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2021 EU Conference on modelling for policy support

Session 5: Assessing and communicating uncertainty in model results

Investigating optimal allocation of green recovery funds in the EU

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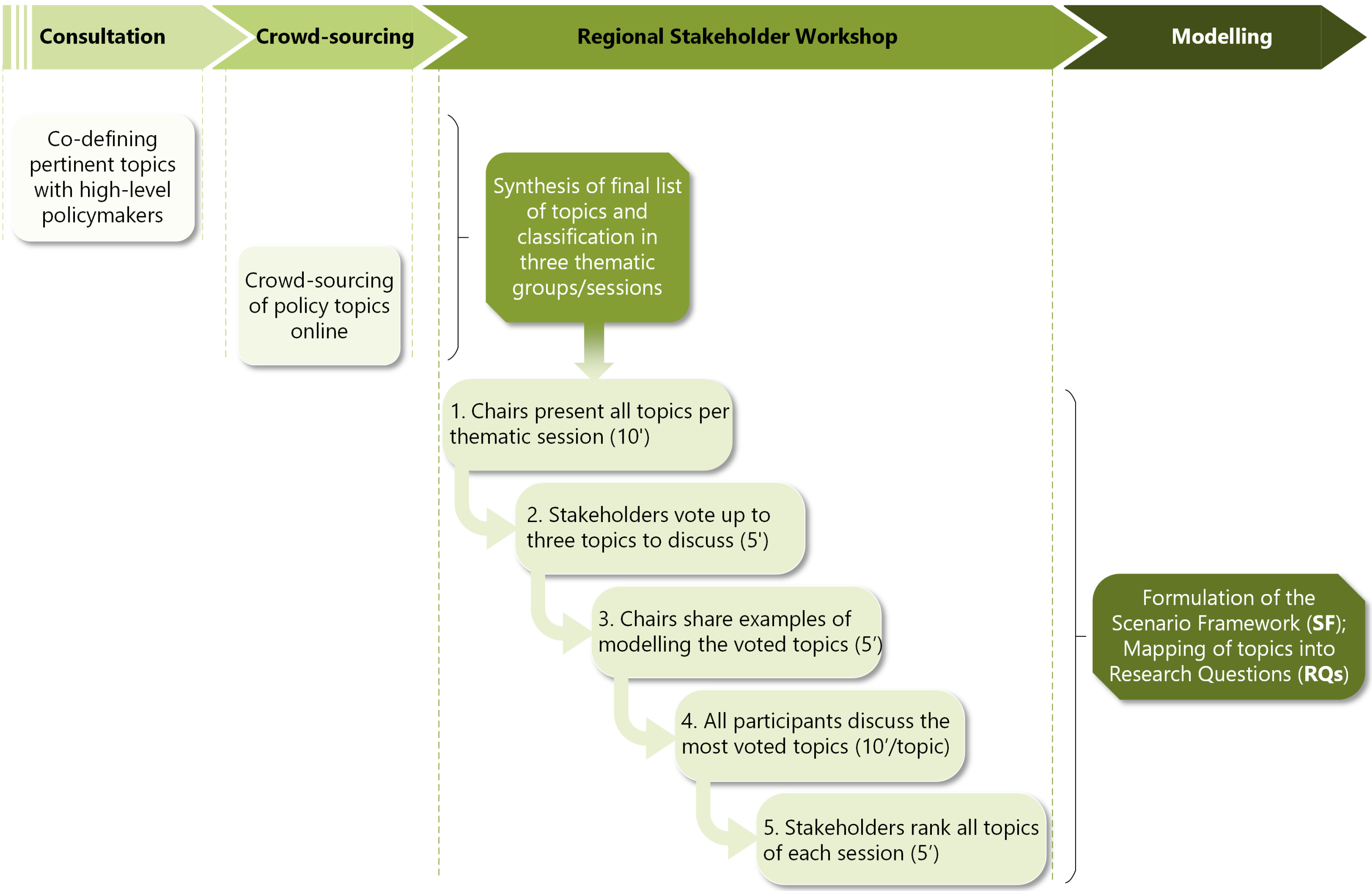
Intro: co-creating with policy/stakeholders

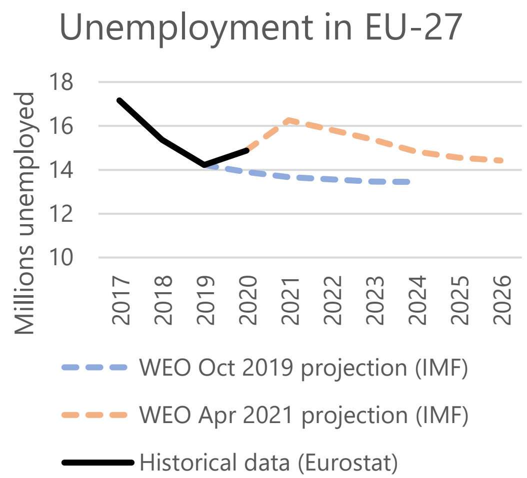


The PARIS REINFORCE project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No 820846.

Policy question: green recovery and jobs

Upcoming economic challenges

Strong economic impacts from Covid-19 pandemic and measures:
- 1.8 million jobs lost in EU-27 between Sept 2019 and Sept 2020
- IMF expects >2 million additional unemployed in 2021 and no full recovery by 2025



Green Recovery Packages

Recovery and Resilience Facility (RRF) from EU recovery funds:
- €200-billion of RRF for green projects
- 29% expected for renewable energy generation *
- 3% for (non-electric) low-carbon mobility *

Also: £ 5 billion clean energy stimulus in United Kingdom

Emission reductions and job creation?

Transition from fossil to renewable energy usually creates net jobs (Markandya et al 2016), but potential differences between low-carbon technologies:
How to allocate short-term (2021-2025) recovery funds to maximise impacts in terms of both job creation and emission reductions within this decade?

* *https://assets.ey.com/content/dam/ey-sites/ey-com/it_it/news/2020/ey-summary-report-green-recovery-v2.pdf*

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Global Change Analysis Model (GCAM)

1. Preparation of baseline with defined EU current policies: *where is the EU headed?*

2. Modelling impact of 10 subsidy steps for 7 low-carbon technologies

3. Abstracting modelling outputs and transform into portfolio inputs (employment factors)

AUGMECON-R

4. Determination of (Pareto) optimal subsidy portfolios within selected budget

5. Robustness analysis of Pareto portfolios using Monte-Carlo simulations

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Results: employment gains in 2025, then 2030

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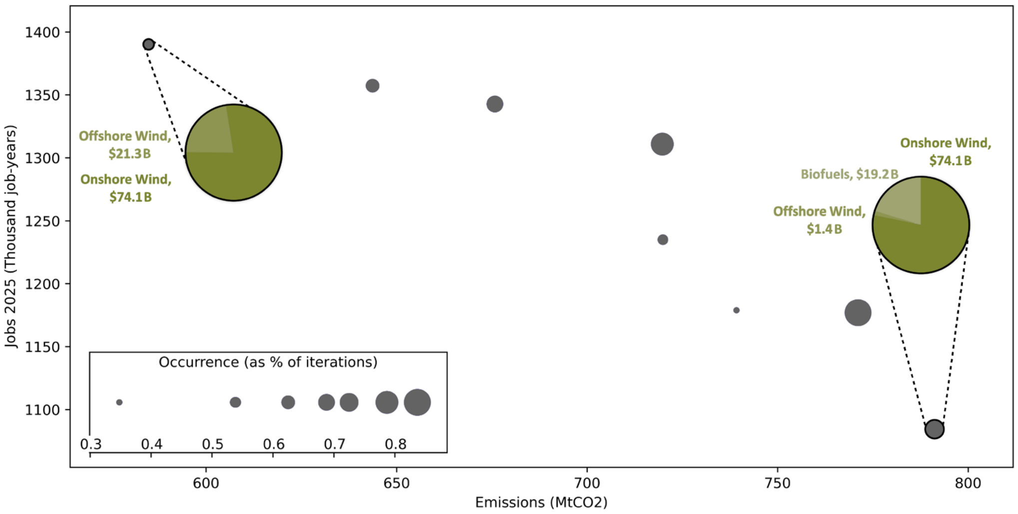


Emissions cuts by end of decade vs. near-term employment gains

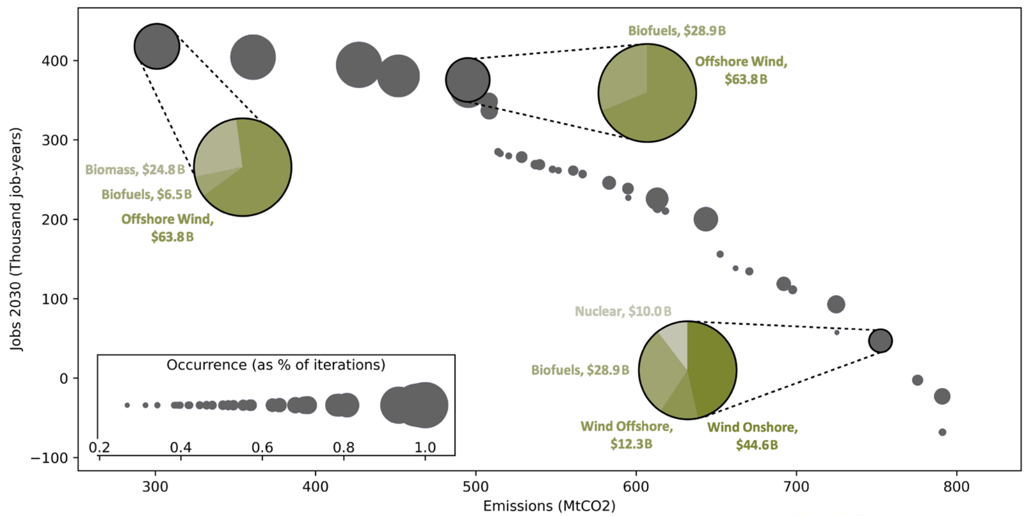
Onshore and offshore wind for employment. From offshore to biofuels for emissions cuts.

Portfolios of max. jobs lose momentum in 2030: *can employment gains be sustained in the longer run?*

Shifting the focus: emissions cuts vs. employment gains both by end of decade

Limited employment gains (in comparison): same spending period & different gains per project stage (more jobs in earlier stages)

Jobs: offshore wind, biomass, biofuels
Emissions: half budget in onshore wind



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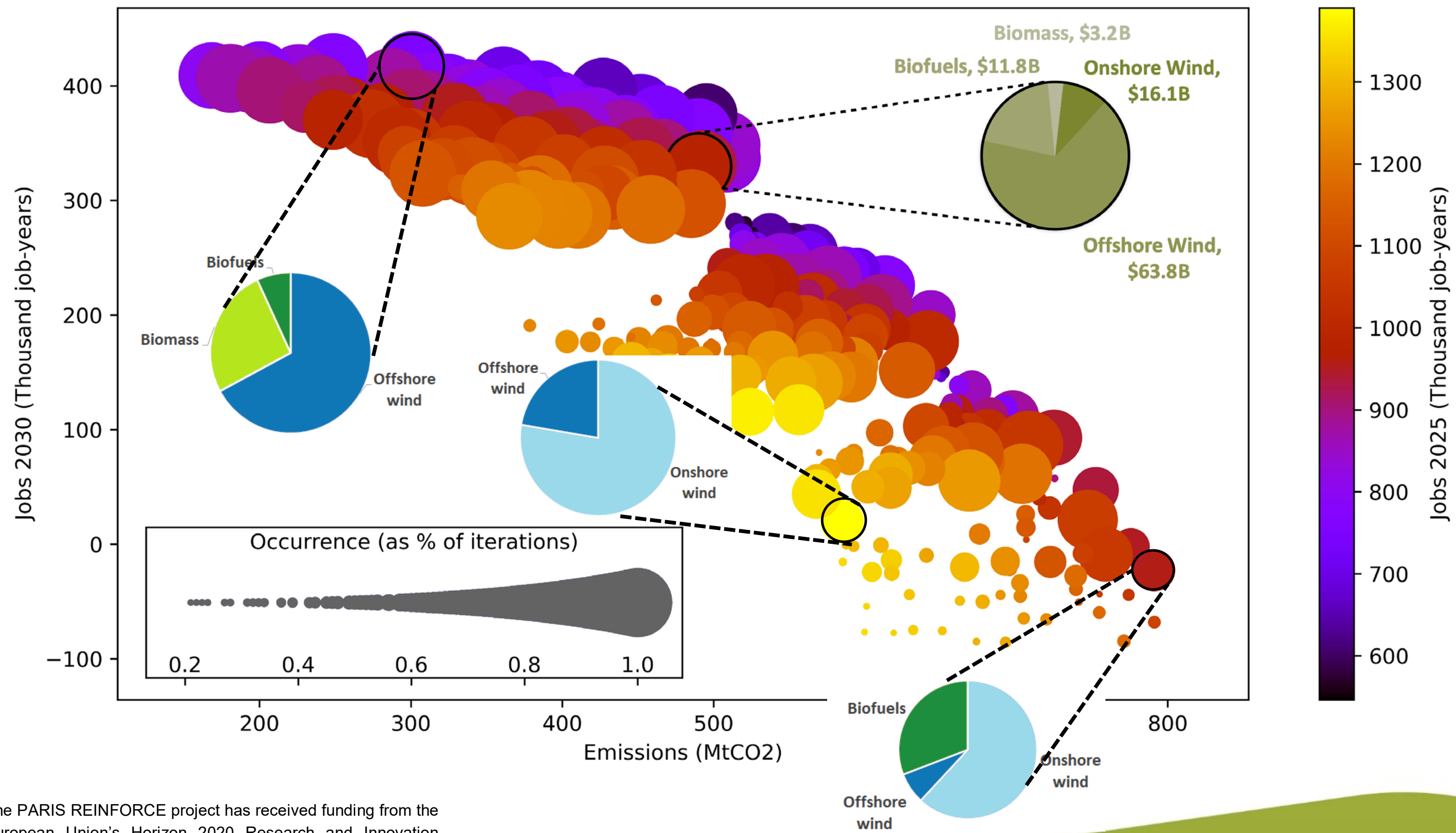
Emissions cuts by end of decade vs. employment gains (both near-term and longer-term)

Can the technological mix be diversified for better balance between near- and longer-term employment gains, by aiming to optimise emissions cuts, employment by 2025, and employment by 2030 simultaneously?



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Synergistic recovery & trade-offs

- Overall, synergies between green recovery investments and employment.
- Clear trade-off between subsidy portfolios performing well in terms of employment and those performing well in terms of emissions reductions

Challenges in assessing uncertainty

Assessing uncertainty is much needed, but is it always feasible/straightforward?

- IAMs already time-consuming; meta-analysis more demanding (objectives)
- Difficulty in implementing same protocol in several IAMs
- Even with several IAMs, our motivation was to do uncertainty analysis in-between model ranges, but results markedly different (model solution)
- Data availability (closed databases, missing data on regional job factors, etc.)

Challenges in communicating uncertainty

- Trade-offs expected across priorities, but Pareto-optimality not as straightforward to convey to stakeholders
- 'Robustness' frequently used, hardly ever defined; hard to grasp among scientists and policymakers/stakeholders alike
- Visualisation of trade-offs and uncertainty is a challenging task (bubble sizes, colours, multiple axes, etc.)

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Thank you!

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Appendix: Further reading

Global analysis of ‘where are we headed?’	Sognnaes, I., Gambhir, A., Van de Ven, D.J., Nikas, A., Anger-Kraavi, A., Bui, H., … & Peters, G.P. (2021). A multi-model analysis of long-term emissions and warming implications of current mitigation efforts. ***Nature Climate Change***, in press.
EU-level analysis (co-creation)	Nikas, A., Elia, A., Boitier, B., Koasidis, K., Doukas, H., Cassetti, G., … & Chiodi, A. (2021). Where is the EU headed given its current climate policy? A stakeholder-driven model inter-comparison. ***Science of The Total Environment, 793***, 148549.
GCAM	Calvin, K., Patel, P., Clarke, L., Asrar, G., Bond-Lamberty, B., Cui, R. Y., … & Wise, M. (2019). GCAM v5. 1: representing the linkages between energy, water, land, climate, and economic systems. ***Geoscientific Model Development, 12***(2), 677-698.
AUGMECON-R	Nikas, A., Fountoulakis, A., Forouli, A., & Doukas, H. (2020). A robust augmented ε-constraint method (AUGMECON-R) for finding exact solutions of multi-objective linear programming problems. ***Operational Research***. In press.
Employment databases	Pai, S., Emmerling, J., Drouet, L., Zerriffi, H., & Jewell, J. (2021). Meeting well-below 2 C target would increase energy sector jobs globally. ***One Earth, 4***(7), 1026-1036.
	Rutovitz, J., Dominish, E., & Downes, J. (2015). ***Calculating global energy sector jobs: 2015 methodology update***. Prepared for Greenpeace International by the Institute for Sustainable Futures, University of Technology Sydney.
Portfolio analysis framework	Forouli, A., Nikas, A., Van de Ven, D. J., Sampedro, J., & Doukas, H. (2020). A multiple-uncertainty analysis framework for integrated assessment modelling of several sustainable development goals. ***Environmental Modelling & Software, 131***, 104795.

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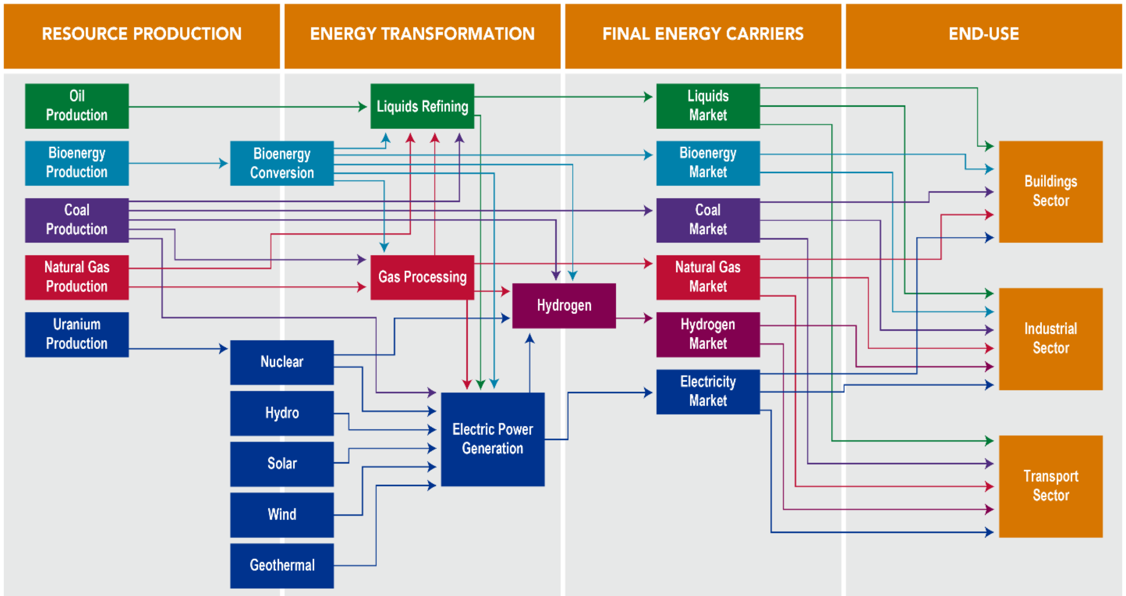
Global Change Analysis Model (GCAM)

- Full representation of energy system, linked to land, water & climate systems
- Allows simulating impacts of wide set of energy and climate policies

https://www.i2am-paris.eu/detailed_model_doc/gcam
http://jgcri.github.io/gcam-doc/toc.html



Model assumptions

- Population: EUROPOP 2019
- GDP: EU Ageing Report (2018)
- Technology costs: Napp et al (2020)

Current Policies

- EU ETS: -43% GHGs by 2030 w.r.t. 2005
- 32% renewables in final energy by 2030
- EE: <13% final energy by 2030 w.r.t. 2020
- Fuel efficiency standards for light and heavy vehicles (62 gCO_2/pkm and 30% reduction)
- 3.5% advanced biofuels in 2030 liquids mix

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Subsidies for 7 low-carbon technologies (6 in electricity, 1 in liquids):

- Solar Photovoltaics (PV)
- Concentrated Solar Power (CSP)
- Onshore wind
- Offshore wind
- Nuclear power
- Biomass-to-power
- Biofuel refining

Each technology subsidised in period 2021-2025 until maximum EU(+UK) clean energy budget is reached, defined as €80 billion. Subsidies apply to all new capacity added from 2021 to 2025, including those units that would have been added without additional subsidies.

Ten subsidy steps * 7 technologies = 70 model runs

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- Three outputs to feed into portfolio analysis.
  - Cumulative CO_2 emission savings from 2021-2030: Directly from GCAM
  - Cumulative job-years gains in 2021-2025 period and in 2021-2030 period: calculated through documented employment factors:

Employment factors 2025	Manufacturing of infrastructure[1]	Construction & Installation[1]	Operation & Management[1]	Refining[2]	Extraction of inputs[2]	Manufacturing import factor	Extraction import factor
	Job-years per GW installed			*Job-years per PJ processed*		*Share of demand from import (based on 2018 values)*	
Wind onshore	4250	2894	278			0.0%	
Wind offshore	12821	6575	183			0.0%	
PV Utility-scale	3775	7325	367			76.7%	
PV rooftop	3775	13561	740			76.7%	
CSP	3627	7255	405			0.0%	
Biomass	2690	12800	1500		29.9	0.0%	0.0%
Nuclear PP	1300	11800	600		7.3	0.0%	100.0%
Coal power	5400	11200	140		26.9	0.0%	52.4%
Gas power	930	1300	140		8.6	0.0%	78.7%
Biofuel refining				7.3	29.9		0.0%
Oil refining				1.5	14.3		87.1%

[1] Rutovitz et al (2015), [2] Pai et al (2021), employment factors are corrected for technology-specific CAPEX and OPEX assumptions over time (Ram et al, 2020)

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Appendix: Methodology steps 4-5

Robust portfolio analysis applied on GCAM outcomes:

- Cumulative CO_2 emission (E) reductions from 2021 to 2030
- Cumulative job-years (J) in the period 2021-2025
- Cumulative job-years (J) in the period 2021-2030

Tri-objective optimisation

- $\max y = [E_{2021-2030}(€), J_{2021-2025}(€), J_{2021-2030}(€)]\ subject\ to\ € < 80\ billion$

Solution: Pareto-optimal set (PS) of solutions (Pareto Front, PF)

- Indicating trade-off between the objectives, within a pre-defined budget

Stochastic robustness:

- Assuming defined probability range of 5% over model outcomes (after model runs)
- Using Monte-Carlo analysis, all Pareto-optimal portfolios are stresstested against this uncertainty to measure robustness.

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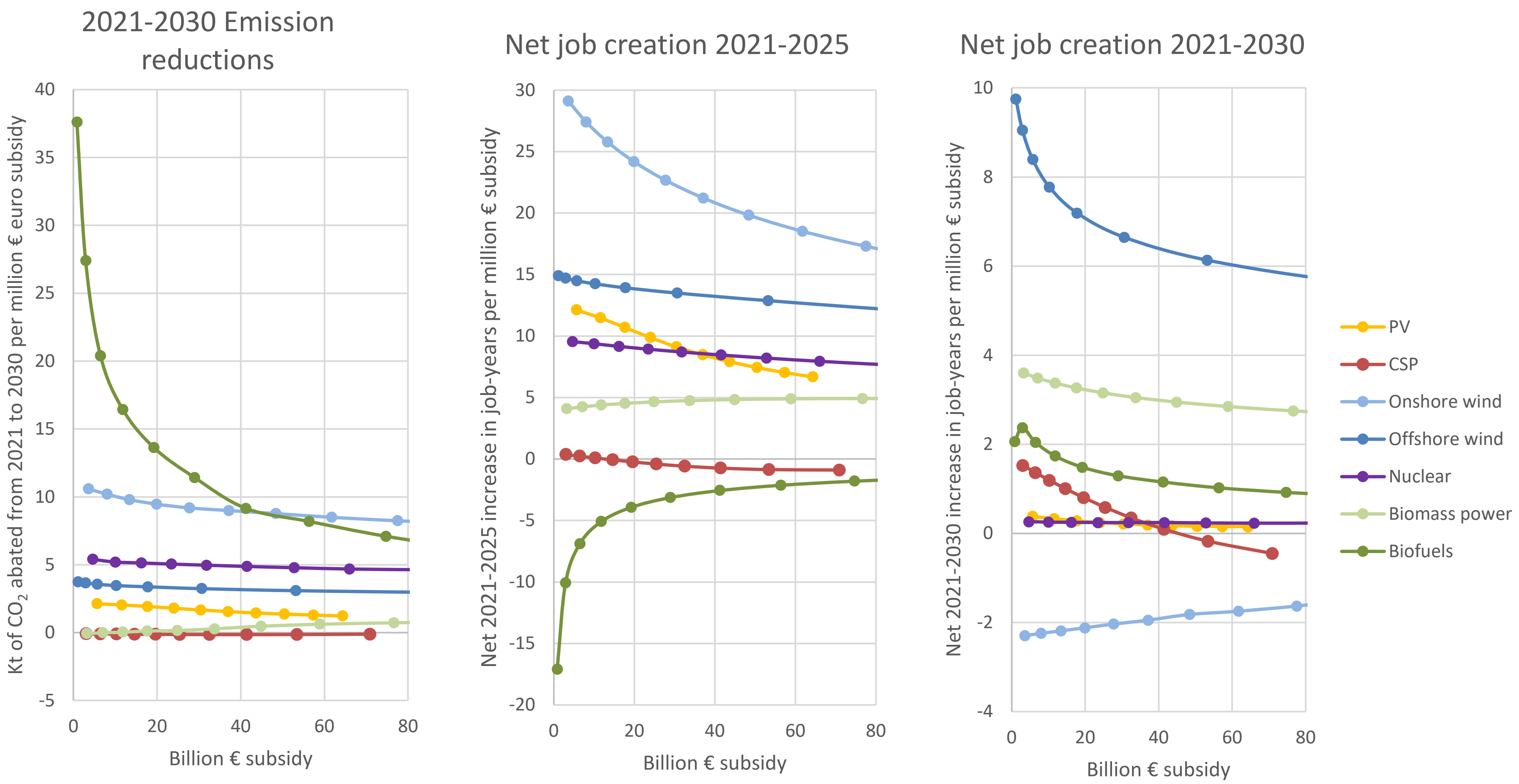
Appendix: Intermediate results



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