Small Modular Reactors in a decarbonized world

Market potential and design

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Outline

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Introduction

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Potential

The maximum market penetration under which the technology breaks even

Conclusion

Conclusions

01 Introduction

Four different nuclear technologies are studied

	Lifetime Extensions (LE) *Extension of existing nuclear power plants. These extensions are usually cheap compared to new investments in any power plant.*	Gen III NPP (GIII) *Investment in new large scale nuclear power plants. These typically represent units >1.4 GW like Hinkley Point.*	Light water SMR* (LW) *Investment in a small modular nuclear reactor of the type developed by Nuscale. These typical represent units >200 MW.*	Molten salt reactor (MSR) *Investment in a modular nuclear reactor of the type developed by Moltex, and possibly with thermal energy storage(*).*
Fuel cost [€/MWh]	7.5	7.5	12	4
Fixed O&M [€/kW/yr]	120	120	120	120
Capex reactor [€/kW]	250-700	7500	5400	2400
Capex storage [€/kWh]				30
Capex turbine [€/kW]				420
Lifetime [yrs]	10	60	60	60
Availability [%]	90%	90%	90%	90%
LCOE [€/MWh]	33.7	70.6	61.7	37.2

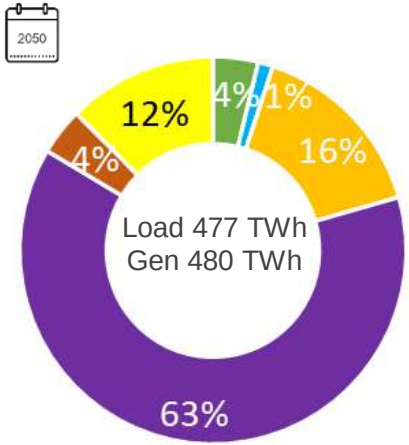
Four main scenarios are studied of which two contain additional sensitivities

	RES (existing nuclear)	+GIII (nuclear reactors)	+LW (nuclear reactors)	+MSR (nuclear reactors)
	This case only contains **existing nuclear and extensions**	In addition to '*RES*', this case also contains **new conventional nuclear** power plants (NPP)	In addition to '*+GIII*', this case also allows **light water SMRs**	In addition to '*+LW*', this case also includes **MSR** and all proposed nuclear technologies
Additional sensitivities	BC – Basecase	BC – Basecase	BC – Basecase (LW: 5400 €/kW; NPP: 7500 €/kW)	BC – Basecase (MSR: 2400 €/kW)
			LW_LOW – -20% LW capex (LW: 4500 €/kW; NPP: 7500 €/kW)	MSR_MED – +50% SMR capex (MSR: 3000 €/kW)
			LW_HI – +30% LW capex (LW: 7000 €/kW; NPP: 7500 €/kW)	MSR_HI – +100% SMR capex (MSR: 4000 €/kW)
			GIII_LOW – -20% NPP capex (LW: 5400 €/kW; NPP: 6000 €/kW)	

Three different countries are studied

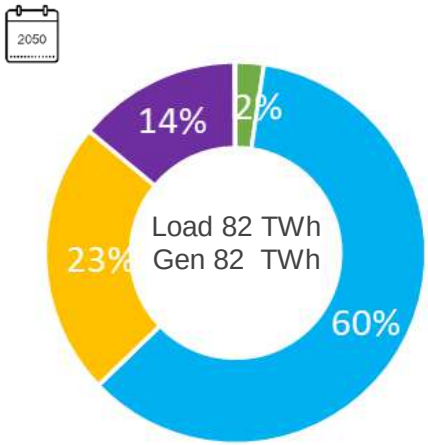
Great Britain

A country in the West of Europe which has **high wind potentials**



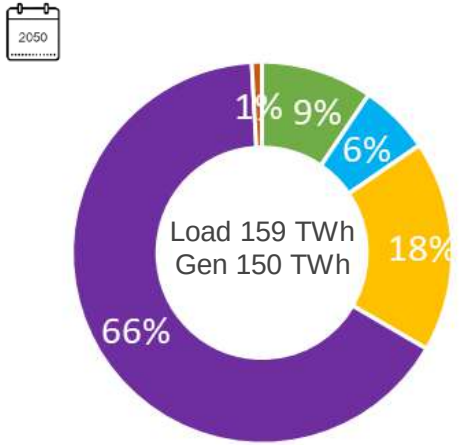
Switzerland

A country that is well **interconnected** in the middle of Europe



Poland (Germany*)

A country in the east of Europe



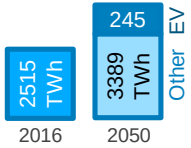
BIOMASS BIOGAS SYNTH HYDRO SOLAR WIND NUCLEAR

(*) As part of this study, Germany was modelled, but the production and capacities were rescaled to match Poland's. Market potential results are shown for PL, but system impacts are measured with a modified DE

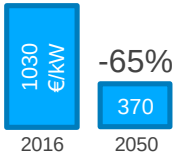
(**) Market shares in 2050 in the RES scenario.

The technologies are studied* in Western Europe in a scenario where power will be decarbonized by 2050

DEMAND GROWTH

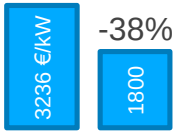


SOLAR CAPEX**

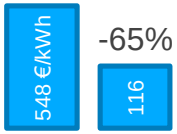


WIND ONSHORE CAPEX**

WIND OFFSHORE CAPEX**



BATTERY CAPEX**



Plus 10% of EV batterie

(*) This study takes into account all the economic drivers but does not consider political and public perceptions
(**) Optimistic renewable assumptions but conservative assumptions for nuclear developments

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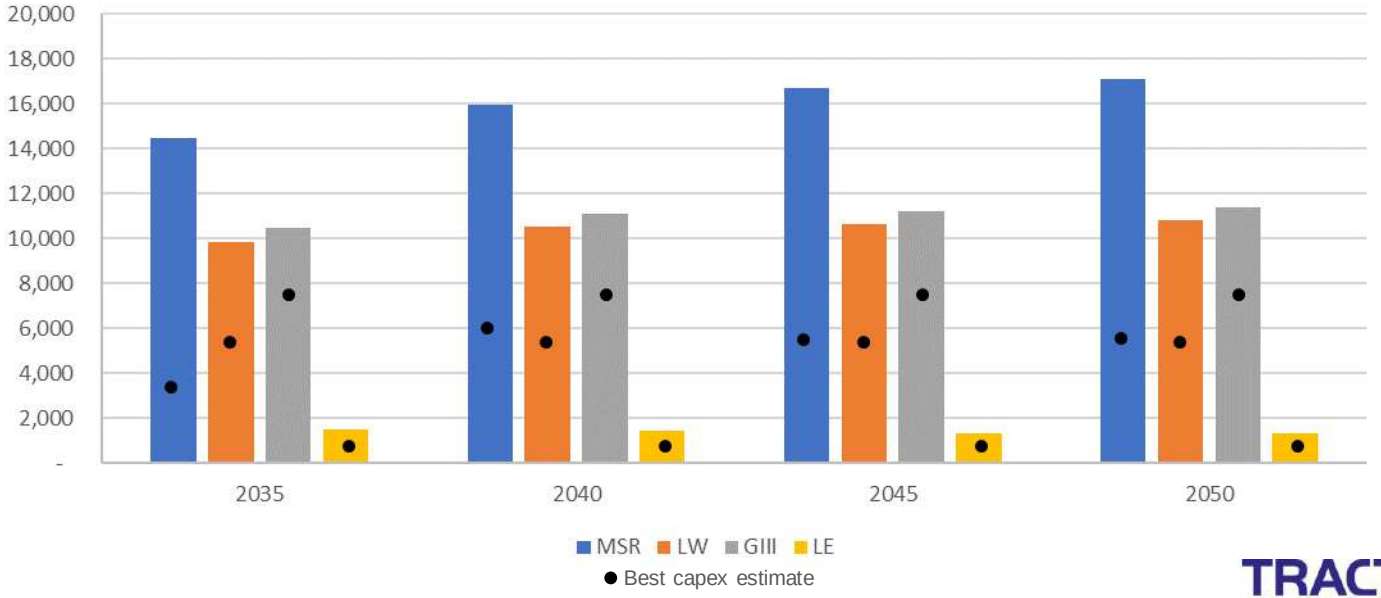
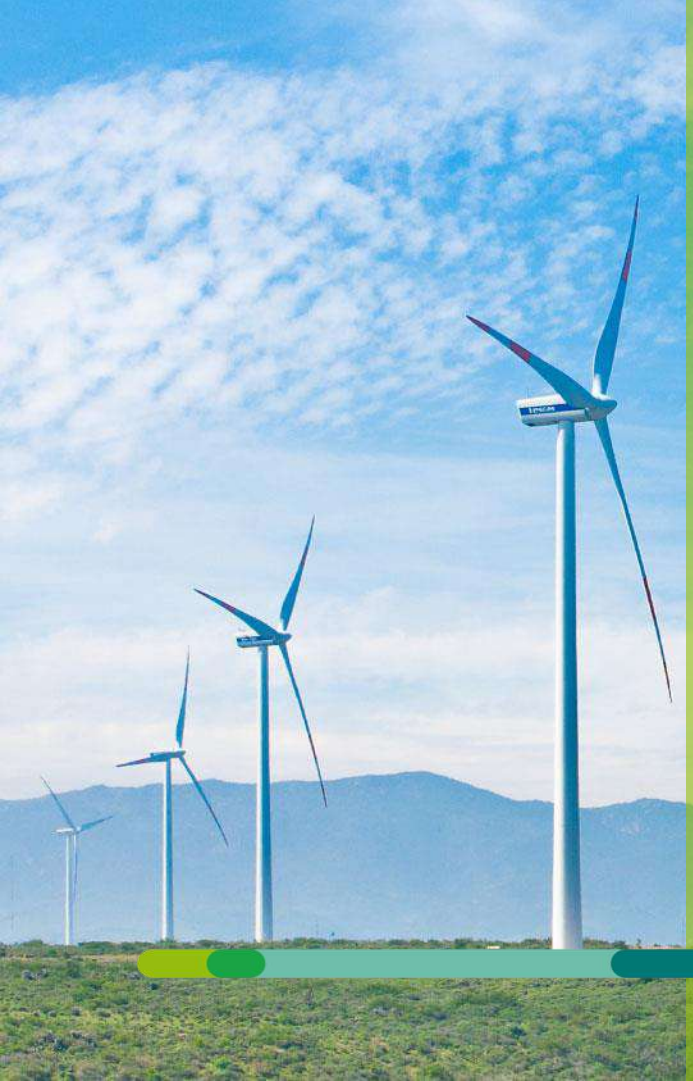
Viable capex across technologies: first conclusion – large margin

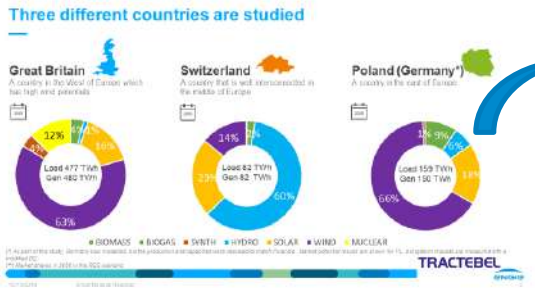
Viable capex in PL [€/kW]





02

Market potential



MSRs market: second conclusion

Great Britain

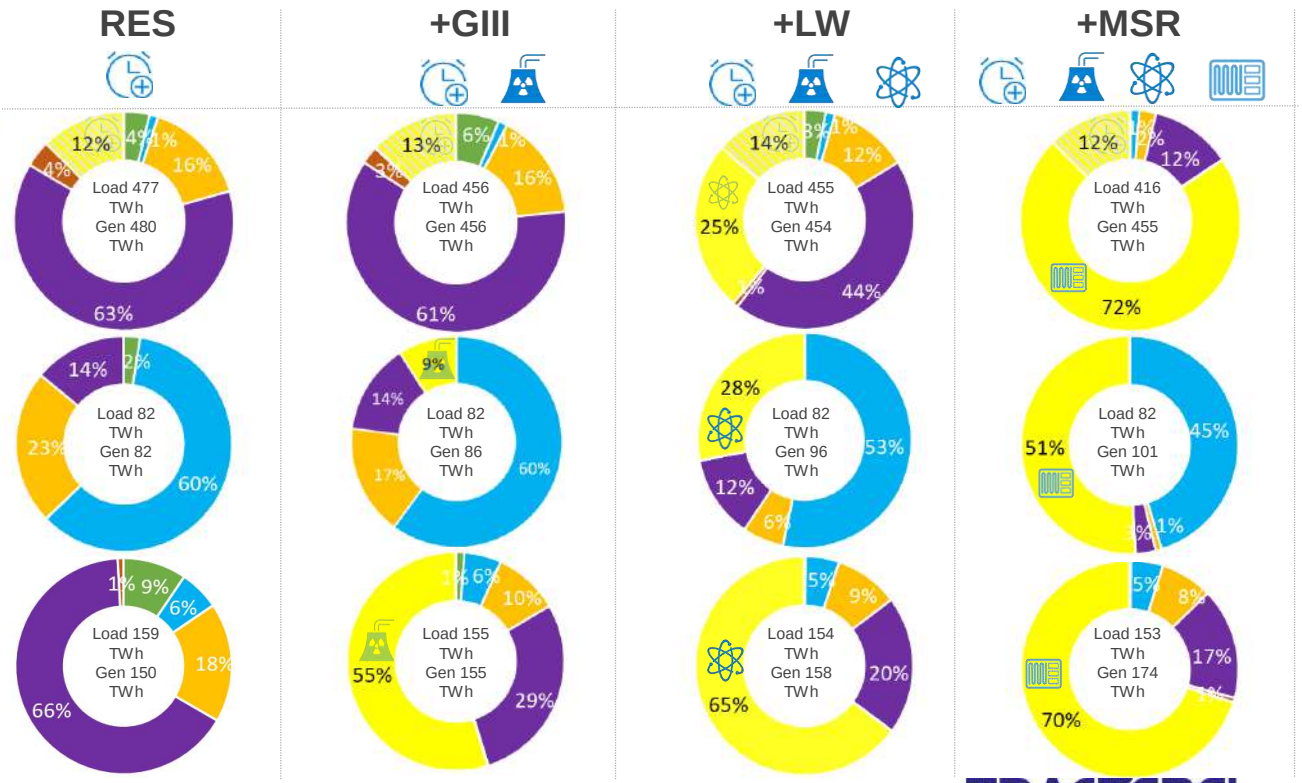
A country in the West of Europe which has high wind potentials

Switzerland

A country that is well interconnected in the middle of Europe

Poland

A country in the east of Europe



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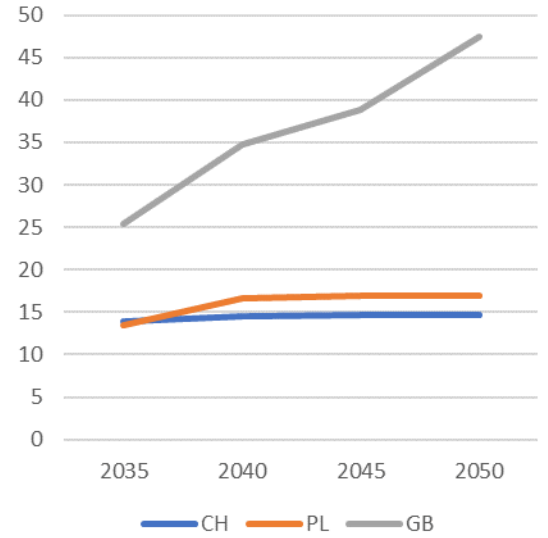
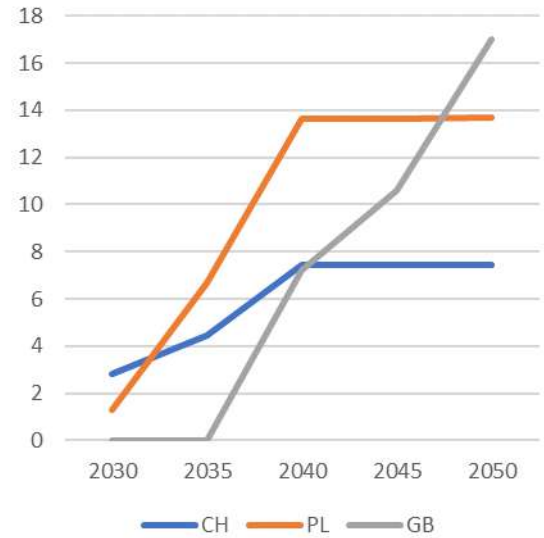
In PL and CH, the saturation point is reached quicker for all technologies, while the nuclear capacity is growing over time in GB

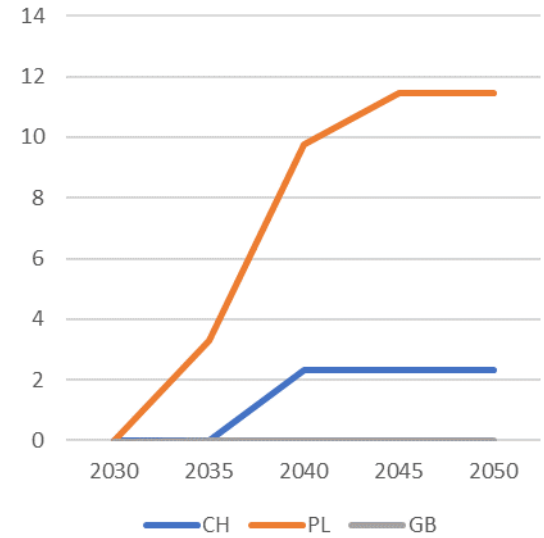
MSR capacity in scenario +MSR* [GW]



LW capacity in scenario +LW* [GW]



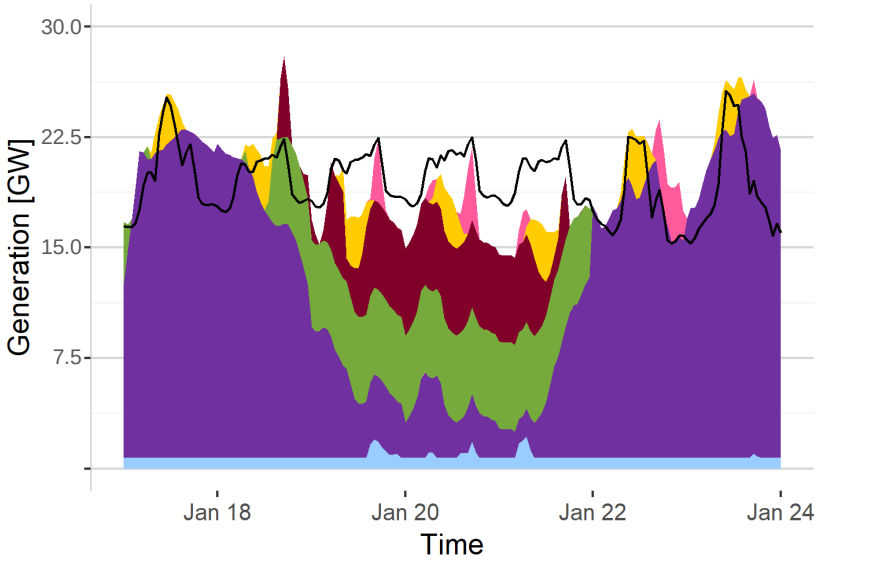
GIII capacity in scenario +GIII* [GW]



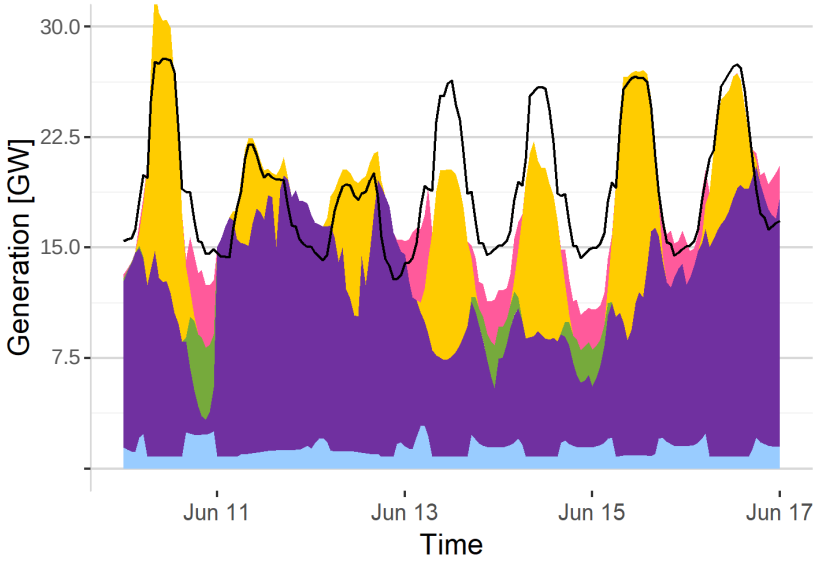
(*) All figures are stated as reactor capacities (which for the MSRs is different from the turbine capacities) in 2050

Production curves

Winter week – PL



Summer week – PL



BATTERIES NUCLEAR SYNTH HYDRO
BIOGAS SOLAR WIND

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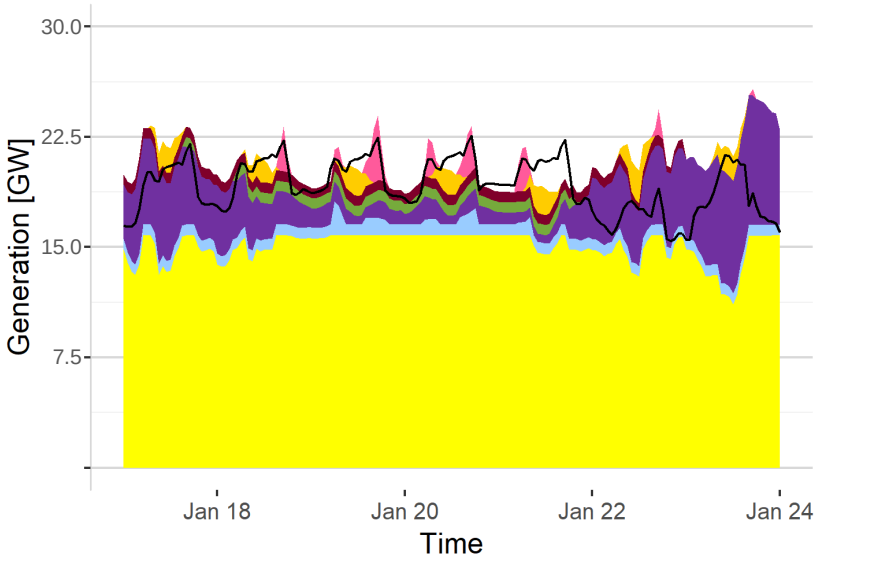
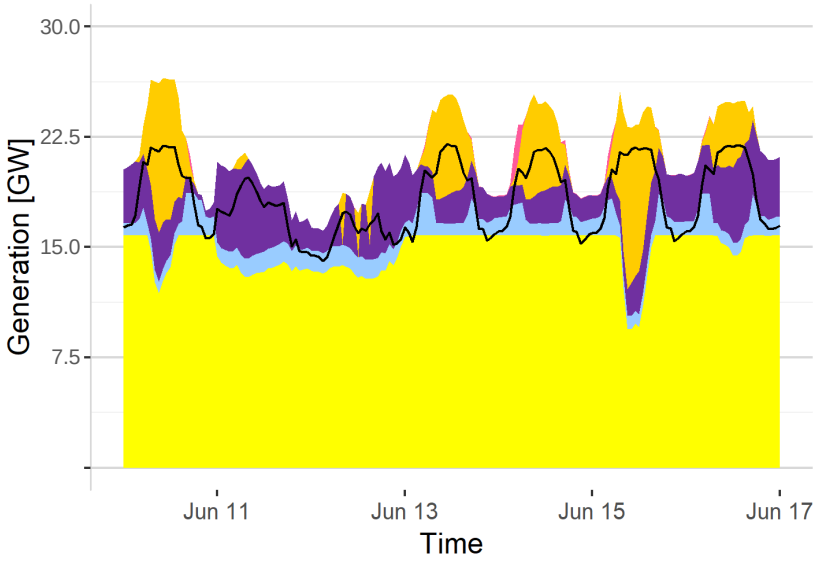
Production curves with Nuclear in the integrated resource plan

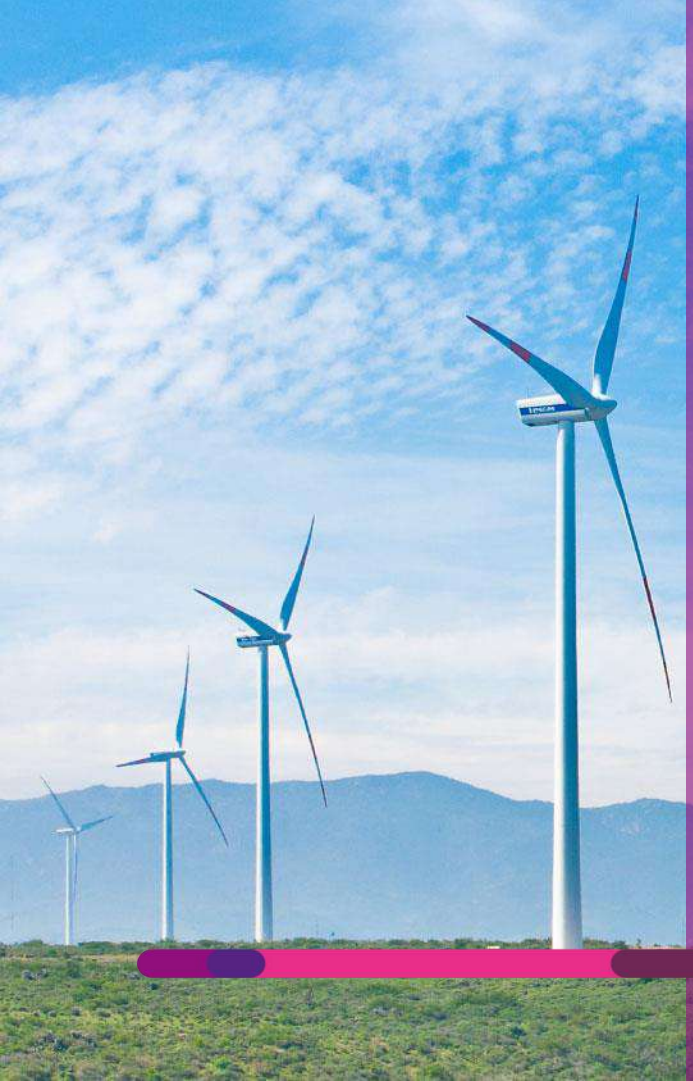
Winter week – PL



Summer week – PL



BATTERIES NUCLEAR SYNTH HYDRO
BIOGAS SOLAR WIND



04

Conclusion & next steps

Conclusion

- In highly decarbonised power systems, nuclear technologies do especially well in countries that lack sufficient renewable energy resources. Value wise, MSR and LW SMRs are the most interesting technologies and reach the highest market quota. This is not unexpected as they have CAPEX and OPEX that are considerably lower, whilst being more flexible than the competing technologies.
- MSR is a flexible technology, operates mainly as a baseload plant due to its low costs and on top of this, it still provides a little flexibility with its storage (up to 7h) and larger turbine (up to 120% of the reactor).
- LW and MSRs compete both with LT and ST storage.