



jointly with



June 2013

Sustainable pathways for the European electricity system: Del A, Method and model package; Del B, Intermediate results

The EU Commission has expressed ambitions to reduce greenhouse-gas emissions by 80-95 percent by 2050. Fulfilling such a goal will inevitably lead to significant impact in all parts of the European energy markets. Given the comparatively advantageous options to reduce emissions in the electricity-supply system, emissions in this sector may approach zero. What will such an electricity-system look like, how will it work and what are the possibilities and the obstacles in such a development?

The work carried out so far has focused on developing modelling tools for analyzing the research questions addressed in the project as well as formulating important intermediate, and still somewhat preliminary, research results and findings.

The research presented here is the collective effort of ongoing subprojects jointly conducted, such as the Pathways project financed by Vattenfall, the "Electricity networks of tomorrow" project financed by E.ON and the NEPP project.

The scenarios

In order to reflect the large uncertainties associated with long-term analyses and in order to handle factors external to the models, we have chosen to define four main scenarios each describing possible future developments for the

European energy systems (see Figure 1, left). The scenarios are defined around two main dimensions: technology and policy.

At this stage, all four main scenarios have been preliminary analyzed by the ELIN model. The results are summarized in Figures 2 and 3. In the forthcoming research work, the scenarios may be further refined and complemented with sensitivity analyses.

Based on the current research some of the more important findings may be summarized into:

- Existing technology and fossil fuels will continue to play a decisive role for at least 20-30 years
- The share of renewables in electricity generation is constantly increased and may reach beyond 50 percent in the EU by 2050 under a climate-policy regime
- Due to ambitious climate-policy targets, the carbon price is likely to become high while the system price of electricity is less affected
- Accelerating efforts to develop low-carbon technologies are needed in the industry sector
- The European building stock can be assessed by archetype building, country for country.
- Realising a large scale CCS is challenging, especially if only off-shore storage is allowed
- Abundance of natural gas may totally change the scene for future European electricity generation

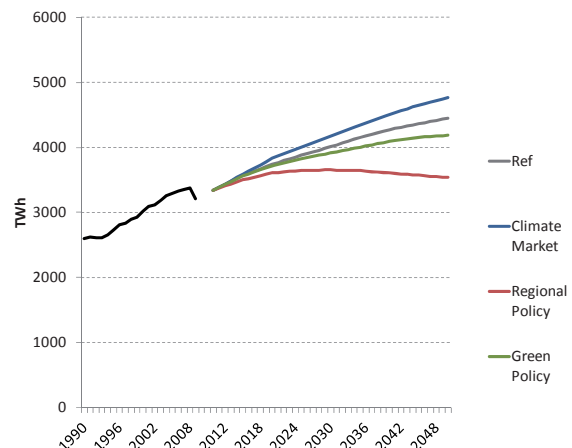
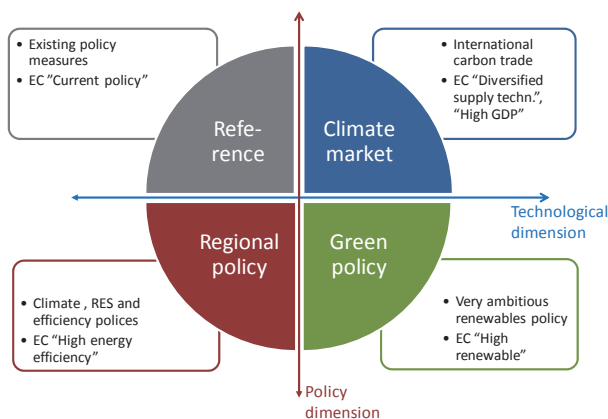


Figure 1. Scenario map (left) and gross electricity demand (right)

- Security of supply can walk hand in hand with climate change mitigation
- Improved strategies for wind location is crucial for reaching high shares of wind power
- The demand-side perspective is important when considering distribution and decentralised production.
- Future potential and climate benefit of biomass depends on many factors.

- The formulation of policies and regulations significantly affect how land can be used for different purposes, including bioenergy
- The debate whether long-rotation forest management with biomass extraction for energy is climate neutral or not, is primarily related to the *timing* of net GHG savings.

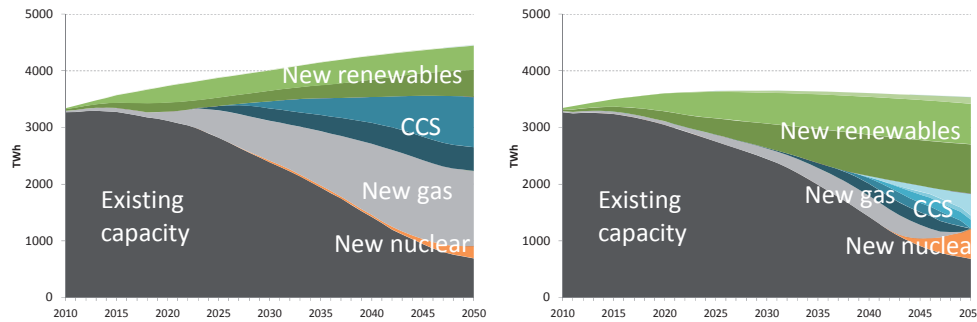


Figure 2. ELIN model results (EU-27+Norway+Switzerland) for the Reference scenario (left) and the Regional Policy scenario (right).

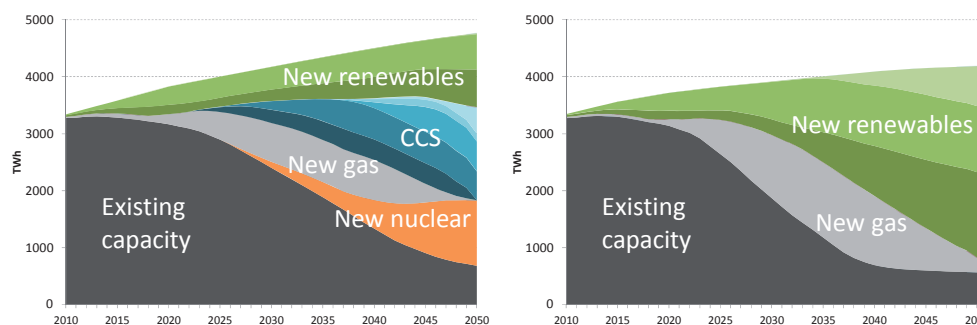


Figure 3. ELIN model results (EU-27+Norway+Switzerland) for the Climate Market scenario (left) and the Green Policy scenario (right).

Here we focus on a couple of these intermediate results.

Existing technology and fossil fuels will continue to play a decisive role for at least 20-30 years

- Due to ageing and unprofitability, existing generation stock is likely to be reduced by around 30 percent by 2030. Thus, in the high-demand scenario “Climate Market”, existing capacity of today may supply only around 60 percent of total demand in 2030. The gap is filled with investments in mainly wind and gas power.
- Beyond 2030, CCS may emerge as a key technology. Given that conditions are feasible, CCS may supply more than 30 percent of total generation in 2050. Central and Eastern Europe together with Spain are the most important regions for on-land storage.
- Natural gas is an important fuel, especially in a mid-term perspective. A large expansion in gas-fired electricity generation enables cost-efficient CO₂-reduction in a short-to-mid-term perspective. Beyond 2040, however, increasing costs and increased competition from practically CO₂-free emitters such as renewable and CCS exerts a downward pressure on the use of natural gas for electricity generation.

The share of renewables in electricity generation is constantly increased and may reach beyond 50 percent in the EU by 2050

- The share of renewables of total electricity generation is constantly increasing over time. In 2050, renewable electricity generation account for more than 60 percent in the Regional Policy scenario and. That share is less in the Climate Market scenario, roughly 40 percent. However, in the “Green Policy” scenario this share is, deliberately, chosen to be much higher (close to 100 percent).
- A high degree of renewable variable generation yields a significant capacity build-up. Even though demand is stagnating and declining post 2030 in the Regional Policy scenario, total installed capacity is almost 30 percent higher in 2050 than today. In the Green Policy scenario, on the other hand, installed generation capacity in 2050 is around twice as large as today.
- Interconnector capacities between countries are significantly increased. This is partly a result of handling the increasing amounts of renewable electricity more efficiently.

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