GERMANY'S "YES" TO RENEWABLES: JUST A QUESTION OF REACHING CO_2-REDUCTION TARGETS?

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Overview

In Germany the deployment of renewables has been forced for decades. At the beginning renewables were promoted as option for reducing environmental burdens and energy import dependency. Furthermore, photovoltaics was seen as innovative technology whereas Germany could become a leader and positive employment effects were expected.
Meanwhile, Germany is struggling with too much renewable electricity entering the grids at certain times, and the leadership role has either been successfully occupied by German firms or usurped by other countries' companies (e.g. Chinese companies). Therefore, the reasons for fostering renewables are more and more narrowed to CO_2 reduction objectives.
Further extension in the use of renewables are considered as main pillar for reaching Germany's GHG reduction targets (i.e. reduction by 80 to 90% in 2050, compared to 1990). Using different scenarios for the German electricity sector in combination with a multi-criteria analysis approach, we analyse the impacts of an extensive use of renewables in Germany with respect to economic, environmental and social factors. Beside scenarios focusing on renewables a reference scenario and a scenario with carbon capture and storage (CCS) are presented. By comparing these scenarios positive and negative impact of an intensive use of REG are carried out.

Methods

In the following scenarios with extensive use of renewables are assessed by using a set of indicators. For getting a comprehensive picture economic, environmental as well as social aspects are taken into consideration. Against the background of transforming existing energy systems in sustainable ones, a countless number of indicators has been developed (see e.g., [IAEA, 2005]). The list contains social factors (e.g. "share of household income spent on fuel and electricity"), economic factors (e.g. "fuel shares in energy and electricity", "energy import dependency", and environmental factors (e.g. "GHG emissions from energy production", "air pollutant emissions from energy systems"). In order to restrict the complexity we select 25 indicators reflecting aspects of each category for our analysis. (Tab. 1.)

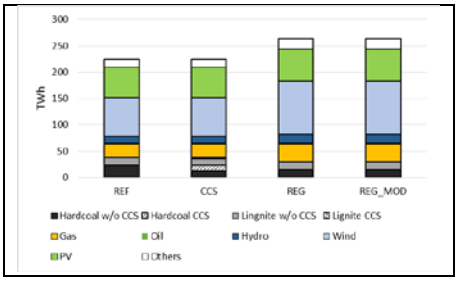
Tab. 1: List of indicators

Economy	Ecology	Society
Net present value of the elec. system	direct CO2 emissions	Pecept.-Trust
Average levelized cost of electricity	indirect and indirect SO2	Pecept.-Economics
Wholesale prices	indirect and indirect NOx	Pecept.-Environment
Annual producer surplus	Cumulated energy demand	Pecept.-Social & Ethics
Consumer surplus	Coal demand	Pecept.-Technological-feasibility
Expenditure on import of fuels	Global warming Potential	Pecept.-Health
Sensitivity to changes in fuel prices	Eutrophication Potential	Pecept.-NIMBY
Sensitivity to CO_2 certificate prices	Acidification Potential	Impact on energy system
		Uncertainties the impacts are linked with

The selection is based on the relevance of the factors in the political discussion in Germany and in the availability of data. For the assessment of the economic factors a dispatch model for the European electricity market is applied. This model enables us to assess e.g. the impacts of changes in the power plants stock on the price of electricity at the spot-market and on consumer and producer surpluses [Rübbelke & Vögele, 2014]
Ecological aspects are taken into account by using data from Life Cycle Assessment (LCA). Beside e.g. direct CO_2 emissions and demand for coal, as impact factors the potentials for global warming (GWP), acidification (AP), eutrophication (EP), and the cumulated energy demand are taken into consideration (see e.g. [Schreiber et al., 2009, Schreiber et al., 2010]). Since not only coal-fired and nuclear power plants but also renewables are affected by perception problems we take a broad range of public perception indicators into consideration applying the assessment scheme published by [Scheer et al., 2014] which includes perception categories like economics (e.g. cost), social and environmental (e.g. noise of wind power plants). All indicators are weighted by the installed capacity in Germany.

Using a multi-criteria assessment (MCA) approach the indicators are aggregated to a composite indicator (see e.g., [Kuckshinrichs & Hake, 2015]). Four scenarios are selected for analyzing the possible impact of deploying renewables in Germany. In the 'Reference' scenario it is assumed that CCS power plants will not reach market maturity in the next 20 years in Europe. In the 'CCS' scenario we anticipate that CCS power plants will be ready for the market in 2030. We assume that in Germany new coal-fired plants will be equipped with CCS. The third scenario is based on the assumption that instead of CCS an increase in the use of renewables (REG) is select as measured for reducing CO_2 reduction. The fourth scenario (REG_Mod) goes in line with "Vision 3" of Entso-E assuming extensive use of REG and high prices for CO_2-allowances (see Fig 1).

Fig. 1: Installed capacity: Germany 2030



Results

Regarding to economic factors the REG scenario shows the best performance for nearly each indicator. Because of the assumed high prices for CO_2 allowances the REG_Mod scenario performs worst (Fig. 2). The REG scenario performs best with respect to ecological and social indicators. Taking into account different weightings for the indicator categories, we calculated composite indicators reflecting more economic, environmental or societal oriented views on the electricity system. In each case the scenarios one of scenario with high amounts of renewables is the favourite one (Fig.3).

Fig. 2: Perfomance Matrix

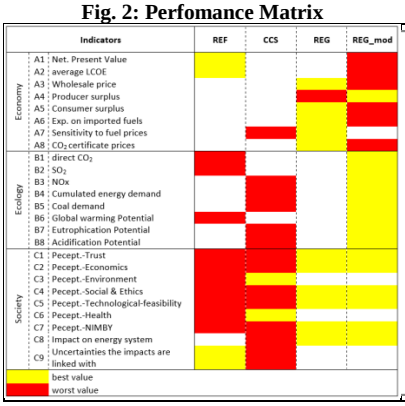
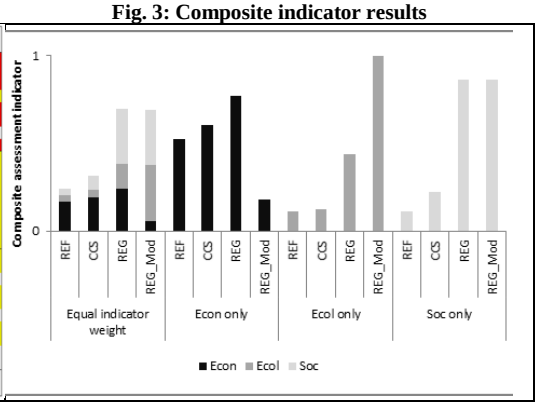


Fig. 3: Composite indicator results



Conclusions

With the help of the multi-criteria assessment approach it is possible an extensive use of renewable has not only advantages with respect to reduction of CO_2-emission but also on other factors. Negative effects will be compensated by other aspects. In our analysis CCS is no appropriate alternative since this technology is linked with high economic, environmental and societal problems. For our analysis we select only 25 indicators since we wanted to test the multi-criteria assessment approach. In further steps additional indicators will be added and the system boundaries will be extended (e.g. by taking efficiency measures into account).

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