whereas most of the experts come from the methodologically opposing perspective and try to describe the observed trends and expected extrapolations into the future. A mismatch between these perspectives became evident. The second part revealed that there is to date no clear vision for decarbonizing the transport sector, as is e.g. available for the electricity sector with clear-cut goals for shares of renewable energy sources or emission reduction targets.

2. Expert workshop about the German Electricity Sector

“System compatibility of conventional and renewable energy technologies for power generation”

ENCI Expert workshop, 28 October 2010, Potsdam (Germany)

Summary by Brigitte Knopf⁵, Michael Pahle, Falko Ueckerdt

For achieving ambitious climate protection targets, Germany faces the big challenge of transforming the entire structure of the energy system within a few decades. Power generation plays an important role here since the transformation of this sector can be achieved at relative moderate costs as a number of technological options for reducing greenhouse gas emissions are already available. The developments of the last years suggest that particularly wind energy will contribute to the transformation with an installed capacity of 26 GW (2009) and a 8.6% share in power supply. In the latest study on grids by the Germany Energy Agency DENA (DENA, 2010), a further deployment of up to 28 GW offshore is assumed until 2020/2025. The energy scenarios that were presented by the German Government in summer 2010 indicate an installed capacity of up to 53.4-64.7 GW in 2050. Furthermore, photovoltaic with an installed capacity of nearly 10 GW (2009) and strong growth rates is also of great importance. In 2010 alone, almost some 10 GW have been added, and if the actual feed-in tariff system is continued, this trend will persist. It is already conceivable that a continued development of the deployment of variable renewable energies will challenge today's infrastructure and electricity markets. In this context, the question of “system integration” and system compatibility of renewable energy and especially of wind energy emerges.

A challenging aspect of system integration is the supply of power from variable renewable energy sources and at the same time guaranteeing the stability of electricity grids. Due to the partly occurring peaks in wind power, there are increasing disturbances or even threats to supply security, which cannot be balanced at short term by electricity grids or market-related measures. In these cases, supply or demand have to be adopted, e.g. by switching off wind power plants. The reason for that is mainly due to the limited capacities of the grid transmission lines. To avoid such situations, grid expansion is a mandatory strategy. During the last years, comprehensive investigations were performed both on national and on European level. Awareness about the problem regarding the extension of grid capacities already exists - at least among experts.

There is however less public attention regarding the following issue: the difference between electricity demand and variable wind energy supply in particular and variable renewable

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energy supply in general (i.e. the residual load) needs to be balanced permanently. The reason for this is the technical requirement that supply and demand need to be equal at all times. In view of the deployment of variable renewable energy sources envisaged, an increasing demand of flexible power for electricity supply is required in the future. In the past, only a moderate variability in demand had to be balanced. With an increasing supply of variable renewable energy on the one hand, the need for balancing has increased. This means that more flexible power plants are required, given no additional measures. On the other hand, the growing generation from variable renewable energies increases the frequency with which conventional power plants need to adapt their output (and at the same time potentially decreases their life-times).

In principle, several technical and institutional innovations are at hand to handle the problem of balancing. These are (a) application of storage technologies, (b) demand side management (DSM) by so-called smart grids, (c) balancing of supply by a European power supply network or the domestic market, (d) virtual power plants for concerted supply. In addition, also constraining generation from variable renewable sources can be an option, e.g. by curtailing wind power during rarely occurring peak periods. It is unclear whether these options will be sufficiently available in the near future for the enormous increase of the deployment of renewable energy sources. A further development of these options is indeed requested and required but the question remains if and how this transformation can be guaranteed by a concrete political design during the transition phase.

This problem becomes apparent by the scenarios that were recently published aiming at a 100% share of renewable energy sources in Germany's electricity sector by 2050. These scenarios and energy transformation pathways are built on the idea of "working back from the target". Most of the above mentioned options are assumed to be available in these scenarios by then. So the main idea is to develop a vision that defines the Government's priorities for energy policy "towards the target". On the other hand, the power supply system still exists in its present form as a result of a long development that has so far provided a high standard in securing supply. From the perspective of the power supply industry, the "thinking from status quo" is thus prevailing. This comprehension emphasizes established technologies and the stability and security of the power supply and adheres to established business models. From this perspective, the requirement is therefore to reduce as far as possible the technical and economical risks by "adaptation in small steps". Both approaches can claim for themselves to contribute important arguments and information to questions of system compatibility. But it remains an open question if both position may find a compromise given existing viewpoints, and to what extent the respective ways outlined may meet eventually.

This discrepancy becomes obvious if the development of new options cannot keep up with the fast increasing requirements concerning the flexibility that was described above. In this case, it could gradually come to a serious threat of grid stability and security of supply in the next years. In order to provide reliable renewable energy supply, substantial investments into storage technologies would be required. But the potential of some of these technologies (e.g. pumped-storage plants) is limited. Other storage technologies are not yet mature enough to be operated in a business environment. Or a network needs to be build that can balance the variability by regionally different conditions. A network expansion however often encounters problems due to its public acceptance. An alternative or at least a short-term solution would be to ensure balancing by existing and/or newly built dispatchable power capacities.

If the "obligation for flexibility" is assigned to other (conventional) power plants, the question will remain if the technologies that are available today are suitable for fulfilling these

requirements. In fact, also dispatchable renewable energy sources such as biomass can be employed but so far conventional fossil capacities are preferred to fulfill these requirements as they are already available. Therefore, it is crucial that coal and gas power plants can provide the required flexibility. In addition, possible negative effects for the development of renewable energies are to be considered. Moreover, it remains an open question whether fossil power plants may still be used when aiming for ambitious emission reduction targets. Therefore, this problem is sometimes called “system conflict” which means that the additional deployment of new fossil power plants must be ruled out in face of a transition strategy towards a completely renewable power supply.

But even if a further deployment of flexible fossil capacity was desirable, the future market situation could probably not offer sufficient incentives. The reason for this is the electricity market’s marginal pricing design: a higher fraction of renewable energy sources reduces the demand for more expensive medium and peak-load capacities and therefore also the average price level (merit order effect). Furthermore, the price margin reached in the course of a day is reduced, which is the crucial economic criterion for the employment of storage capacities. Thus, a development and deployment of modern storage technologies could be substantially delayed.

Resulting and remaining questions:

1. Is there actually an urgent problem with flexibility? For which period can a ”break down“ of the electricity grid be expected and how would this look like in detail as e.g. very frequent short power failures or a complete collapse of supply during longer periods?
2. How well have future alternatives such as storage technologies already been developed? When will they be marketable or introduced to the market? How can incentives be created for the development of storage technologies?
3. Which relevance has the potential development of electricity grids for guaranteeing security of supply? What is the relationship between grid and storage technologies – complement or substitute?
4. Are the flexible capacities sufficient for balancing? Are Carbon Capture and Storage (CCS) power stations flexible? In particular, is there a conflict between new coal power plants and a further development of renewable energy sources?
5. What will be the consequences if no incentives for investments for the required technologies and capacities are induced by the market? How should a market be designed that can cope with this challenge?
6. To which extent should the flexibility of renewable energy sources be mandatory for adhering system stability?
7. To what extent does the feed-in tariff system (EEG) in its current form contribute to exacerbate the problem of flexibility and which regulative possibilities and measures exist for improvement?

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http://www.dena.de/fileadmin/user_upload/Download/Dokumente/Publikationen/ESD/Flyer_dena_Grid_Study_II_Englisch.pdf

3. Stakeholder-Dialogues within ENCI LowCarb

Summary by Jan Burck⁶

In order to further develop climate scenarios that reflect feasibility on a socio-political level, Germanwatch and the Potsdam Institute for Climate Impact Research (PIK) held Stakeholder dialogues that were designed to integrate public preferences in the model-building process. The dialogues included the transport and electricity sector and took place in two rounds. The first round of dialogues included a moderated debate on various topics and a standardized questionnaire. The judgments and preferences of the stakeholders were then used to frame the scenario definitions and corresponding parameter configuration of the energy-economy model REMIND-D. On that basis Germanwatch and the PIK created scenario pathways that were presented to the stakeholders in the second round of dialogues. Here the stakeholders discussed the plausibility and potential socio-political consequences of the model-based scenarios.

Stakeholder-Dialogues Part I:

3.1 Transport sector: "Which (transport-) future is possible?"

The first round of the stakeholder-dialogue in the transport sector took place at the bureaus of Germanwatch in Berlin on the 27.05.2011. Among the 13 participants were representatives of Daimler, the German association of the bio-fuel industry (VDB), the "Allianz pro Schiene", that advocates for railway transportation, the German Bicycle Club (ADFC), the association of German transportation companies (VDV) and environmental Groups such as the WWF. The debate was divided in four sections: freight transport, passenger transport, efficiency and fuels. After the discussion of each section the stakeholders were given a standardized questionnaire that asked for their position in a certain issue and their judgment on the issues' future development.

1. Freight transport

Key issues in this section were the trends of the transport service and its connection to the GDP as well as strategies to reduce carbon emission such as more rail-based freight transport, regional economic cycles and changes in regional planning and transparent product labelling. In 2010 the freight traffic caused approximately 7% of total CO₂ emissions in Germany. At the moment there is a trend towards more performance (ton-km). This presents a serious problem for ambitious emission reduction scenarios. The situation was reflected in the survey: Almost half of respondents think it would be good if the trend for increased freight traffic

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volumes could be inverted. But at the same time almost the entire stakeholder answered that it is realistic that freight traffic will increase.

The majority of the stakeholders were also in favor of a decoupling of freight transport and GDP growth but in their realistic judgment only half of them saw a decoupling. In the discussion they argued that there needs to be a change in mind-set on the political level: At the moment politicians see growth of freight transport directly connected with economic growth so there is few initiatives to reduce freight traffic. Also freight transportation is usually thought of as traffic on the road which causes more investment in road systems than in other infrastructure. In order to achieve ambiguous reduction goals not only the investment structure needs to change, but also fiscal and regulatory policies are needed.

The problem about handling more freight transport on railways is that the infrastructure and the transport capacity of the railroad have to be increased enormously. For example, a local connection to companies is often not available. Therefore it could be considered to design future business parks bimodal (road and rail). Again, the stakeholders were largely in favor of bimodal business parks, but the majority thought it is unrealistic. In the discussion they criticized the structural priority of the road system, here is a political initiative needed. They also criticized the *Deutsche Bahn* (German Railroad Company) for investing in big representative projects, not in development of the infrastructure on a local level. But the discussion showed that the stakeholders were not sure if a large amount of new railway sidings will be used at all.

The decarbonization of the transport sector is particularly problematic because long distances are CO₂-intensive, at the same time the transport is so cheap that businesses often prefer long paths if they are useful for efficient production. One way to address this situation is to strengthen regional business cycles, and to give greater value to the topic of emissions reduction in urban and regional planning. The stakeholders considered the strengthening of regional economies mostly desirable, but they are mixed on their realistic estimation. Concerning the increased importance of the issue of reducing emissions in urban and regional planning, there is a strong correlation between their desire as stakeholders and their opinions as experts.

The Stakeholders also discussed the idea of a new labeling of products which documents its carbon footprint. Some found a labeling system desirable but argued that only informing the demand-side is not a sufficient instrument. Problematic is also to collect reliable data.

2. Passenger transport

With in the passenger transport, the discussion included topics such as the general trends (volume, modal-split), the possible role of governmental intervention and change in consumer behavior.

As far as general trends studies suggest that the overall milage in passenger transport is decreasing due to a shrinking population. At the same time the percentage of motorized individual traffic (MIT) (80%) is not likely to change. The stakeholders were undetermined whether its proportion could decrease to 50% by 2050, although a slight majority would be in favor of such a development. They did agree largely upon the issue that in the future traffic will be more multi-modal, which corresponds with their interests.

Also they discussed the role of certain modes of transportation in the future:

- ⤴ Pedestrian traffic and bicycle: From the perspective of the most stakeholders is highly desirable to have a high degree of the passenger transportation done on foot and bike, as eight approvals showed. Whether an increase in bicycle and pedestrian traffic is a realistic assumption the stakeholder assessment was mixed: seven considered it essential to highly realistic, four said it is rather unrealistic.
- ⤴ Railway: The shift from car to rail receives a positive assessment: A vast majority thought it is realistic that the train is an alternative to the car. All stakeholders were in favor of such a change
- ⤴ Long-distance busses: At the moment the German market for the long-distance passenger transport is liberalized, this creates an opportunity for the interregional bus services by private companies which would be in direct competition with the railway. Stakeholders did not provide a clear assessment of whether they think such a development is realistic or welcomed.

Besides the general assessment of alternatives in passenger transport, we asked stakeholders to estimate to what extent a government funding generally, and of different modes of transport from their point of view is desirable and realistic. They were not clear whether reducing the price of public transport by state subsidies is a good instrument, nor did they have a homogenous position on how realistic such a development is.

They favored that traffic-related or environmental considerations should be more part of future spatial and urban planning than it is today, especially when designating future residential areas. Furthermore they welcomed the idea that emission reduction should play a crucial role in spatial planning. They also considered this to be highly realistic.

For the issue of sustainable consumption, they favored that it could bring a change to the modal split, but only half of them considered being a realistic development.

3. Efficiency

In the third block the stakeholders discussed the efficiency potentials of vehicles and railroad as well as the rebound effect.

Vehicles

Concerning vehicles, efficiency could either mean very low fuel consumption or the change of car concepts. That cars with a fuel consumption of one liter/100km prevail on the market in the future is welcomed by more than half of the stakeholders. However, only a slight majority thought that this development is realistic.

The participants found the development of new car concepts more likely. One could think of electric or plug-in vehicles. However, it was noted that the adaptation of the demand-side has more effect than a technology shift. Thus cars must adapt to the way they are used, for example, small cars for the city, larger for the holidays. It follows, however the problem that the purchase of several cars may be more CO₂ intensive than one car with a moderate consumption for all uses. In the case of car-sharing there is the problem of peak times (holidays), in which many people need the same type of car at the same time. It was noted that for safety reasons new car concept are often not attractive and that electric cars have to be sold for the same or lower prices, otherwise they will not earn a big market share.

A political regulation to create incentives to buy smaller cars was discussed controversially: Although the majority was in favor of such policies, only half of the stakeholders found it realistic. The discussion centered around the issue whether incentives are the best way to

reduce carbon emission from MIT or if high prices or technological research would be more effective. Also possible instruments to create incentives were discussed.

Railroad

Also in the field of rail transport, numerous measures have been expressed that might increase efficiency: limit top speed, a higher capacity utilization of the trains and the rail network, this includes a control center of the entire rail network that can coordinate all trains in order to avoid stops, as well as the expansion of transfer points for freight transport. The stakeholders were undecided in the issue of lowering top speed considering their positions and judgments. The participants agreed, however, that the utilization of the rail lines should be increased, which corresponds to a large extent also to their interest. They also discussed that in principle, a service demand must be met and depending on the case different efficient solutions must be found (e.g. regional trains are often inefficient on the countryside). Furthermore a carbon free energy mix for the railroad should be considered as an important efficiency measurement.

Rebound effect

The rebound effect explains that emission savings due to more efficiency are offset by new acquisitions or more use, which require additional energy. The discussion showed that the stakeholders consider the rebound effect in the transport sector mostly negligible. Factors such as time, parking space, etc., limit the use of vehicles, which are saturated in Germany. Fuel costs are not a limiting factor, so the use of cars is not increasing through efficiency gains. The rebound effect is more important in trams and busses, in which energy efficiency is compensated due to higher levels of comfort.

4. Fuel substitution

In addition to the efficient handling of passenger and freight transport, there is the possibility to use other technologies to reduce carbon emissions in traffic. Concerning the car, there were many developments in recent years, mainly electronic or electronically-supported engines (hybrid and plug-in hybrid technology or electric cars). Also, the substitution of fossil fuels by bio-fuels or hydrogen is a possible option. The discussion focused on hybrid technology and bio-fuels.

In the discussion on electronic or electronically-supported engines, there was skepticism to which extend technologies that are more expensive than the existing ones can prevail. It was noted that only a fraction of buyers is willing to spend more money for new technologies, particularly in the infrastructure sector, which is dominated by a cost-benefit calculus of the consumer. At the same time hybrid vehicles could be used especially in the city, but have no sufficient coverage for rural areas. Therefore the stakeholders' judgments on the development of hybrid and plug-in hybrid were mixed. In the case of electric cars a great majority welcomed and considered it realistic that electric vehicles will displace regular ones in urban areas.

The assessment of the stakeholders on bio-diesel and bio-ethanol is very diverse: They were equally in favor and against a 50% share of biological fuels in the diesel/gasoline use in the future. However, a high share of bioethanol was assessed to be unrealistic.

Besides the intensive discussion about hybrid technology and biofuels the questionnaires also asked for a judgment on gas, hydrogen, and the electricity mix for rail transport. Gas was not

considered to be realistically an increasingly dominant fuel by a slight majority of the participants. Hydrogen to become an important fuel source is not welcomed or considered realistic either. Concerning the development of the electricity mix of the rail transport the opinion of stakeholders was more uniform: A majority considers it very positive that rail transport will be nearly carbon free in the future. A great majority of the participants thought this development is realistic.

The discussion showed that it remains open what technologies are suitable for long distance travel. It was noted that hydrogen-based cars for long distance travel are technically feasible, the efficiency is twice as high as fossil engines, there are no problems with long refueling/recharging time and it is the infrastructure that will cost money. But the discussion also showed that in the cities remain problems with e-Mobility.

3.2 Electricity sector: "Which (electricity-) future is possible? On the path to a CO₂-free power supply"

The first round of the electricity sector took place on the 30.06.2011. 15 stakeholder attended the dialogue: RWE, one of the four big German energy companies, two German grid companies (50Hertz, TenneT), a trade union of the mining and energy sector (IG BCE), the German association for renewable energies (BEE), a renewable energy company (Lichtblick), the German consumer association (vzbv) and environmental groups (WWF, NaBu, Klima-Allianz). The dialogue was divided into four sections: power grid expansion and social acceptance, the mechanization of landscape, energy efficiency and transition technology. The workshop was particularly interesting because it was held in the phase when the German government discussed and presented their new energy policy that included the shorted runs of nuclear power plants.

1. Power grid expansion and social acceptance

It is still uncertain in what form and how many new grids are needed, especially as there is little reliable and transparent data on the topic - which was also criticized in the discussion. What is clear is that the German power grid must be significantly rebuilt and enlarged to accept a greater share of renewable electricity supply. The necessary reconstruction is tackled by the resistance of the local population, particularly at the higher (110 MV) - and high-voltage level (380 MV). In the discussion it was noted that this grid expansion is one of the biggest obstacles to more renewable energy supply and can escalate to a major social conflict. The central question of the first block was therefore: How can we increase the local acceptance of network development?

Although all stakeholders would favor if the grid expansion would not fail due to local opposition, more than half of them thought this could be a realistic scenario. They discussed various solutions to this problem:

- Transparency (in the planning and construction process).
- Options for early citizen participation.
- Profit participation (to the local authorities or the citizens).
- Broad public debate (about the goals of the process and the possible role of the population).

The survey showed that a majority of the stakeholders approve - despite higher costs - the construction of under ground cables, at the same time a slim majority also thought this is going to happen.

At the same time an overwhelming majority were in favor of not leaving nature conservation concerns behind grid development issues. However, in their realistic assessment only half of them thought nature conservation concerns will be more important than grid expansion issues. The same picture with bird conservation: a majority voted not to leave bird issues behind grid issues, but in their realistic outlook they were divided up.

Besides the discussion about expanding the network in Germany, the expansion of the European network was discussed. Participants would welcome a European coordination. However, the stakeholders were again divided as to whether this will actually be the case. A more European-oriented power network was discussed, among other reasons, because then

the production capacities of neighbour regions could be better used. A prominent example is the Desertec project. The majority of the participants found its realization to be realistic.

2. The mechanization of the landscape

Renewable energy sources have a much higher land use than conventional centralized systems. Already at present wind and solar power plants are affecting the landscape - with a share of only 17% of electricity supply. A share of 100% would signify a very different landscape. Already resistance emerges from groups campaigning for the preservation of the landscape. Protest is also motivated by health and aesthetic aspects. An increase of the protest could hinder further development massively. In this part of the workshop we therefore tried to evaluate how renewable energy development and nature conservation and aesthetic concerns can be reconciled.

Wind turbines

Offshore wind farms were one of the technologies, which provoked few reservations. This was also reflected in the survey: The majority of the participants were in favor of more offshore wind farms and a large majority thought it's very likely that more farms will be build in the future.

Onshore wind turbines were evaluated by some participants with enthusiasm. However, it was noted that there is potential for more aesthetic designs. This advocacy was reflected in the survey; the participants were in a large majority for more wind power and also considered it realistic.

Geothermal

The landscape change of geothermal power generation is not as important. A large number of participants stayed neutral, but most were in favor. A slim majority considered more development of geothermal energy in Germany to be unrealistic.

Biomass

Electricity production from biomass with waste wood was largely supported. A majority of stakeholders found this development to be realistic.

Biomass power plants using corn were evaluated mostly negative. It was argued that the problem with substrate supply from corn is the enormous demand for land; this is currently limited to 60% and will increase to 80% in German law. The survey confirmed this picture: A big majority of stakeholders were against the expansion of electricity supply from corn. A slim majority thought that the development will be in this direction.

Solar systems

Freestanding solar panels were evaluated negatively by the stakeholders if they are built on grassland, which means that an alternative use is excluded. There will be an increasing competition for space. Compared to other land use for renewable energy (wind power, networks), it was noted that the latter seem much more permeable than large-scale solar panel

parks in open areas. The positions to freestanding solar panels were divided up, but a big majority thought they are going to be built.

Photovoltaic systems on roofs were hardly of concern for participants. This also explains the results of the survey: Most of the participants welcomed development in that direction and thought they are realistic.

Pumped storage power plants

The panel was divided about whether pumped storage power plants are a relevant issue in Germany. On the one hand, the low potential was highlighted; on the other hand planned construction projects were mentioned. It was also stated that the Norwegian pumped storage potential cannot be considered for the balancing of the German electricity market. Even if there is an important potential the Norwegian population put great emphasis on the conservation of their landscape. The realistic assessment of the stakeholders was very balanced. Nevertheless a slim majority of the stakeholders would welcome this development.

Aesthetic Discussion

The discussion revealed that acceptance of landscape changes is closely linked to prevailing aesthetic judgments. These judgments must therefore be involved in the planning and design of RES. It was noted that the mechanization of the countryside is perceived differently both in different countries and in different milieus in the German population. This was also visible in the lively debate. A further mechanization of urban space is not as dramatic as the space is already dominated by interventions. At the same time urban people have to take the objections of rural people into account seriously, because they perceive the interventions in the landscape more intensively than themselves. For example, infrastructure projects were in the workshop discussed in a less controversial manner than in the media. Even environmental groups have such a heterogeneous membership structure, that it is hardly possible to obtain a common position on landscape issues. In general, the aesthetic values of the population have to be taken seriously. It was critically noted that the present stakeholders do not mainly wish to preserve the existing landscape such as possibly other active groups.

In addition, it is not clear how much renewable energy plants are required, so the quantitative dimension could influence acceptance. However, not all technologies will be strongly represented in all regions, but will have focal points in certain regions. In addition all RES constructions have the possibility be dismantled much less complicated and costly in comparison to nuclear power plants.

Finally, the concept of industrial heritage was also discussed. It has its own aesthetics, which is associated with specific energy used and is evolving in the course of this energy transformation. Specifically relevant is this, for example concerning pipelines associated with an energy system based on coal. For new technologies, we would need, therefore, a new aesthetic that reflects the changes and stimulates imitation. It was considered to be important to think about what might look like a non-fossil industrial culture and heritage.

3. Energy Efficiency

The effective use of electricity is one of the most efficient measures to reduce carbon emissions. According to a study of the BMU (German environmental ministry), the potential of energy efficiency to cut emissions, ranks third after the expansion of renewables in

electricity generation and efficiency measures in the heating sector. The question of the third part was how to increase energy efficiency in households, the commercial and service sector and in the industry can be achieved. In all sectors arises also the problem that each sector has the opportunity to take action on the supply and demand side.

Development of electricity consumption

For the industrial sector stakeholders anticipated a reduction in power consumption. Moreover a slim majority welcomed the decrease in electricity consumption. The development of the electricity consumption of households was seen more conservatively: They were undecided whether the consumption will rise or not. Nevertheless, the majority would welcome a reduction.

Development of the electricity price

For industrial customers, the stakeholders saw clearly an increasing price. The majority of the stakeholders also voted in favor of price increase. Also for households, a price increase seemed to be realistic for a majority of the stakeholders.

Measures for energy efficiency

A major obstacle for raising the energy efficiency of households saw the stakeholders in the relatively low electricity prices and the billing system. The constant price throughout the year and the increasing average number of electrical devices in the home indicate that electricity costs represent only a small share of the household budget and as well that there is a lack of awareness regarding the CO₂-intensity of energy consumption. Ways to address this may be, for example, the upfront payment, or a rating of the value of each kilowatt-hour on the price: The price could be based on the use of various devices and different times of day. This would be possible with a smart metering system, which would indicate the actual consumption and the use of time according to different consumption categories. Consumers could orient their electricity consumption considering real-time electricity prices and energy suppliers could better adjust the actual supply (demand-side management). Another possibility could be an extreme price increase. The immediate reaction was that a price increase could easily become a social issue. Moreover, the price-elasticity of household electricity consumption is not clear so the consequences of price changes are difficult to predict. In any case, drastic changes are needed, concerning for example the price or offer structure, but also regarding the awareness, to reach a behavioral change. Interdictions could deteriorate the social acceptance; an incentive system would be better according to the stakeholders. Also a competition of less ecological and greener lifestyles has been proposed in order to achieve greater efficiency. The example of smoking shows, that massive changes in behavior are possible.

In the survey, all participants were in favor of a greater use of demand-side management systems. Also, the participants agreed that such measures will be applied in the future. Electricity prices that vary according to daytime were also desirable for the majority stakeholders. This was consistent with their realistic assessment: Almost all of them estimated that this will be come standard. Smart metering was also supported by a large majority of stakeholders.

A problem concerning the electricity savings through greater energy efficiency is the rebound effect: Financial savings through reduced power consumption are reinvested in additional

equipment, which in turn require electricity, so power consumption reduction is not as strong as it could be. On the contrary: The rebound effect could result in a situation where no power is saved. Stakeholders said that this is likely to happen; a majority thought negative consequences of the rebound effect are likely.

Supply-side measures

The problem of the discussed measures is that they focus on the demand side. It was noted that single individuals are difficult to mobilize. Therefore it is also necessary to push producers to create more efficient electric devices. This would be conceivable, for example through a top-runner program, initiated and controlled by a government in order to support the most efficient devices within a given period. Another suggestion would be to use emissions trading permits for white goods. In any case, efforts should not be placed only on either supply or demand side, measures need to be combined. Also, the effect of public debates on both sides was noted as an important factor.

Other measures

In addition to measures concerning prices and energy demand within the existing market design it has been noted that we have to fundamentally think about new business models. One suggestion was the development of leasing models in which the customer does not pay the device but its service. After a certain period of time he receives a new device that has the highest efficiency level. Especially promising is such a concept within small businesses and factories, which have a higher saving potential than households. However, this would change the prevailing notion of ownership. The social reactions are difficult to estimate but there are business opportunities, perhaps also for the established utilities.

4. Transition technology

After the German government has decided to shut down the German nuclear power plants by 2022, the question arises how the energy supply is guaranteed in the period in which the RES cannot cover the majority of demand. Currently, they contribute about 17% to the power mix and in 2020 it should be 35-40%. The possible options are the (domestic) lignite, coal and gas. The problem is that these are energy sources, which counteract ambitious climate targets. The question to the stakeholders was to present their position on possible bridge technologies.

Lignite

Lignite coal is the most carbon intensive option among the three energy sources, under condition that no CCS technology is used. Since lignite is available domestically in Germany no import is necessary. Although a vast majority welcomed that lignite will not be used after 2030, a slim majority considered it realistic that it is converted into electricity after 2030.

Hard coal

Contrary to lignite 72% of coal consumption is imported. The trend is increasing, because the subsidies for coal mining will stop in 2018. Currently, plants with a total capacity about 12 GW are under construction and in planning, which will - according to one participant - also be used. The question is whether coal-fired power plants could be shut down altogether in the

near future, without compromising the power supply. In each case, it was discussed that a shutdown of coal-fired power plants should not cause the import of coal-based electricity from abroad, which would not change the global carbon footprint.

The stakeholder were undecided if the coal-based power plants that are in construction will be built, although a majority of them voted against it. The opinions changed on the question of whether coal-fired power plants that are in the planning process will also be connected to the grid. In the discussion the opinion was occasionally expressed that no further construction of power plants is necessary. This converges with the survey: A big majority of participants was against a future operation of the planned power plants. Also, an overwhelming majority considered it unrealistic that the planned power plants will actually produce electricity.

Carbon capture and storage (CCS)

CCS technology allows separating CO₂ emissions from power and industrial plants and storing it. However, it is uncertain when such technologies are widely available and whether it will meet safety requirements. The discussed points were: In case that new fossil power plants are actually built, it would be better to integrate CCS technologies than not doing it. Another option is to equip existing power plants with CCS. The majority of the participants thought that this will happen in the future. Nevertheless the participants did not show a clear opinion on whether or not CCS will be available on a large scale in Germany. Also they had a very heterogeneous position towards the availability of CCS and equipping existing power plants with it.

Gas power plants

Power plants that run on gas were considered to be the most climate-friendly choice of fossil power sources. Also for reasons of system compatibility they are the best option, as they have in general a high degree of flexibility. The stakeholders noted that if there should be a development towards more gas use in the future it should come from different supply countries in order to avoid total dependency. It should also be thought about the production of methane in times of over-production from renewables. The methane could be converted into electricity by gas power stations in demand periods.

Concerning the construction of gas power plants, the assessment of the stakeholders covered their strategic position. They had a very clear opinion: The majority considered it likely that more natural gas power plants are built in the coming years and would welcome this development. A similar distribution of votes was found in the issue of methane production from renewable power plants.

Base load

In addition to the options concerning the technology transition there were intense discussions on how the electricity market could operate in the future. Many participants expressed the opinion that the role of large, central power plants will increasingly be to balance electricity generated by renewables. This is necessary if either the renewable production is low or the demand is particularly high. It should be thought about a system that deploys fossil power plants as complementary capacity to prioritized renewable energies. In the discussion studies were quoted stating that no new coal plants would be needed, only 5 GW of new gas-fired power plants by 2020. Currently only one good is traded on the electricity market - MWh

produced electricity - in the future there will be trade on certain energy supply services. The discussion mentioned a market for the provision of non-fluctuating production capacity, backup capacity and system stability.

Investments in new power plants

From the new role of central power plants leads to the following problem: The paying-off expectations are changing and therefore there is fewer incentives to invest in new power plants. Currently, utilities expect the payback of investments for new power plants in 20 years. However, they do not build new power plants if the market conditions are not clear and the construction induces resistance in society and politics. Also the fuel price fluctuates much anyway, creating uncertainties for planning a power plant. A market for capacities could be a way to create incentives for the construction of power plants. This should be implemented politically. In particular, the construction of gas power plants could then be interesting again. Here, the question arose whether it would make sense to build new coal plants, rather than to continue operating older, because the newer would be more efficient. It was noted that in any case new business models for the construction of power plants are needed. For example, a system was presented based on decentralized gas-fired power plants, so-called "home power plants" that could be installed in large numbers in basements of private homes. Through an intelligent IT technology they could be operating within short time.

4. Stakeholder-Dialogues Part II

In a second dialogue Germanwatch and the PIK presented the model-based scenarios that were developed on the basis of the stakeholders' estimations. They were asked to evaluate the plausibility of the scenarios and discuss possible social and political effects. At the beginning the scenario-building process was explained, leading to the presentation of the developed three scenario paths. After this section the results and consequences of the scenario calculation in the respective sector was presented giving the stakeholders the opportunity to comment on the scenario-design and critical issues.







4.1 Transport

The second dialogue of the transport sector was held in Berlin on the 4th of October 2011.

1. Presentation of the process



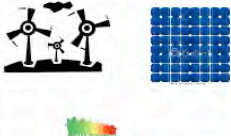



Jan Burck explained at the beginning, in which stage the development of the scenarios currently is, summarized and presented the outcomes of the first workshop concluding with the scenario paths that evolved from it. At the core of the modeling process is the idea that basically there are two options for every key issue of a sector: "continuation" and "change"

Scenario components transport sector

Component	Option "continuation"	Option "change"
Freight transport		
Modal Split		
Fuels		

In the transport sector the option “continuation” signifies for freight traffic that a high share of the transported goods will continue to be done on the road. The option change shifts the transported goods to the rail and regional economic cycles have higher importance (second symbol). In the field of passenger transport the option change means a shift from individual mobility with motor vehicles and electric cars to public transport and the bicycle. In the area of fuel, under the option change, an increased conversion is made to more bio-fuels and hydrogen.


















Likewise in the electricity sector the options continuation and change exist: The option "continuation" signifies the continuity of existing coal-powered power plants. The option "change" allows the model to decommission coal-powered power plants, before they are written off. In the area of the potential of renewables, the scenarios range from an expansion in terms of today's standard in the continuation option to an increasing expansion compared to current terms. In the field of CCS-technology the option "continuation" means that CCS is not available in this scenario, in the option „changes" it is available by 2020.

Scenario component	option "continuation"	option "change"
Existing coal power plants		
Renewable energy potential & energy efficiency		
CCS		

From this, a matrix can be designed with possible development paths. The combination of the scenario modules was done with convergence criteria and among the wishes of the stakeholders. Three scenarios developed from this:

- **"Continuation"** option of continuation in all three scenario modules.

- **"Paradigm Shift"**: Reduction of coal-fired power stations, massive expansion of renewable energies and increase in energy efficiency, no use of the CCS-technology, freight traffic increasingly on the rail, expansion of public transport, existing fuel mixture.
- **"Paradigm Shift +"**: massive expansion of renewable energies and increase in energy efficiency, availability of CCS-technology by 2020, freight traffic increasingly on the rail, expansion of public transport, change of the fuel mixture to bio-fuels and hydrogen.

Electricity Transport					
					
					CCS
			"Continuation"		
				"Paradigm Shift"	
					"Paradigm Shift +"

Queries regarding the scenario modules:

- ⤴ A geographical dimension cannot be included in the model, therefore the pre- and on carriage of the freight traffic cannot be taken into consideration.
- ⤴ In case of bio-fuels, is the model able to differentiate between fuels of the first generation, which are produced from rape seed, and the second generation which are based on lignocelluloses?
- ⤴ The possibility to produce gas in times of an over production of renewable energies is not taken into consideration in the model.
- ⤴ The technology costs are extracted from literature and consultation with experts.

2. Working method and results of the model

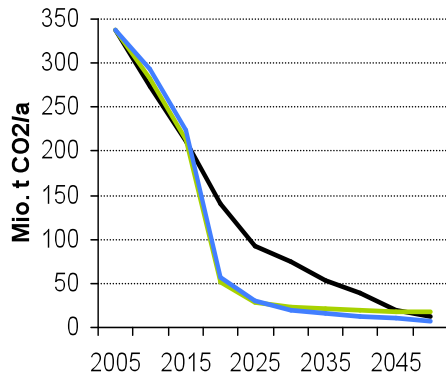
In the following part, Eva Schmid explained how the model REMIND-D works: It is a hybrid bottom-up/top-down model, which means that existing development paths are not continued, instead, framework requirements are set in advance and an intertemporal algorithm is optimizing within these conditions.. The most basic condition is a CO₂-budget reduction ranging to 85% until 2050 in comparison to 1990. This means the existing goals of the German government, regarding the expansion of renewable energies are achieved. Also

included are boundary conditions, which are pinned politically, i.e. an assessment of the potential of renewables - the instruction from the stakeholders of the first dialogue. The model decides on its own, in which sector CO₂ is being saved when. For further information on the model, please consult the model explanation.

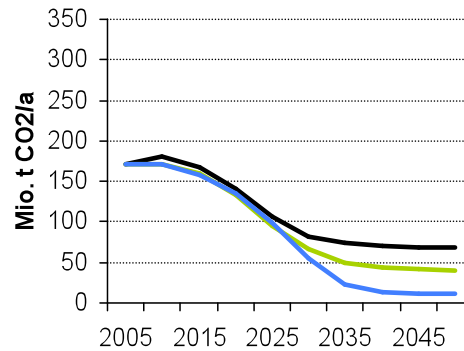
Each of the scenarios received certain boundary conditions, to portray the different development pathways.

- **"Continuation"**: The model has preset terms for coal-powered power stations, in order to depict the continuity in all modules. In the traffic sector is one condition that freight traffic with HGV will increase, corresponding with current prognosis.
- **"Paradigm Shift"**: Central condition: There is a must-run condition for coal-powered power plants, after that the model freely decide in the electricity sector, depending on the price for CO₂. In the traffic sector it is determined that the km-tons of the freight traffic will not be less than in the current state. A higher potential for onshore- and offshore-wind energy is assumed. CCS-technology is not available.
- **"Paradigm Shift +"**: Restriction in the electricity and traffic sector, likewise in the "Paradigm Shift", furthermore is the CCS-technology available from 2020 onwards. Hydrogen-powered vehicles are available from 2015 on.

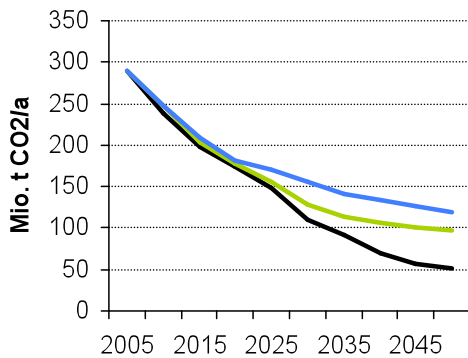
Energy related CO₂-emissions



(a) Electricity Sector



(b) Transport Sector

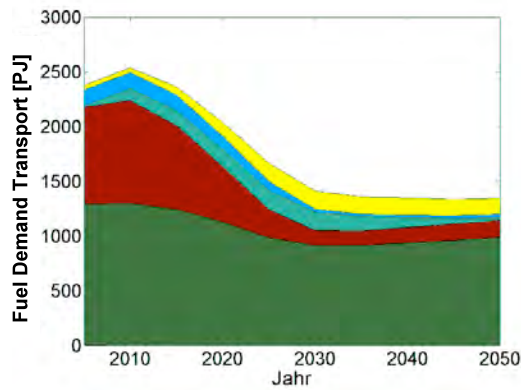


(c) Heat Sector (Industry and RES&COM)

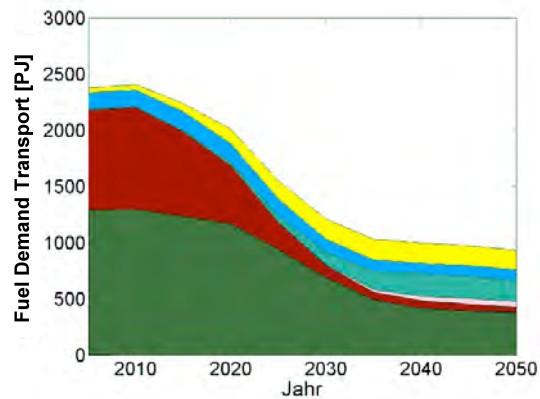
Some substantial consequences were shown in the following part, based on the scenarios. In case of the energy caused CO₂-emissions it can be seen, that the “Continuation” scenario is reducing much slower in the electricity sector, because the boundary conditions constrain that existing coal-powered power plants cannot be switched-off. In the other two scenarios, the model decides to turn them off as soon as possible. Only a small reduction is achieved in the “Continuation” scenario in the transport sector, because the boundary conditions include a continuation of the current freight traffic, which means that it is still conducted for the most part via the road. As indicated above, to maintain the CO₂-budget, the heating sector is forced to reduce more emissions

Fuels

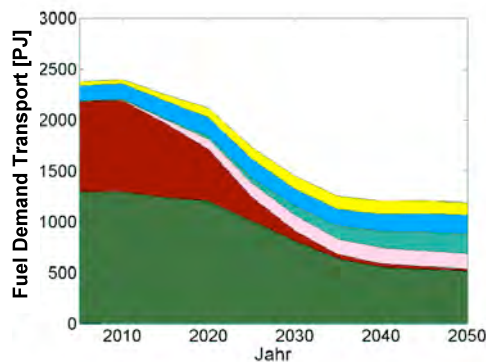
Fuel consumption is decreasing massively. The most important role plays diesel, which is still used in freight traffic. In the "Continuation" scenario diesel consumption is reduced less, because freight traffic is still mainly done via the road. Petrol is reduced extensively, because from a certain point in time, it is just used as a so called "range-extender", for electro cars. In the scenario "Paradigm Shift +" hydrogen powered cars play an important role, beside gas- and electro cars. The share of bio-fuels is extending to a high degree from 2030 onwards. It is interesting to see that, with a raising scale of decarbonization, the model uses more bio-mass in the fuel production, than in other sectors. The used amounts of bio-mass are assessed quite conservative and are for the “Continuation” and “Paradigm Shift” scenario below the nature conservation-plus scenario of the UBA (Leitstudie 2009). No import of biomass occurs.



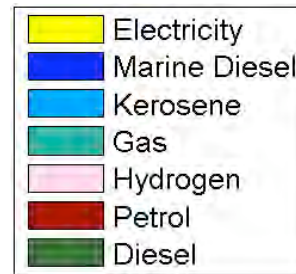
(a) "Continuation"



(b) "Paradigm Shift"



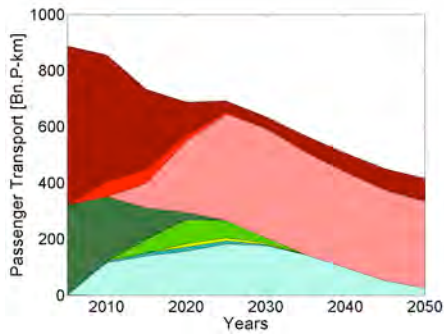
(c) "Paradigm Shift +"



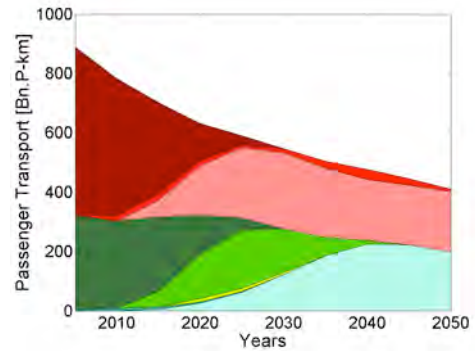
Passenger transport

Motorized individual traffic will be for the most parts conducted with plug-in-hybrid vehicles. In addition, gas hybrids are driven in the "Paradigm Shift" and "all-technology options" scenario. In the latter hydrogen-hybrids are important in the motorized individual traffic. Learning effects of technologies, as i.e. the battery technique, are considered in the model. The individual motorized traffic reduced from about 900 to about 500 passenger-kilometers. This is a boundary condition, which was desired from the stakeholders in the "Paradigm Shift" and "all technology" scenario. It is a result of the model in the "Continuation" scenario.

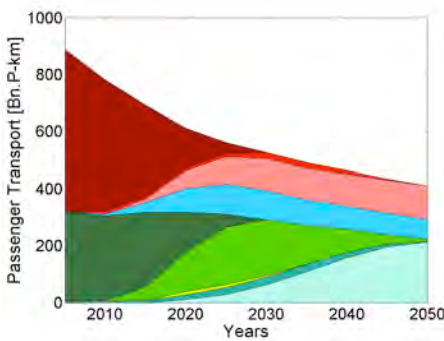
The boundary conditions of the first stakeholder meeting can be seen again in the area of personal transport: While in the "Continuation" scenario the modal-split does not change severely, and thus the passenger-kilometers figure remains constant in public transport, in the other two scenarios a higher figure of passenger-km was stipulated, in order to represent a changed modal-split. In the future, hydrogen-powered buses, suburban trains, electric short- and long-distance traffic trains, diesel-powered long-distance buses and the airplane are going to share the public transport sector.



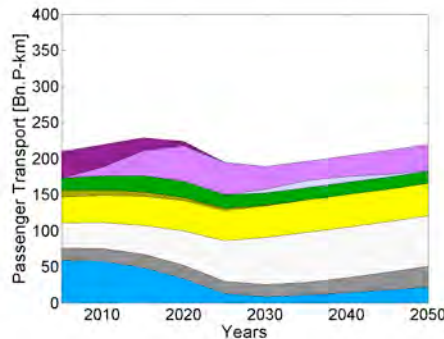
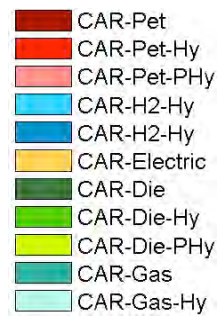
(a) "Continuation"



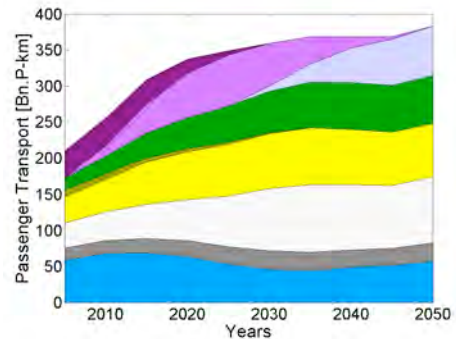
(b) "Paradigm Shift"



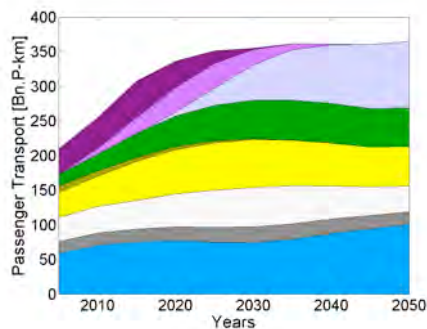
(c) "Paradigm Shift +"



(a) "Continuation"



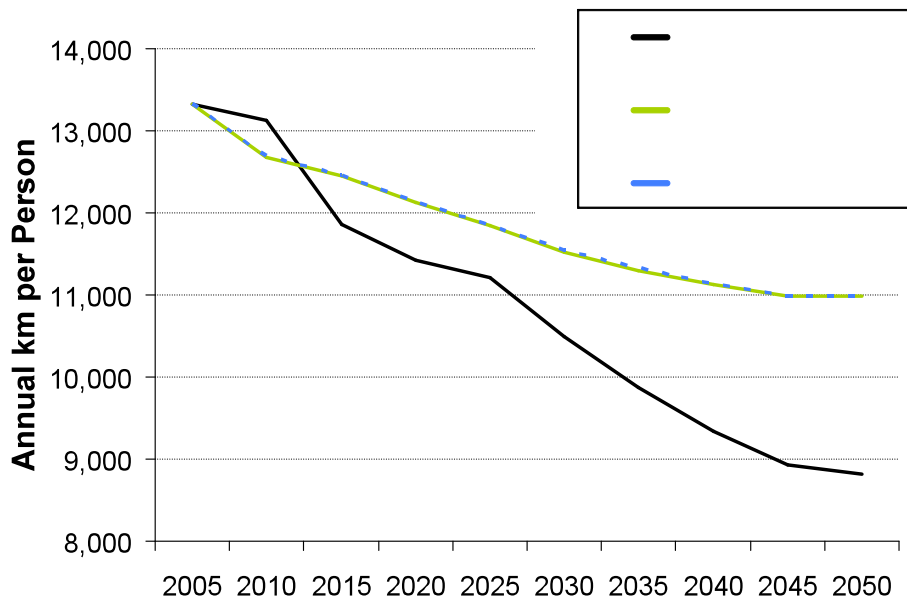
(b) "Paradigm Shift"



(c) "Paradigm Shift +"



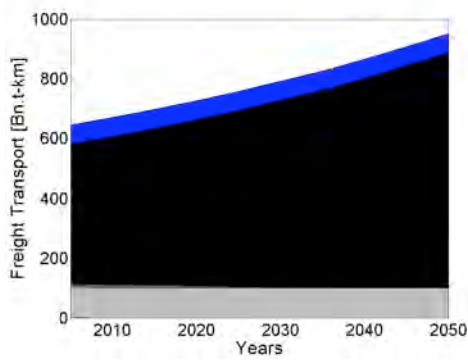
The share of public transport in the total passenger-km rises in the short-distance traffic in both scenarios from a current of about 15% to 50% in 2050 and in the long-distance traffic from 25% to 45%. In the "Continuation" scenario the share of public transport, without a default in the entire personal transport performance, does not rise significantly in the short-distance traffic. In the long-distance traffic it does though significantly, from the year 2025, to finally 55% in 2050. Simultaneously the passenger-km per capita must be reduced essentially: In the "Paradigm Shift" and "Paradigm Shift +" scenario from today's 13500 km to 11000 km and in the "Continuation" scenario to ca 9000 km, due to high CO₂-production in other sectors. It is imaginable, that parts of this difference could be taken over partially, by other non-motorized traffic carriers, which cannot be considered by the model (i.e. bicycle). The simultaneous rise of public transport and the reduction of the total passenger km per capita are due to a strong reduction of passenger km in the motorized individual transport.



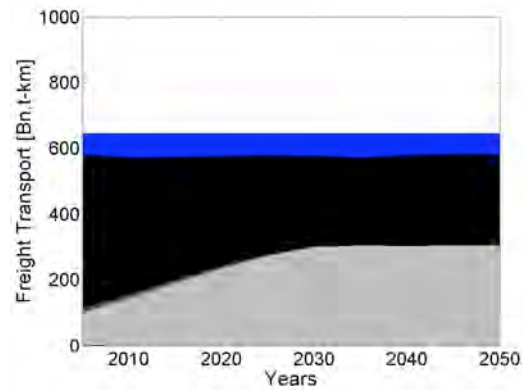
Freight transport

In the "Continuation" scenario a rise is stipulated in the freight traffic sector, which is oriented on a major transport study⁷. The other two scenarios were required not to drop under the figure of the current yearly ton-km. The model calculates on such conditions an expansion in the freight traffic until 2050. In the "Continuation" scenario the ton-km of the railway stay constant.. A linkage of GDP and freight traffic is not stipulated in the model. Interestingly, a decoupling from economic growth and ton-km is occurring in the "Paradigm Shift" and "Paradigm Shift +" scenarios.

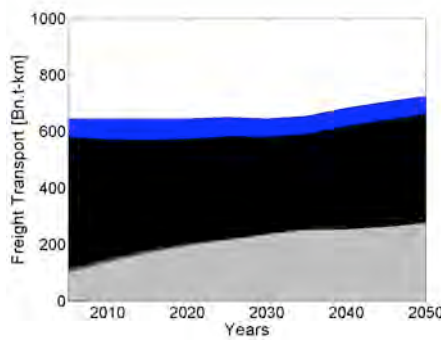
⁷DLR/Shell/HWWI 2010: Shell LKW-Studie. Fakten, Trends und Perspektiven im im Straßengüterverkehr bis 2030. (Shell Goods Vehicle Study). http://www-static.shell.com/static/deu/downloads/aboutshell/our_strategy/truck_study/shell_truck_study_summary_en.pdf



(a) “Continuation”



(b) “Paradigm Shift”



(c) “Paradigm Shift +”

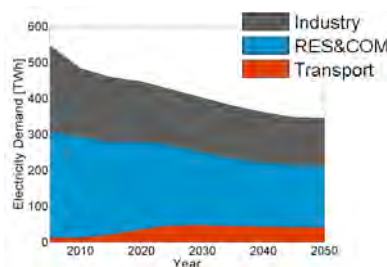


Further factors

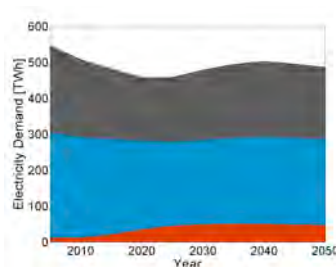
As the transport sector is related closely with other variables, they are shown as follows:

Electricity sector

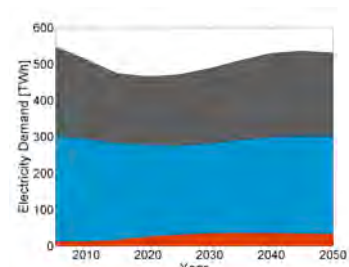
The electrification of the transport sector does not lead to a high share of the electricity demand.



(a) “Continuation”



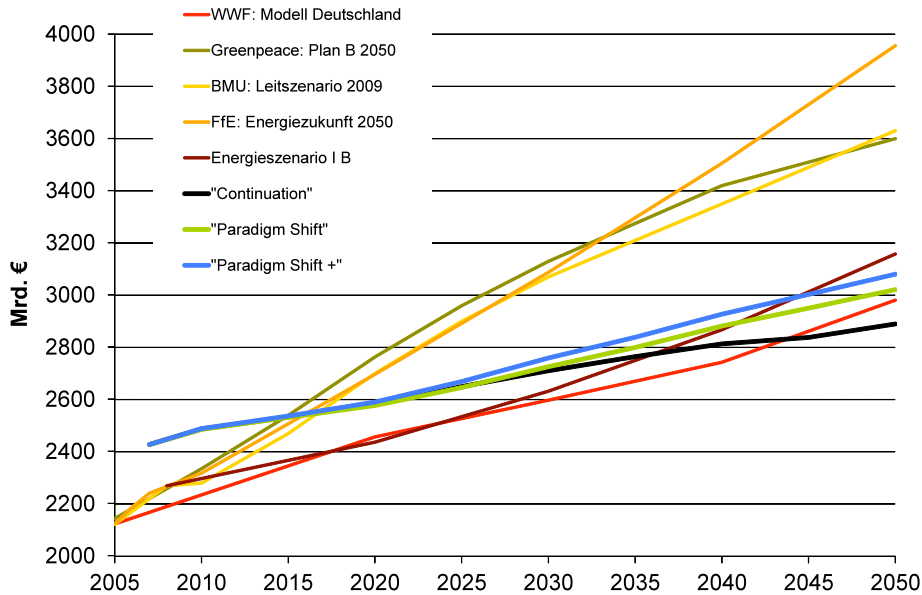
(b) “Paradigm Shift”



(c) “Paradigm Shift +”

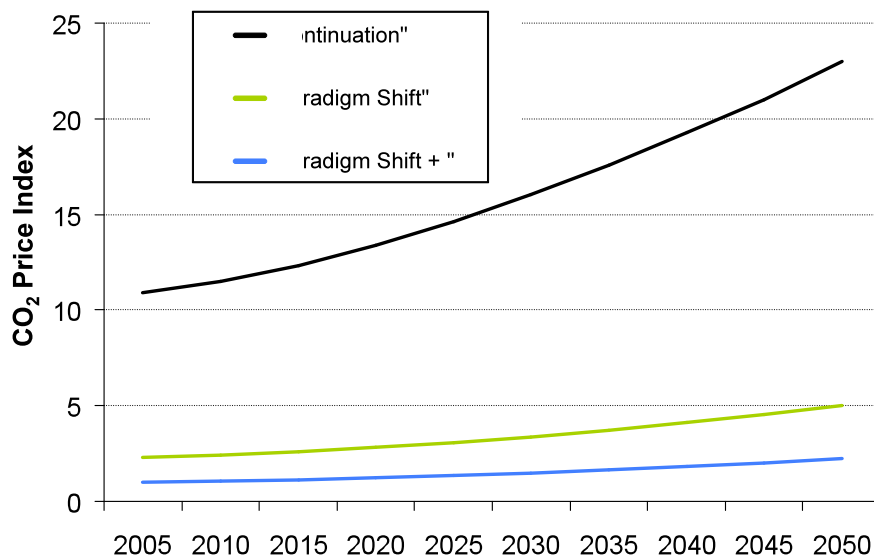
Economic growth

The GDP is increasing the most in the "Paradigm Shift +" scenario. All three scenarios stay within a range calculated in other studies as well.



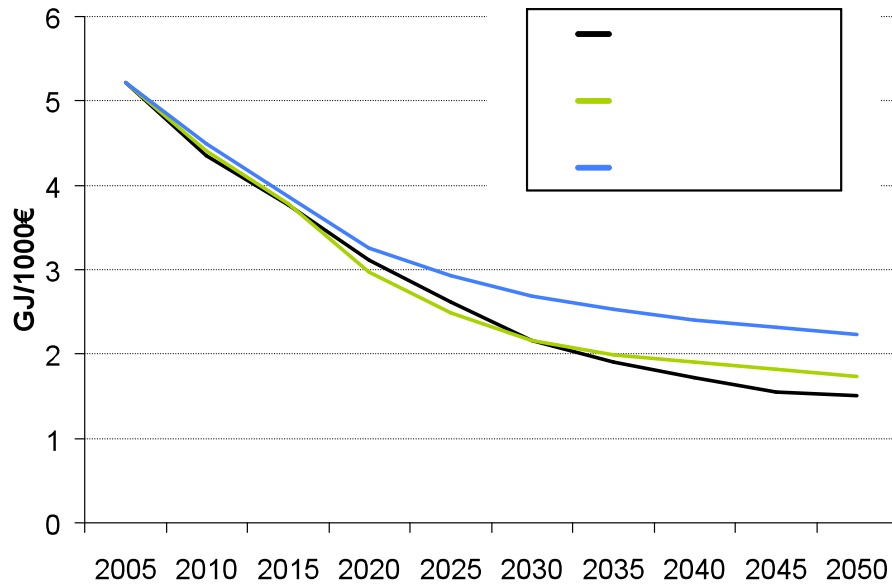
CO₂-price

Although a CO₂-price for Germany alone is rather unrealistic, this chart does inform about the price of CO₂ in the different scenarios. An international emission trading scenario could not be considered in the scenario. Because the price for CO₂ is rising enormously in the "Continuation" scenario, it was standardized to price in the "Paradigm Shift +" scenario of 2005. A different price in the base year is due to the intertemporal modeling. Because of the high preset emission level of CO₂ in the "Continuation" scenario, due to the use of coal-fired power plants and the continuation of freight traffic, enormous pressure is applied on the price for CO₂.



Energy intensity

Energy intensity is a measure as for how strong economic growth and energy consumption are coupled. All scenarios show an efficiency rise of the economy, linked to the energy demand.



3. Discussion

General comments and questions on the model by the stakeholders

- Monetary incentives (taxes, etc.) are not taken into account in the model. Answer: This is related to the design of REMIND-D. The central question is: How behave the different sectors within given reduction targets.
- Prices are stylized in the model: Though the model includes certain prices (primary energy), the linkage of price and demand is not shown very detailed. Answer: This was done in such a manner, because Germany is price taker for fossil energies on the world market and elasticity of demand is low. The model solely calculates the CO₂-price, as if there was no political regulation.
- The shift of transport to the rail is a substantial move for the decarbonization of the transport sector. The bottleneck is the missing infrastructure, which however is not considered in the model.
- Societies develop rather slowly; therefore the "Continuation" scenario is the most realistic, although there are, in some areas massive cuts, too. Discussion: It is difficult to evaluate, which of the scenarios is most realistic.
- E-bikes as a traffic carrier is not included. Sales are rising and particularly in addition with "bike-speed-ways" a relevant size could be reached.
- Future technologies in the field of local traffic in the city are not taken into consideration. Discussion: Realization cycles for new traffic technologies are too long, they do not need to be considered.

- Is there a possibility for a calculation with a 95% CO₂-reduction? This would be a condition to stay below a climate warming of 2 degrees. Answer: The "Continuation" scenario almost cannot solve within such a condition.
- The "Paradigm Shift +" scenario anticipates the use of CCS from the year 2020. This is not very realistic, because at the moment CCS failed politically. Answer: This is being considered in the model, to see what options amount from this.

Fuels:

- Human strength is not being considered in the model (i.e. driving bicycle), but could be added, for example to the decreasing passenger- km, which would moderate the decrease in the total passenger km.
- The share of bio-diesel in the diesel production is increasing rapidly by the year 2030. From today's perspective such an increase is not producible, or rather not desirable. Especially for freight traffic on the road an alternative fuel is not available. Gas is rather an alternative for the individual traffic.
- The main part of bio-fuels originates from technologies, which nowadays are not available on a large-scale.
- To decrease emissions of the freight traffic massively, the entire transportation system would have to be restructured severely. Until now there are little signs for such a process.
- Are the political measures feasible, in order to cover the modeled demand of fossil fuels (military intervention)?
- The refineries produce a preset ratio of diesel and petrol. There is already a diesel shortage and petrol surplus in Europe at the moment, which would even exacerbate. Discussion: In the model is a stylized refinery sector depicted.

Passenger traffic

- The public transport must at least be doubled, according to the model. However, there has not been a public-friendly traffic policy throughout the last 50 years, since transportation on the road was a more attractive object for politics. To double the public transport, an infrastructure extension of 40% and intensified phases are necessary. There is a competition between goods traffic and passenger traffic, because of insufficient networks. The "Deutsche Bahn" has no visions for that. Furthermore the current plan approval procedure, the expansion rate and lacking political will make a doubling impossible --> this is a potential reason for the failure of the model.
- The model only uses technologies for 2030, which are not ready for series production yet. This is an element of uncertainty which displays massive research and development demands.
- Car-sharing: Experience shows that if there is lower vehicle ownership people drive less. How can this be considered in the model?
- It is more realistic that combustion engines are gone by 2040, not 2030.

Goods traffic:

- In goods traffic potentials for savings are smaller than in passenger traffic. Even though high saving possibilities emerge by using bio-fuels, especially in the second generation.
- Freight traffic is running on European level, which must be considered in the model. 55% of the street and rail traffic is border-crossing. According to a study, the shift from street to rail starts by a toll of 26 cents per km.

4. Political measures

For not sticking in the world of models, the stakeholder discussed and suggested changes in politics and concrete political measures on basis of the scenarios:

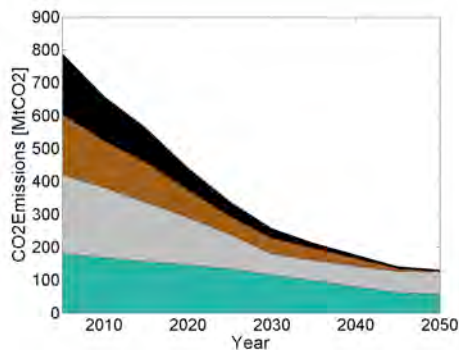
- Shorter plan approval procedures
- Clear separation of operation and network
- Federalism is a problem: there is no nationwide coordination for rail projects, i.e. a nationwide rail system expansion plan
- Also there is no national coordination body
- “Goal for a railroad network in 2050”: an aim vision must be developed how the infrastructure must grow in the next years. Discussion: political will is missing because no growth of public transport has been registered. Here a societal transition must be initiated. Counter-argument: some experiences show that society has changed more than politics on community level in this field. Still there is the problem of missing willingness to bear the cuts emerging with political measures.
- Next to missing willingness there is the problem of lacking financing. Money is needed for the local traffic, it is necessary to think about a car toll. Counter-argument: More money does not always mean a better network.
- The energy input for passenger and goods traffic reverses. Solutions in goods traffic should get priority in politics since it is more important in long term.
- City of short distances. Political willingness on community level is missing. Counter-argument: the city of short distances often involves conflicts (central shopping malls).
- CO₂ - taxes
- CO₂limits for vehicles in freight traffic.
- Safety in road traffic is an important aspect to motivate people to walk or bike.
- To reduce motorized individual traffic, the public transport should be connected with other means of transportation (Bike transport in trains, bike/ pedal electric cycle hiring points at stations, simple car-Sharing-Systems at stations, etc.)
- Separation of passenger and goods rail network.
- Shortages in goods traffic are also collecting points; here is a modification and expansion necessary.
- Research and development for new fuels and engines.

4.2 Electricity

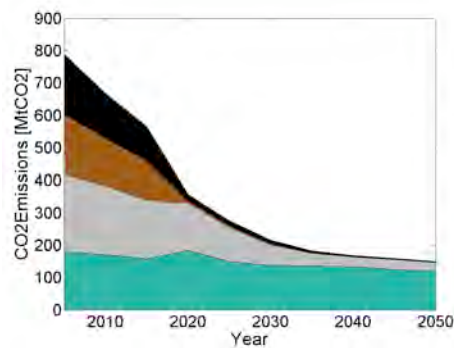
The second dialogue of the electricity sector was held in Berlin on the 5th of October 2011. The presentation of the scenario-building was the same as above, only the results and consequences differ.

Emissions according to energy source

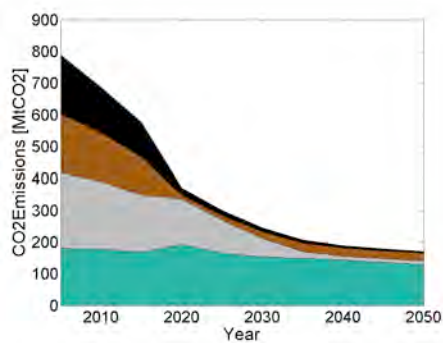
In the "Continuation" scenario, due to the exogenous guidelines, coal is being emitted substantially longer than in the other two scenarios. In these, the model decides to turn-off energy production based on coal by the year 2020. Only in the "Paradigm Shift +" scenario remains a rest of brown coal with CCS. The use of crude oil decreases massively likewise by 2020. Gas contribution to the energy production increases strongly in all scenarios.



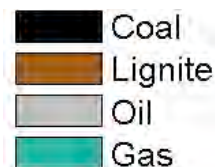
(a) "Continuation"



(b) "Paradigm Shift"

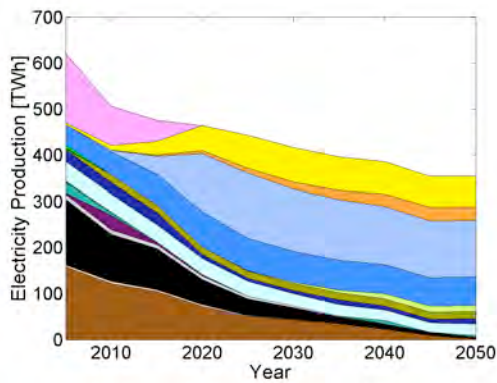


(c) "Paradigm Shift +"

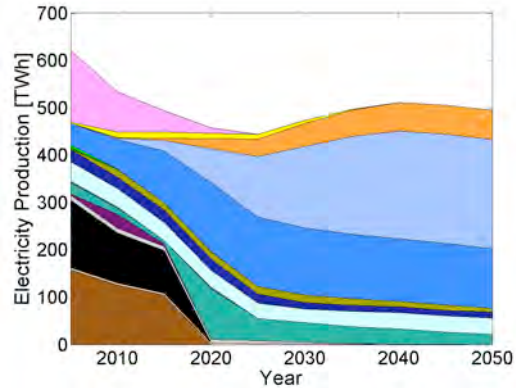


Electricity production

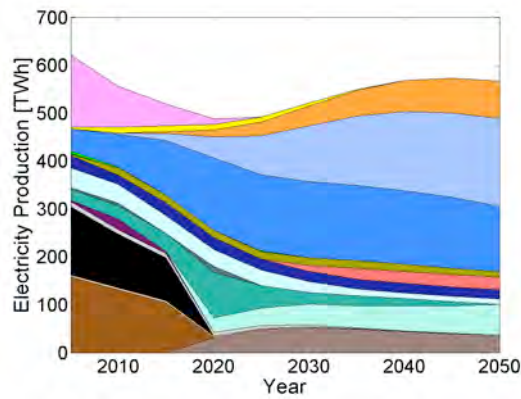
Electricity production decreases in the "Continuation" scenario, because of the specified runtimes for coal-powered power stations and the given CO₂-budget. New gas power plants, which could offset the fluctuation of the renewable energies, cannot be built in this case, due to the tight CO₂-budget. Hence, a very strong expansion of the renewable energies is not possible in this scenario. Electricity production can increase in the other two scenarios from the year 2020 onwards, because much less CO₂ is emitted by turning-off the coal-powered power stations. The low increase of photovoltaic conversion (PV) in both of these scenarios is due to the low "capacity credit" of PV. As wind energy is less dependent on the weather, the model decides to build more of this technology. The scale of the expansion of wind energy is based on analysis of the potential of wind energy.



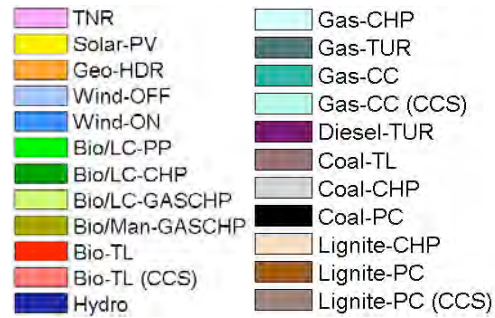
(a) "Continuation"



(b) "Paradigm Shift"

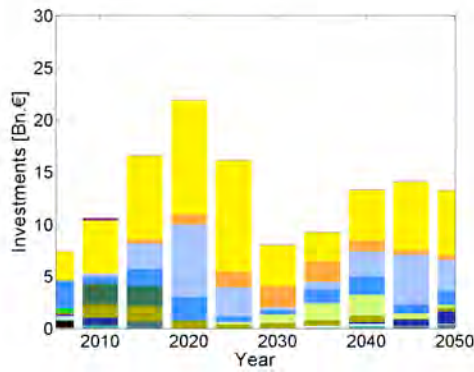


(c) "Paradigm Shift +"

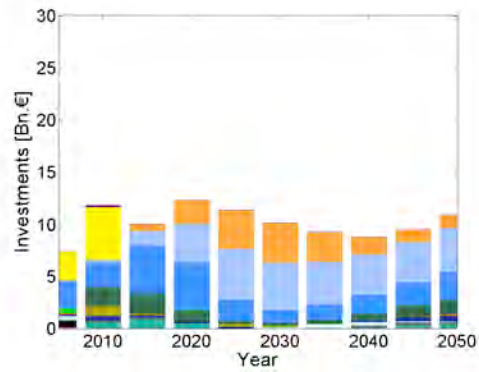


Investments in the electricity sector

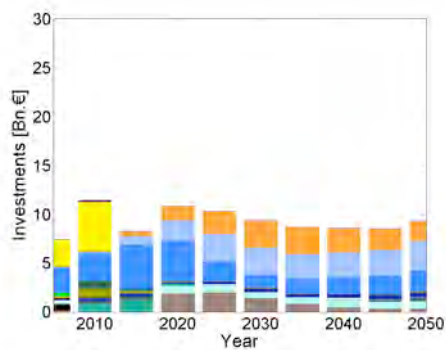
The investments are developing corresponding to the production: PV investment has to take place especially in the "Continuation" scenario. This is not the case in the other scenarios, owing to the missing expansion.. In these expansion concentrates on wind energy and geothermal energy.



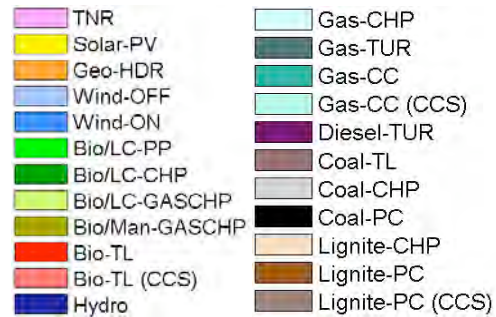
(a) "Continuation"



(b) "Paradigm Shift"

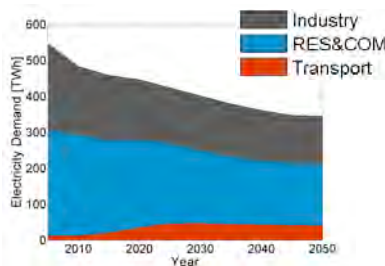


(c) "Paradigm Shift +"

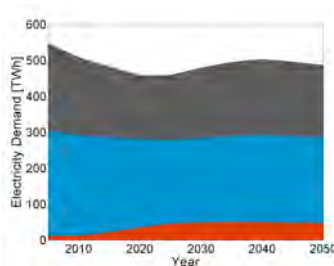


Energy demand

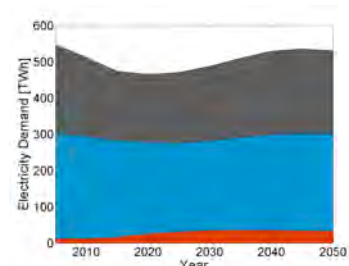
The energy demand is limited through decreasing production within the "Continuation" scenario. This means if coal-fired power plants are running in the long-term, the demand needs to decrease, otherwise the climate target will not be reached. In the two other scenarios the demand is more or less constant. In none of the scenarios the electrification of the transport sector leads to a substantial increase of the energy demand.



(a) "Continuation"



(b) "Paradigm Shift"



(c) "Paradigm Shift +"

3. Discussion

General comments and questions on the model by the stakeholders

- The "Continuation"-scenario does not correspond with the existing legal framework. No coal-fired power plant runs as much as illustrated and the RES-priority is missing. This path seems to be the status quo even though it is a development without regulations. Answer: the model rather illustrates the immanent logics of the system. For example in the "Continuation"-scenario: If fossil energy sources continue to be politically supported, it is very unrealistic to reach the 80% target. The scenario can be seen on the contrast slide.
- The Merit-Order-Effect is not considered in the "Continuation"-scenario even though it has an impact on the usage of the different power plant types. For the usage of coal-fired power plants it should draw a convex curve.
- It is unrealistic to assume a coal-fired power plant expansion without CCS.
- It is unrealistic to expect a power down of coal-fired power plants until 2020.
- Business plans remain unaccounted for in such a macro model like this. It could happen that energy companies stop working because it is not profitable to keep coal-fired power plants running or to build new ones. In general the legal framework for energy companies is very unclear right now. But they have a great effect on the market design. How could the assessments of the power plant operator be considered in the scenarios?
- A European embedding is missing especially regarding the question of the CO₂ price. This makes a strong difference for the costs.
- There are no cost considerations for the case that nothing changes and climate change adaptation costs rise. Answer: This was supposed to be covered by the CO₂ price. Possibly this price does not imply all social costs.
- The natural gas prices are very relevant for the future. Those must be especially considered in the model.
- Slackness of change, which is influenced by social and political reasons, is not displayed. Maybe there are possibilities to integrate these delays in the model.
- The scenario needs to be embedded in the European level. This would make a big difference for many variables.

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