Project No 308329

ADVANCE

Advanced Model Development and Validation for Improved Analysis of Costs and Impacts of Mitigation Policies

FP7-Cooperation-ENV
Collaborative project

DELIVERABLE No 7.9
Policy Brief on Bottlenecks and lock-ins in decarbonizing energy supply

Due date of deliverable: October 2016
Actual submission date: December 2016

Start date of project: 01/01/2013 Duration: 48

Organisation name of lead contractor for this deliverable: PIK

Revision: 0

Project co-funded by the European Commission within the Seventh Framework Programme		
Dissemination level		
PU	Public	PU
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

The ADVANCE project has received funding from the European Union's Seventh Programme for research, technological development and demonstration under grant agreement No. 308329.

Policy Brief

Electricity supply sector decarbonisation and the role of wind and solar power

Early and deep decarbonisation of power supply is essential

As discussed in the preceding chapters, early and deep decarbonisation of electricity supply is a core element of effective climate protection strategies. Given the long life-times of power supply infrastructure, achieving these potentials at an early stage is essential to avoid further lock-in into a fossil-intensive system. Moreover, low-carbon electricity supply systems pave the way towards further emission reduc-tions in the buildings, industry and transportation sectors via accelerated electrification.

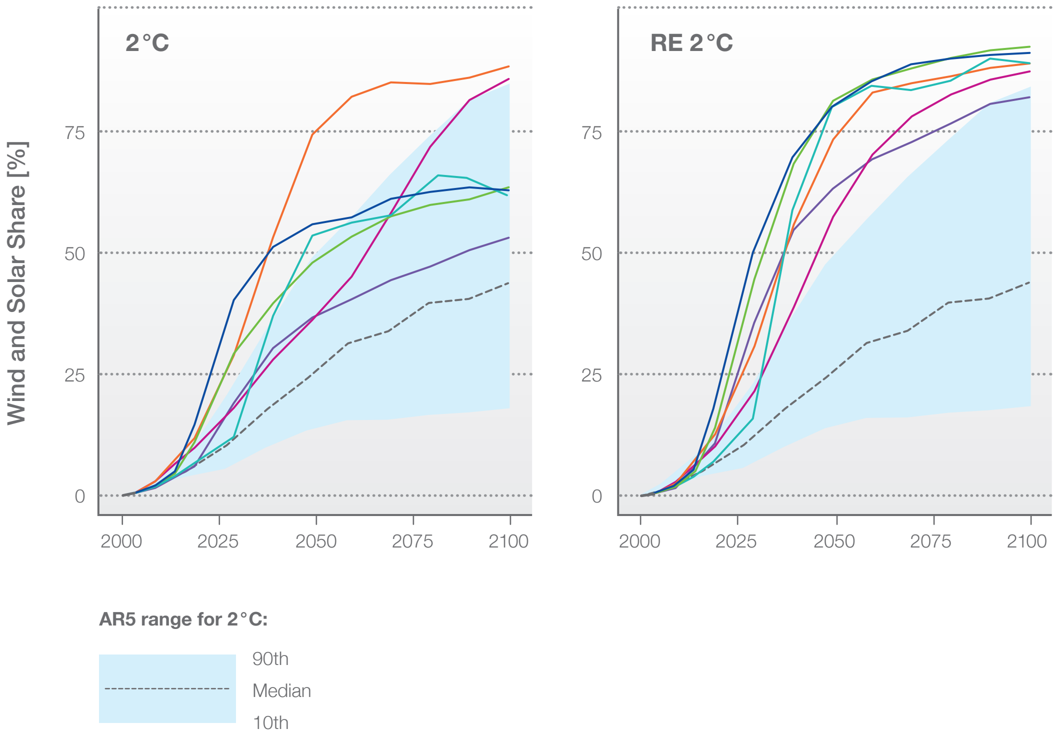
Wind and solar can satisfy most low-carbon power supply

The power supply sector offers a particularly high degree of technology flexibility with renewables, nuclear, and carbon capture and storage (CCS) as alternative mitigation options. With average market growth rates of more than 40 % per year for solar PV, and around 20 % for wind power, over the last decade, these “new renewable” energies are often seen as the most promising technologies for a low-carbon future. Moreover, wind and solar technologies have experienced substantial cost reductions in recent years due to technological progress and economies of scale. As there is still plenty of potential for additional innovation, further cost decreases are expected in the future. Yet many scholars and decision-makers have argued that the prospects of wind and solar power are diminished by the variability and uncertainty of their supply; unlike conventional electricity from fossil or nuclear plants, their electricity output fluctuates with varying wind speed and solar irradiation.

ADVANCE has performed pioneering research to accurately account for the effect of variability on the economics of wind and solar-based power in integrated assessment models. It has developed aggregated IAM modelling approaches based on insights from detailed hourly electricity sector models. ADVANCE has also developed refined datasets on wind and solar resources available for power supply across different world regions. Based on these innovations, we can derive more robust insights into the potential role of variable renewable energy sources for carbon-free electricity supply and climate change mitigation. Specifically, we find that under stringent emission constraints in line with the 2 °C limit, wind and solar will be the main contributors to power sector decarbonisation, and that previous studies based on simpler approaches have tended to underestimate their potential. In these scenarios, carbon prices of \$50 / tCO_2 and higher by 2030 make fossil-based power generation increasingly unattractive, while the near-term decreases in technology costs of wind and solar make these renewable technologies highly competitive.

We even find that power supply can be almost fully decarbonised without nuclear and CCS. Such scenarios feature shares of combined wind and solar of 60 - 80 % by mid-century. An expansion of grid interconnectors and the provision of additional flexibility, via increasing deployment of electricity storage or demand response, are important factors for enabling such renewable-based power systems, while limiting curtailment of wind and solar electricity to less than 15 % in most regions.

Fig. 1: Share of wind and solar in global power supply until 2100 in 2 °C-consistent climate protection scenarios with the full technology portfolio (left panel) and renewable- focused decarbonisation without nuclear and CCS (right panel). Blue shaded areas indicate the 10 – 90 % range of results from 2 °C scenarios assessed in the IPCC's Fifth Assessment Report (AR5). The coloured lines represent ADVANCE results from different models.



Power sector decarbonisation results in environmental co-benefits, especially in terms of reduced air and water pollution

Power sector decarbonisation requires a shift from conventional fossil to alternative sources, including renewables, CCS and nuclear. On the one hand, the phase-out of fossil fuels can be expected to result in environmental co-benefits beyond reduced GHG emissions, such as reduced air pollution from coal power plants. On the other hand, climate policies can also have adverse side-effects, for example land requirements to produce biofuels.

ADVANCE has coupled integrated assessment modelling of the energy-economy system with life-cycle assessment of energy technologies. These were formerly largely separated strands of research. This important innovation has allowed us to comprehensively quantify environmental co-benefits and adverse side-effects of the low-carbon transition, and to quantify alternative power sector decarbonisa-tion strategies in terms of their environmental impacts.

A key finding is that the co-benefits of the low-carbon transformation tend to outweigh adverse side- effects. In particular, climate friendly power systems considerably reduce air pollution, and greatly decrease the release of toxicants to watersheds, while coal mining is responsible for considerable environmental impacts from leaching mine dumps.

Wind and solar based power supply leads to higher environmental co-benefits

In terms of new risks compared to conventional electricity supply, potential areas of concern for low carbon pathways are land requirements (predominantly bioenergy), ionising radiation (due to nuclear power) and mineral resource requirements (for wind, solar and power grids).

To inform decision-makers of the consequences of their choices, ADVANCE compared the risk profiles of renewables-based power sector decarbonisation (with nuclear and CCS excluded from the portfolio of technology options) to a climate protection strategy largely based on nuclear and CCS (with wind and solar limited to a combined share of 10 %). We find that renewables-based strategies are superior in terms of minimising environmental impacts. They greatly decrease air and water pollution as well as total water demand and avoid ionising radiation impacts from the use of nuclear power.

An important drawback of a renewables-based strategy is the substantial use of mineral resources, such as steel, copper and aluminium required for constructing wind turbines, solar panels, grid infrastructure and storage systems. For instance, even if technological progress is accounted for, copper demand for power infrastructure could amount to 5 million tonnes, equivalent to about 25 % of current total copper consumption under global mitigation strategies.

While wind and solar emerge as being comparatively environmentally friendly, biomass is associated with greater environmental impacts than the other renewable supply options. Similarly, hydropower can result in substantial indirect greenhouse gas emissions and upstream energy requirements. Even though it contributes less than 10 % of power supply in either scenario, bioenergy dominates the land footprint of power supply, exceeding land requirements for wind and solar installation, and for grid infrastructure.

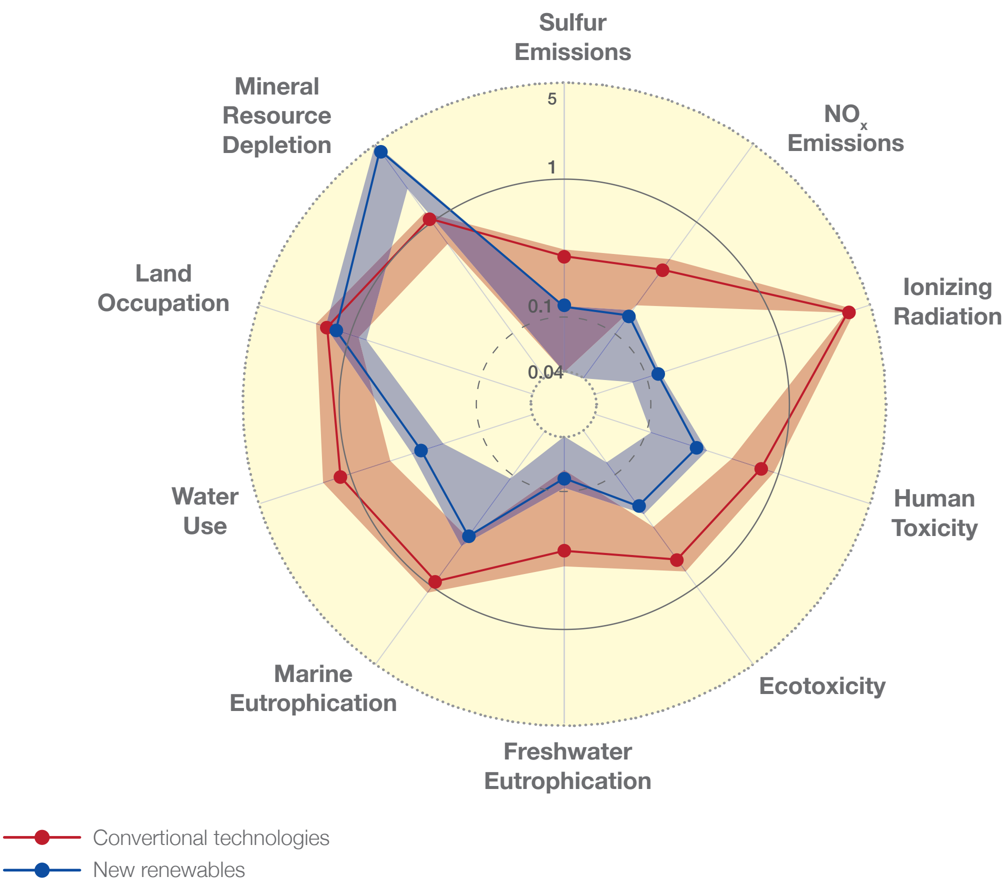


Fig. 2: Comparison of non-climate environmental impacts of power sector decarbonisation strategies based on new renewables (high contribution of wind and solar) or conventional technologies (high contribution of CCS and nuclear). Impacts are shown for 2050 and relative to those that would occur in the absence of climate policies, i.e., values smaller than 1 indicate a decrease of impacts due to climate policies. Note that a logarithmic scale is applied.

Acknowledgement: The research leading to these results has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement No 308329 (ADVANCE).