The energy turnaround in Europe and its consequences for renewable generation, energy infrastructure and end-use

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ABSTRACT: The energy turnaround in Europe represents a transition process, by which fossil resources are replaced by renewable energy. As the hydropower potentials are to a large extend exploited in Europe, wind and photovoltaic represent the technologies with the highest growing rates in the future. As the potential of these renewable resources is limited, efficiency in the end-use becomes in future a precondition for a successful turnaround. The sectors of buildings, households and mobility represent the highest efficiency potential. Energy active settlements with integration of renewable energy sources, local demand side management and storage capacities will form the backbone of transition. Replacement of combustion engines in cars by electric power train will bring improvement of efficiency by 70% and substitution of fossil fuel by renewable energy. The battery of cars can also be used as flexible energy storage in Smart Grid or Micro Grid management systems either grid to car or also to a smaller extend car to grid.

1 INTRODUCTION

Europe's energy strategy tends to low carbon and high renewable contend in energy. In history the Kyoto Protocol and low carbon dioxide dominated the energy strategy until about the year 2005. To reach the emission targets a broad assessment reaching from carbon capture and storage to new gas fired power stations with higher efficiency and lower emissions was initiated. Today renewable generation and efficiency in the end-use form the main targets. This is laid down in the package for climate protection SEC(2008) 85/3, giving for each member state of the EU individual target values for emission reduction and renewable energy content in the end-use of energy. The so called "20-20-20 until 2020" target aims to reduce in the mean of all EU member states the emissions by 20%, increase renewable energy content to 20% and improve end-use efficiency, related to the case without measures, by 20%.

In Europe historically and according to diverse preconditions, the member states have different intentions in their energy strategy:

- Keeping nuclear as main energy source
- using coal from local resource for energy
- Full turnaround to renewable energy

In the long range until the year 2050 the overall target will be a portion of 80% of renewable energy in the end-use and will result in a synchronization of the strategies of EU member states.

The transition process from predominant fossil to mainly renewable is linked to some preconditions:

- Local potential of renewable energy such as wind, photovoltaic, hydropower
- Extension of the energy infrastructures for integration of renewable energy sources
- Providing balancing energy for the fluctuating renewable generation from more flexible thermal power stations or from pumped hydro power stations or local battery storages in adequate capacity
- Reduction of end-use demand by efficiency measures, especially in the sectors of buildings and mobility
- Development of technologies for energy efficient buildings with low energy demand
- Integration of renewable energy sources especially photovoltaic in buildings
- Development of Smart Grid and Micro Grid and "intelligent energy" technologies.

This necessitates interdisciplinary research and development under ecological and economical aspects.

2 SHORT AND LONG TERM STRATEGIES

The energy turnaround is characterized mainly by replacing fossil energy by renewable energy sources and thus avoiding CO_2 emissions. In history hydro power formed the main source of renewable energy. As the hydro potential in Europe is limited, in future wind and photovoltaic will be the main sources. Wind has a big potential up to about 300 to 500 GW in the EU. PV will have the same potential. Wind generation is connected mainly to the transmission grid and necessitates extensions for higher grid capacities in the existing grid or of building a new super grid in Europe with extra high voltages of 800kV of 1.000 kV.

Photovoltaic will in future be mainly situated on the roof or the facade of buildings, thus avoiding land use. PV will therefore mainly have influence on the low or medium voltage distribution grid.

Here mainly the integration of PV in buildings will be considered as this paper is focused on the decentralized aspects of the energy turnaround.

2.1 *Short term strategies*

In the short term range until 2020 PV and wind energy will grow in its generating capacities. A first mark is, if the installed power of both reaches the peak load in the grid. This can result in partly fully displacement the fossil operated power stations by fluctuating renewable energy.

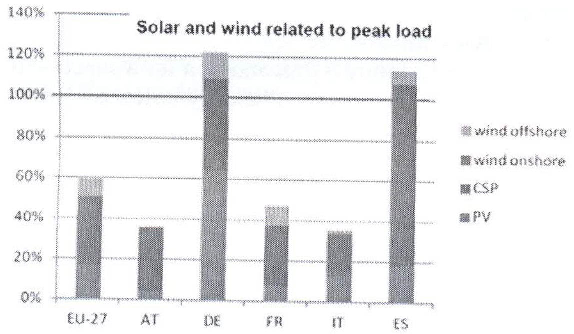

Figure 1. Solar and wind power in relation to peak load in European Member states (2020).

As shown in Figure 1 according to the National Renewable Action Plan [NREAP] in two European countries, Germany and Spain by high installation rates this could happen until 2020. To guarantee security of supply the backup power stations have to be operated more flexible than in history. The number of start-ups and shut-downs will nearly be doubled and the power stations have to be able to bring high gradients of power for shut down e.g. in the morning during sunrise and start-up in the afternoon till sunset.

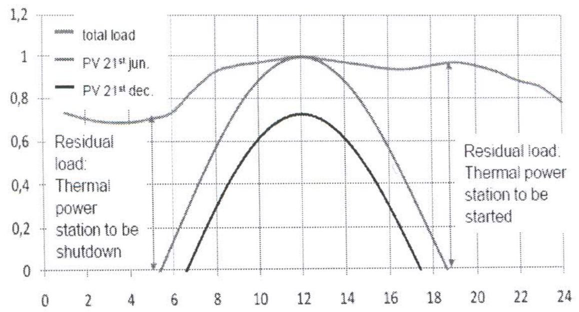

Figure 2. Residual load balancing.

As shown in Figure 2 the difference between load and renewble generation , which is called residual load, has to be provided from storage capacities or from flexible power stations.

2.2 *Long term strategies*

In the long term range until 2050 the renewable energy sources can significantly exceed the peak load of the grid. In this case the provision of storage capacities is necessary. But long term storage capcities are very expensive, so in future it will be better to cut-off surplus generation instead of providing these capacities.
In Austria in a research project it was found, that for long term storing of a surlus of about 8% of the annual demand, the existing storage capacities would have to be extendet by the factor 100. This seems to be uneconomic and is also limited by the resources available for this purpose.
In the long range it will thus be necessary to include also decentralized energy balancing concepts in the electrical energy system. At the one hand by increasing the efficiency in end-use, the deman can be reduced. At the other hand the by local demand side management (DSM), the energy demand can be better adopted tor the generating charachteristic of the renewable energy sources.
In Figure 3 the change in energy demand in an energy active settlements from today to the year 2050 is shown:

- Thermal insulation of buildings will reduce the demand for heating.
- New efficient appliances and illumination will reduche the electricity demand.
- The fossil operated car will be replaced by an electrical vehicle, which can be charged by PV and has the ability to feed a limited amount of energy back to the grid (car to grid, C2G).

As the energy demand in the private sector represents about 30% of the overall demand of a country and the demand for mobility a further 30%, by using electrical cars and heat pumps for heating about 60% of the fossil energy demand can be replaced by renewable electricity from wind, photovoltaic and hydropower [Power Vision].

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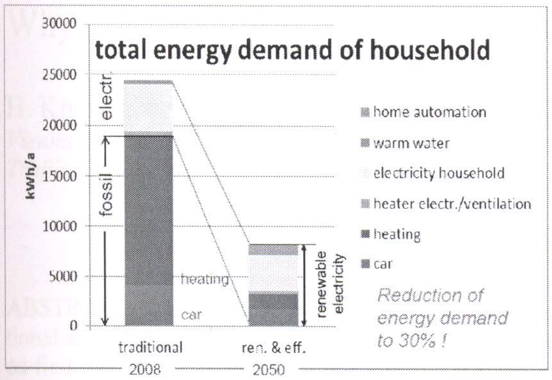

Figure 3. Reduction of energy demand in households until 2050.

Thermal insulation of buildings, heat pumps, efficient end-use, and electrical cars can reduce the energy demand in to 30% related to a conventional household of today.

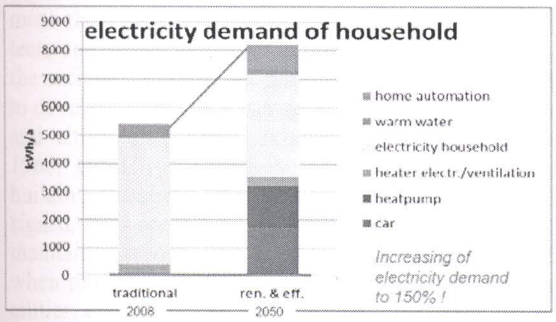

Figure 4. Development of electricity demand until 2050.

The electricity demand will be increased in household to about 150% until 2050, as a consequence of the energy turnaround (Fig. 4).

In Figures 3 and 4 for the year 2050 an improvement of efficiency in end-use according to an investigation in Austria is assumed. By a questionnaire the potential was investigated by Ghaemi [Ghaemi 2011], as shown in table 1. About 70% of all households consist today on only one or two persons. Here smaller flats and newer appliances are used, so the efficiency potential is relatively small and between 23 to 27%. Households with children have a higher efficiency potential, because of lower income and thus using elder appliances.

Table 1. Efficiency potential in households [Ghaemi 2011].

Number of persons per household	demand today	demand efficient	efficiency potential
	kWh/a	kWh/a	%
1	2,830	1,840	-23
2	3,580	2,612	-27
3	5,750	3,240	-44
4	5,820	3,700	-36

In general, most significant potentials in energy savings are in the sectors of building and mobility.

- Thermal insulation and heat pump application with renewable electricity can bring down the demand to about 10% of today.
- Replacing fossil operated cars by electrical vehicles can improve the power train efficiency by 70% and substitute fossil energy by renewable electricity mainly from wind and photovoltaic.

3 CONCLUSION

Buildings and mobility are the sectors with highest efficiency potential in the end-use of energy. In the long term run, here with renewable generation the energy turnaround can take place.

Still some research and technological development is necessary to reach this target. As the rate of refurbishment is under realistic aspects only some percent per year, the energy turnaround will need some decades to be successful.

4 REFERENCES

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