Clean technology learning under decarbonisation pathways : a POLES model based approach

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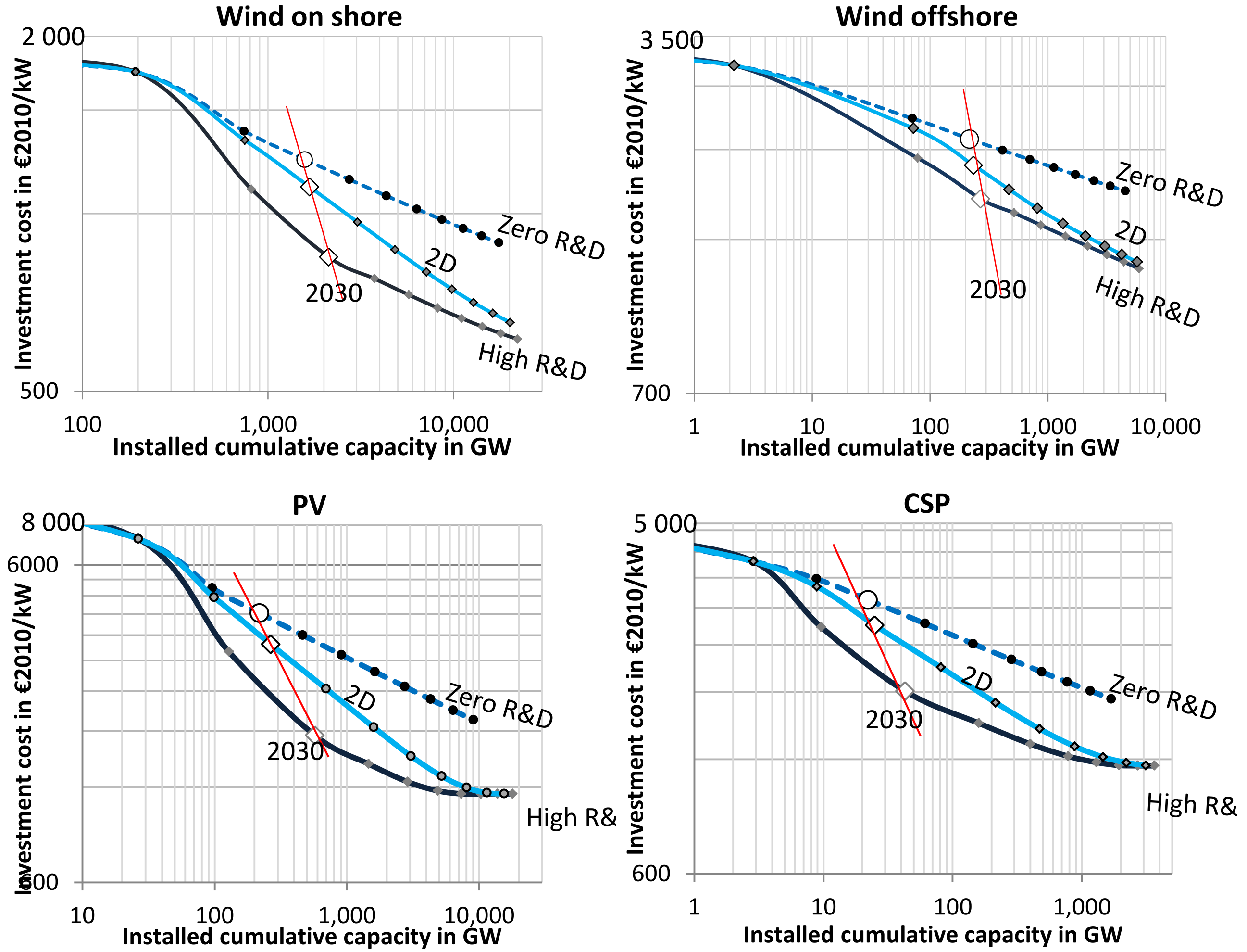
1. Introduction

1. One of the objectives of 3.5 WP is to explore various aspects of deploying new clean energy technology and the associated learning processes, with various settings for energy and climate policies up to 2050.
2. Use new learning curves estimated by UOXF in the endogenous technical change modelling of the POLES model to study :
   1. the impact of changing parameters on technological learning (R&D, breakthroughs, early action)
   2. the impact of changing competitive environment on learning (energy efficiency, nucoff, lack of CCS)
3. Technology learning in Rippels NDC, 2°C and 1.5°C

2. Learning process in the POLES model

1. Poles model may use :
   - Exogenous or endogenous learning
   - Learning by doing or $$INV_{i,tech} = INV_{i,tech,t-1} * \left(\frac{CUMCAP_{tech,t-1}}{CUMCAP_{tech,t-2}}\right)^{crda_{i,tech}} * \left(\frac{(CGERD + CBERD)_{tech,t-1}}{(CGERD + CBERD)_{tech,t-2}}\right)^{crdb_{i,tech}}$$
   - Two-factor learning curves providing a simple representation of two key drivers of technological change: learning by doing and learning by searching.
2. Looking back to past learning rates since the 1980s clearly shows that learning curves display non-linear profiles: technology-development trajectories are sometimes slowed or accelerated by market conditions, industrial competition or changes in the prices of raw materials.
3. The review literature on learning by UOXF provide a useful benchmark on a technology-by-technology basis, which we hope will improve the analysis of model projections in the long run Rippels scenarios.
4. Integrating more variables (spillovers, network effects, material prices) into the analysis, though, may also pose questions about data reliability (public and private R&D), and this is one reason for the popularity of the single-factor specification.

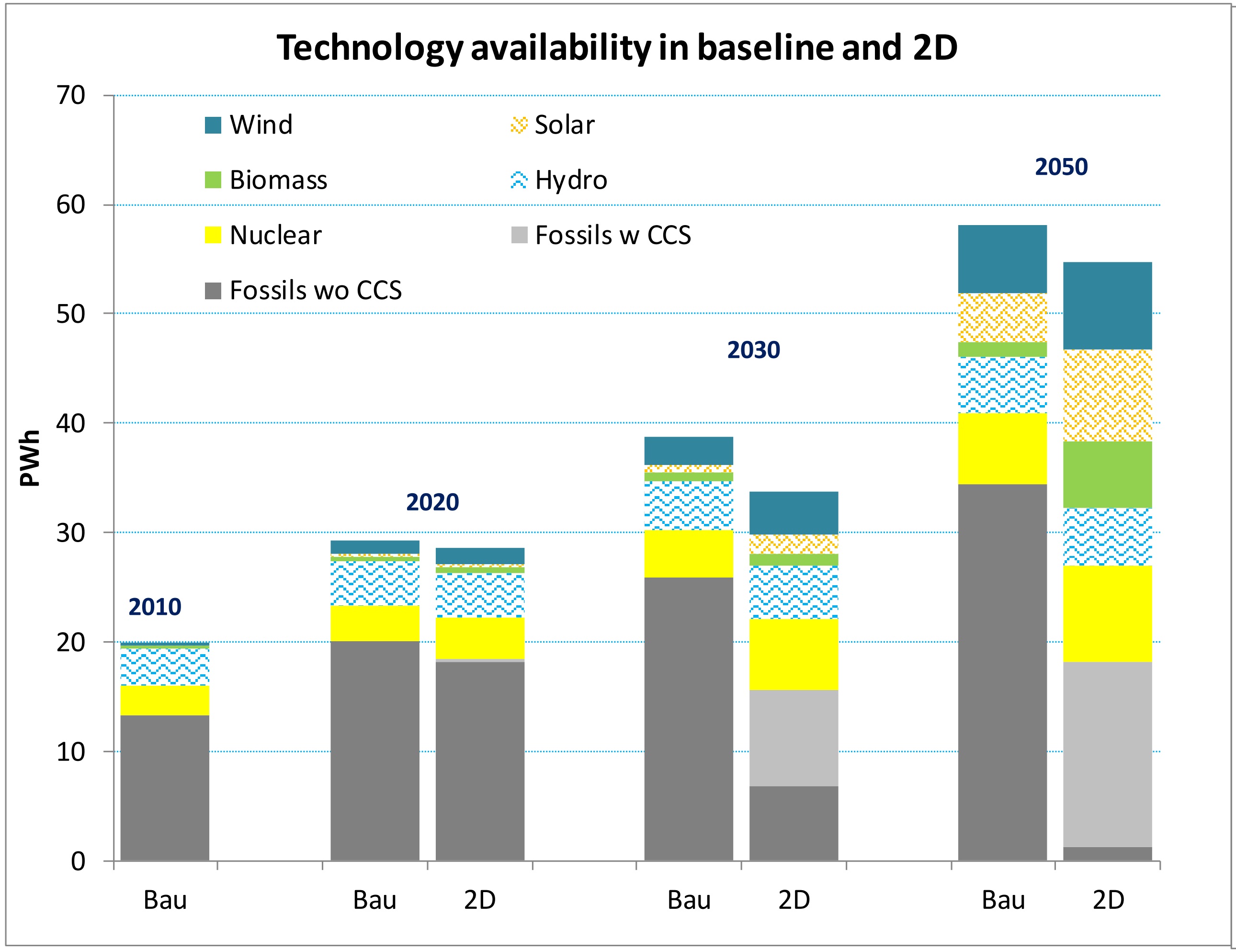
3.The impact of changing parameters on technological learning : Extended versus compressed R&D budgets

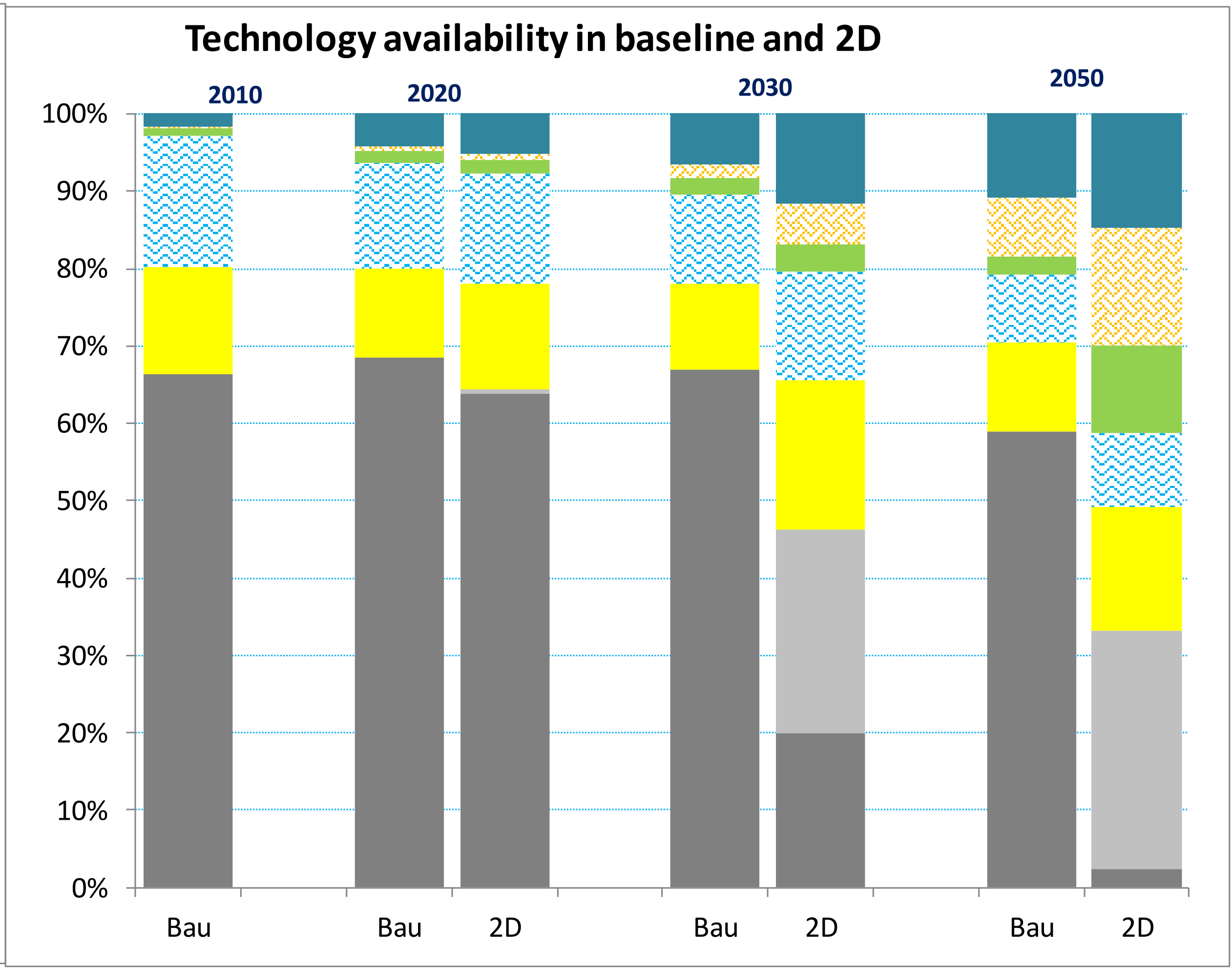


The removal of the wind and solar R&D budgets results in a major deterioration in the wind and solar investment cost reductions compared to the baseline.

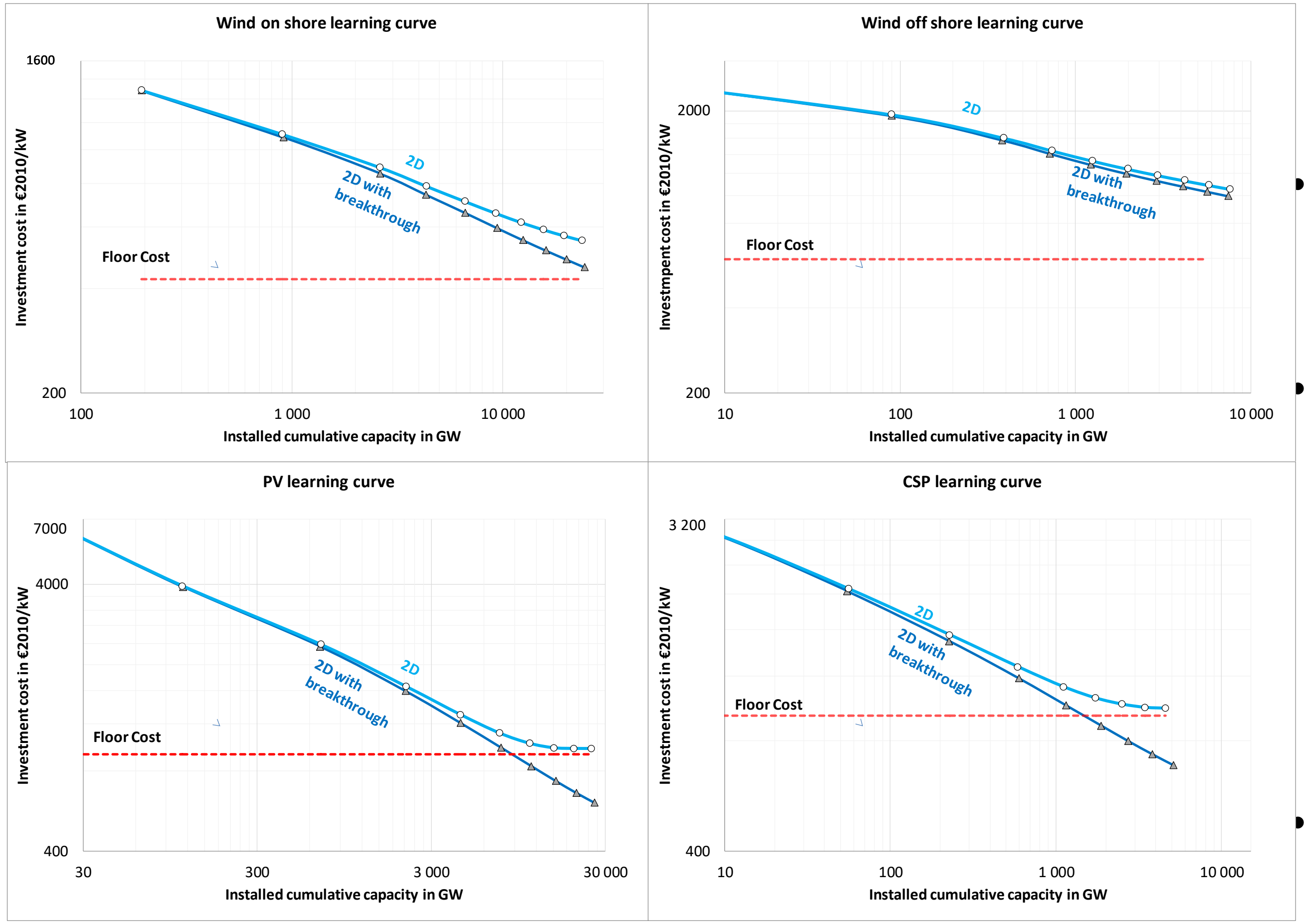
Conversely, the “High R&D” scenario induces a significant improvement in the investment cost up to 2050, followed by a slackening in the end of the century, because of progressively converging cumulative R&D budgets and of the narrowing gap between deployment constraints.

3.1 Ambitious (2D) versus baseline climate policy scenario





The impact of changing parameters on technological learning : Breakthroughs in new energy technologies



- Technological breakthroughs are simulated through a reduction of the floor cost in the TFLC equations
- Breakthroughs can have a major or a limited impact according to the deployment conditions of each technology family.
- In the current version of the model, constraints to the deployment of wind energy due to available resources and to the adequacy problem in the electricity system significantly limit the impact of a breakthrough on wind turbines, while the corresponding constraints seem less binding in the case of PV and CSP solar technologies.
- This probably calls for careful cross technology examination of the nature and binding aspect of the resource and system constraints for the development of each technology.

The impact of the changing competitive environment on learning

4.1 “Low” energy intensity level assumes an ambitious efficiency pathway for the world, corresponding roughly to a 50 % increase of the energy-intensity reduction rate compared to the “BAU” case.

The resulting electricity demand reduces the need for renewable technologies and profoundly changes structural conditions. Solar and wind generation shrink and reduced cumulative capacities for renewable technologies induce a higher apparent learning in the high-efficiency scenario, because of the stronger impact of the learning-by-searching component.

We can also consider various types of barrier to technology deployment connected with public acceptance of potential environmental hazards, possibly leading to one or more key technologies for long-term decarbonization becoming unavailable on a large scale. For eg less competition to solar and wind energy due to a nuclear setback (NucOff) or less available bioenergy (LimBio).

Surprisingly, the changes in the electricity mix in these cases are more limited than in the low energy intensity scenario.

6. The role of learning in Rippels climate policies scenarios

- The impacts of early versus delayed action differ depending on the parameters of the learning curve characterizing each technology.
- The low 2030 target induces an acceleration of deployment in the short to medium-term, but depending on the technology and the shape of its learning curve, the impacts on apparent learning are mixed.
- Examination of the impacts of learning on the electricity sector or on total abatement costs shows that the improvement in technology costs and performances is an essential component in containing abatement costs in the very long run.
- Thanks to the learning effects, ambitious stabilization targets (B2D) can be met with limited cost increases for the energy sector. In the long run, the levelized average cost of electricity production might even be lower in the constrained case than in the base case.
- In the mitigation cases, after a first wave of cost increases in the electricity sector, when low carbon technologies have not been fully deployed and have not reaped the full benefit of learning, costs decrease after 2030 in the electricity sector. The total energy-system cost increases over a longer period, but after the middle of the century, the marginal and total abatement costs stabilize, resulting in a decline of the global abatement costs from 2.5% in 2050

Conclusions

- Learning process, has a crucial role in transition and in limiting the costs of mitigation policies.
- Very complex process: many technologies, actors, competition, changing material prices => need for continuous research in the topic.
- Use Poles model to analyse sensitivities on:
  - the impact of changing parameters on technological learning (R&D, breakthroughs, early action)
  - the impact of changing competitive environment on learning (energy efficiency, nucoff, lack of CCS)
- Find complementarities with Oxford and other consortium members to better study the learning process