Renewable integration

Workshop "High Penetration of PV Systems in Electricity Grids"

Lisbon, May 11th, 2011

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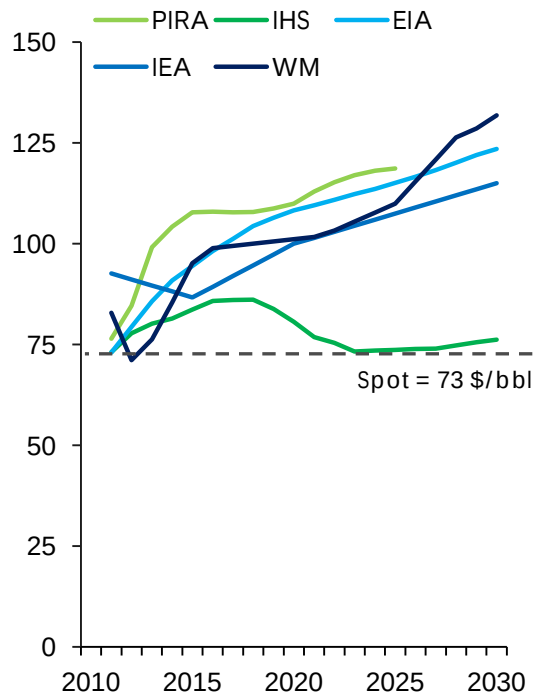
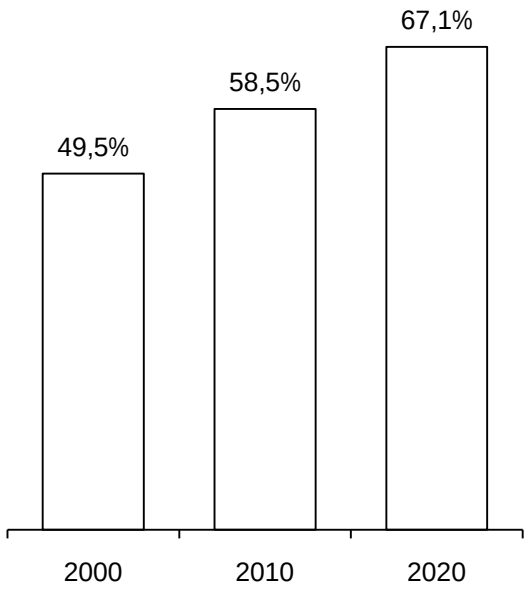
Energy Planning

Rising fossil fuel prices, growing energy dependency and climate change will shape Energy Policy

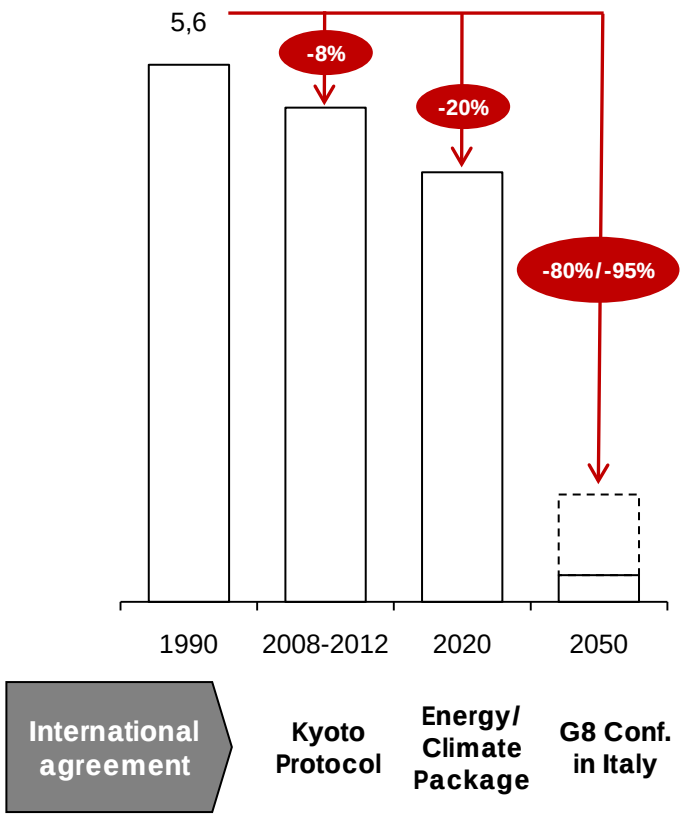
Forecasted oil price
$\$_{2008}$/bbl



EU-27 energy dependency[1]
(baseline scenario)



EU target emissions levels
$GtCO_2e$



1. Source: EC, DG TREN, "European energy and transport trends to 2030 – update 2007"

Six recent studies present proposals for a sustainable European Energy Policy up to 2050

1

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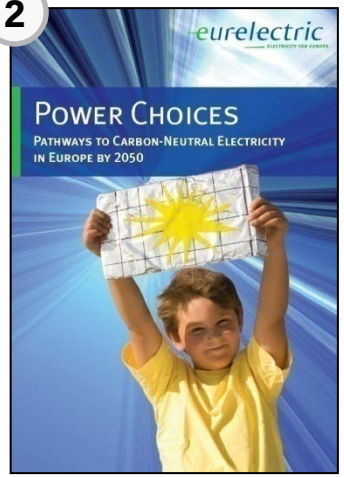

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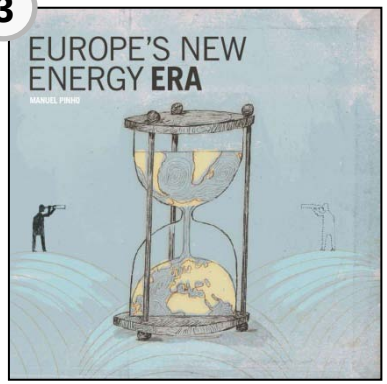

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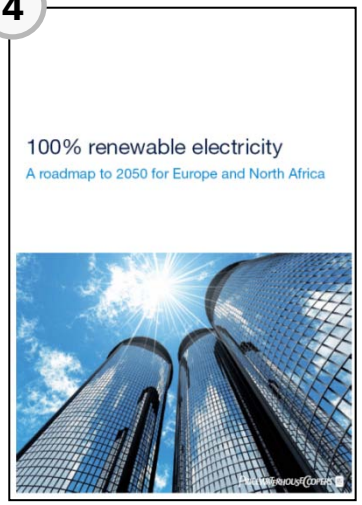

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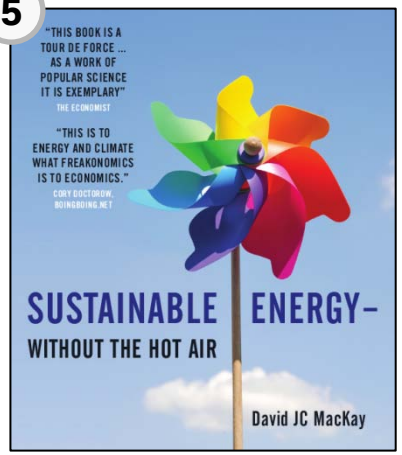
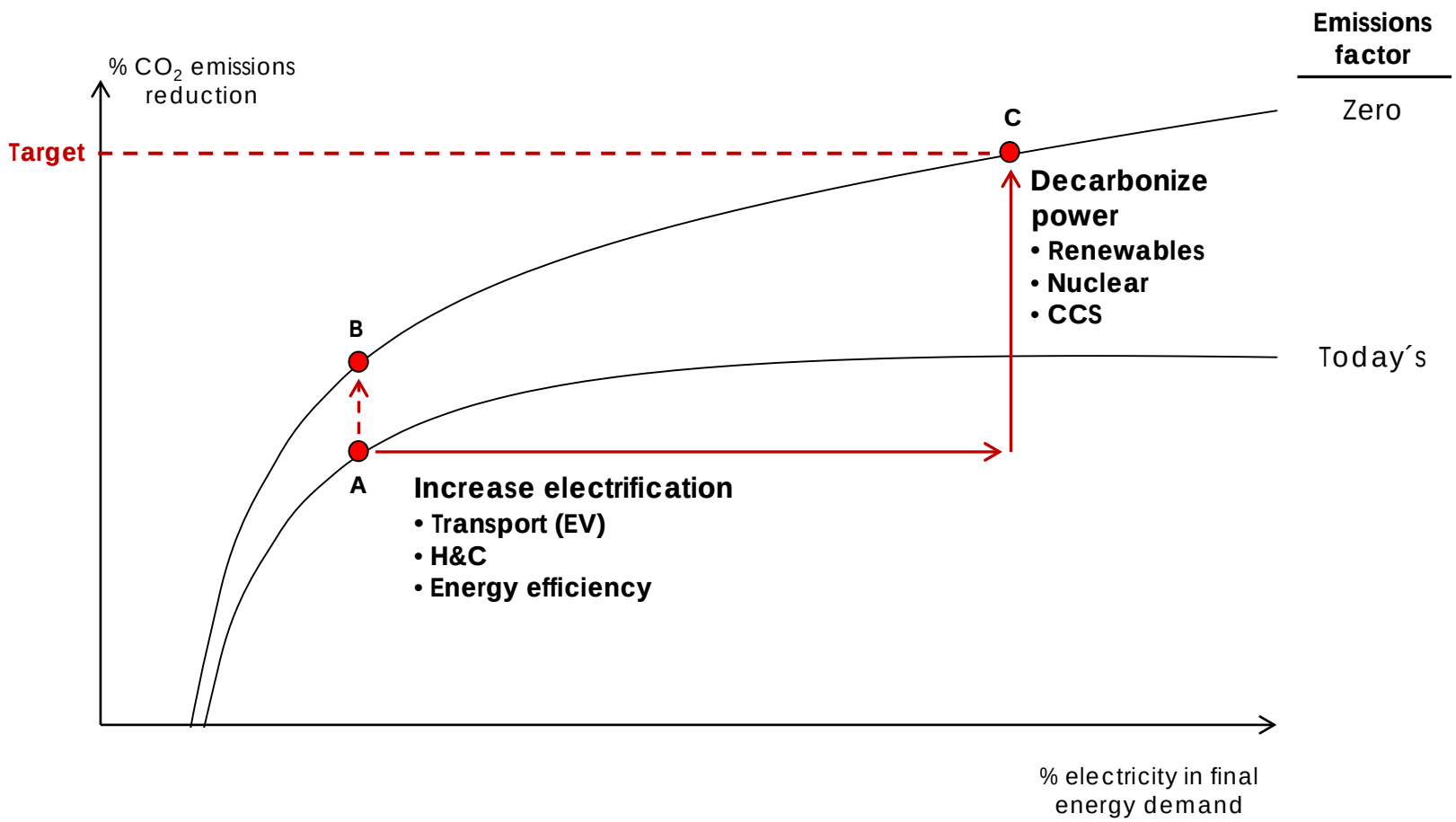


Several studies developed to influence European 2050 energy policy review which is to be discussed in 2010

Strongly reducing emissions implies increasing electrification of energy demand and decarbonizing power sector supply

Emissions reduction as a function of the share of electricity in final energy demand

%



Major electrification is widely regarded as the most viable pathway to achieve emission reduction targets

Major arguments for electrification

Higher efficiency

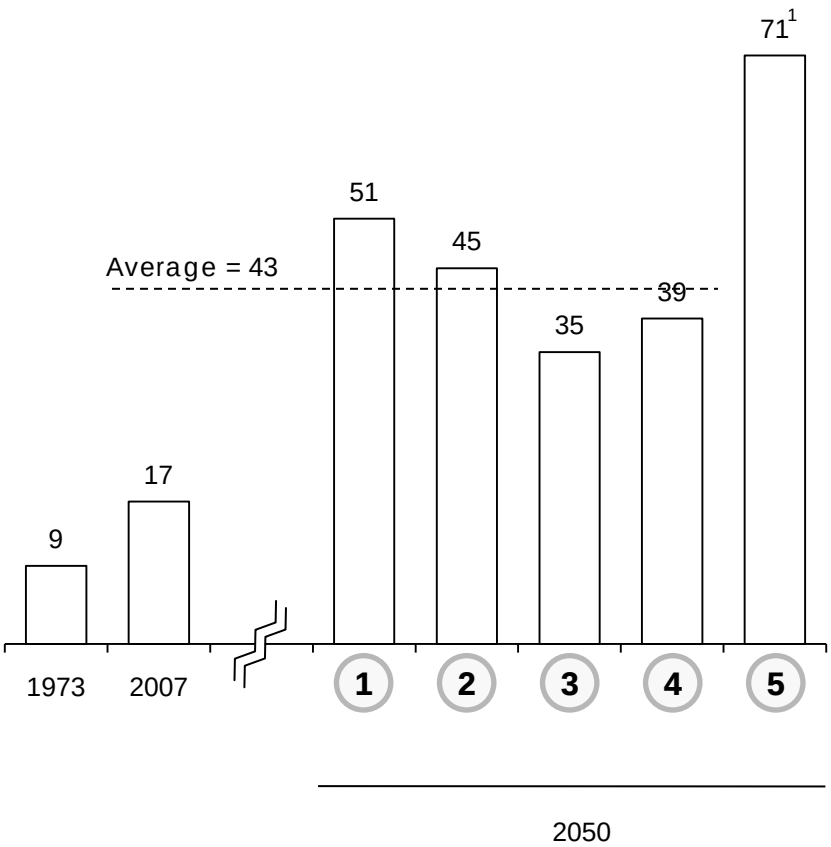
- Electricity based end-use technologies are much more efficient than fossil fuel based
  - potentially allows for a reduction in primary energy consumption

Easier decarbonization

- Multiple zero carbon power generation technologies available at competitive costs
- Centralized nature of power sector facilitates implementation of low carbon policies

Share of electricity in final energy demand

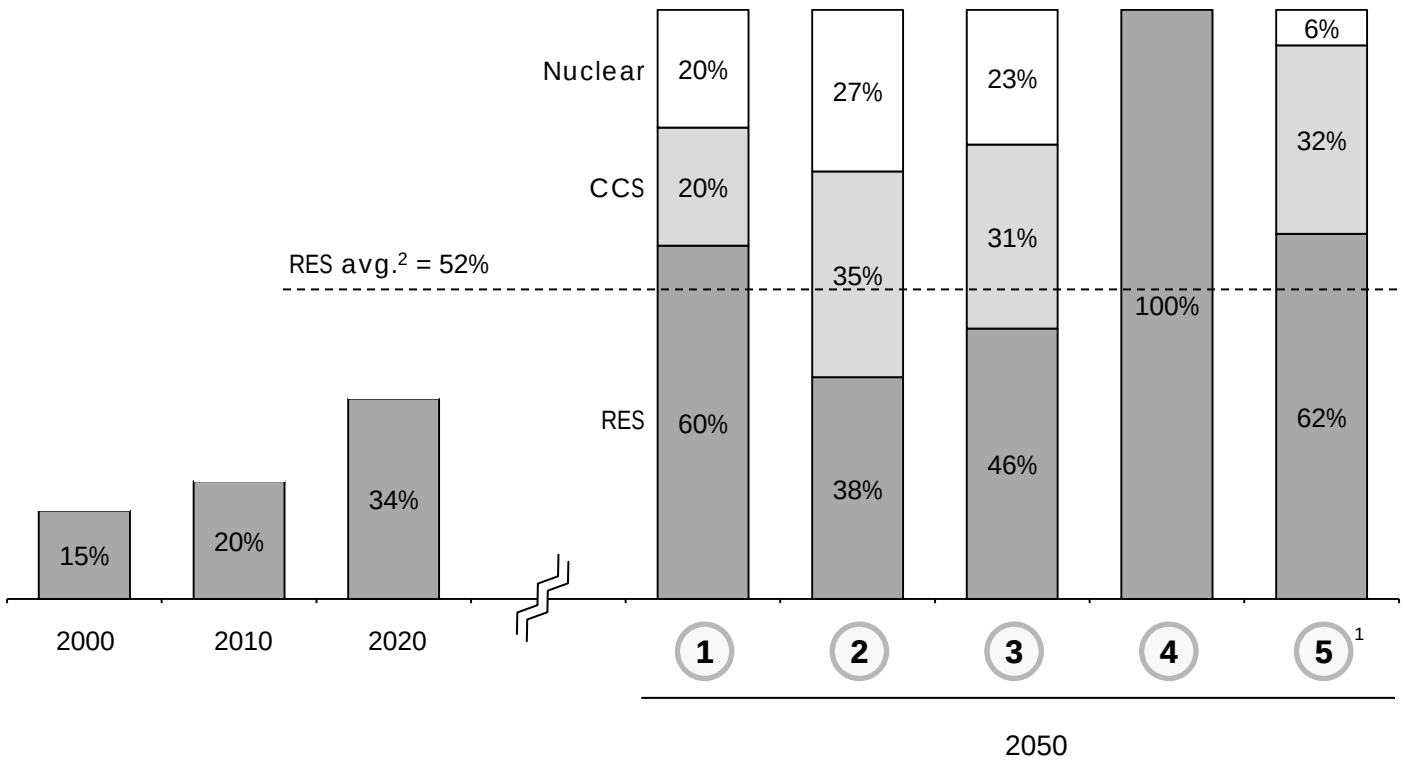
%, 1973-2050



1. Only UK
Source: IEA - Key World Energy Statistics (2009)

Decarbonization of power generation is only viable with a mix of Renewables, Nuclear and CCS

Power generation mix according to different studies
%, 2000-2050



Emissions only allowed for peaking units working a few hours per year

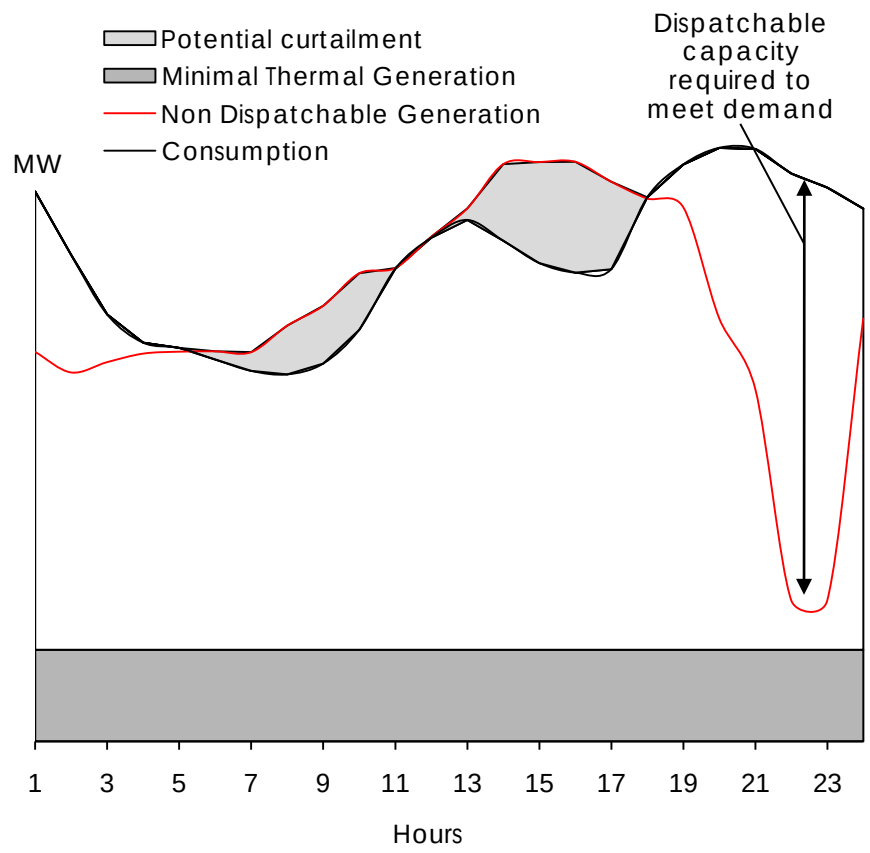
1. Only UK; 2. Excluding study #4

High share of intermittent RES in the mix may imply significant curtailment, but also considerable idle backup capacity

Integration of high volumes of undispatchable generation creates new challenges....

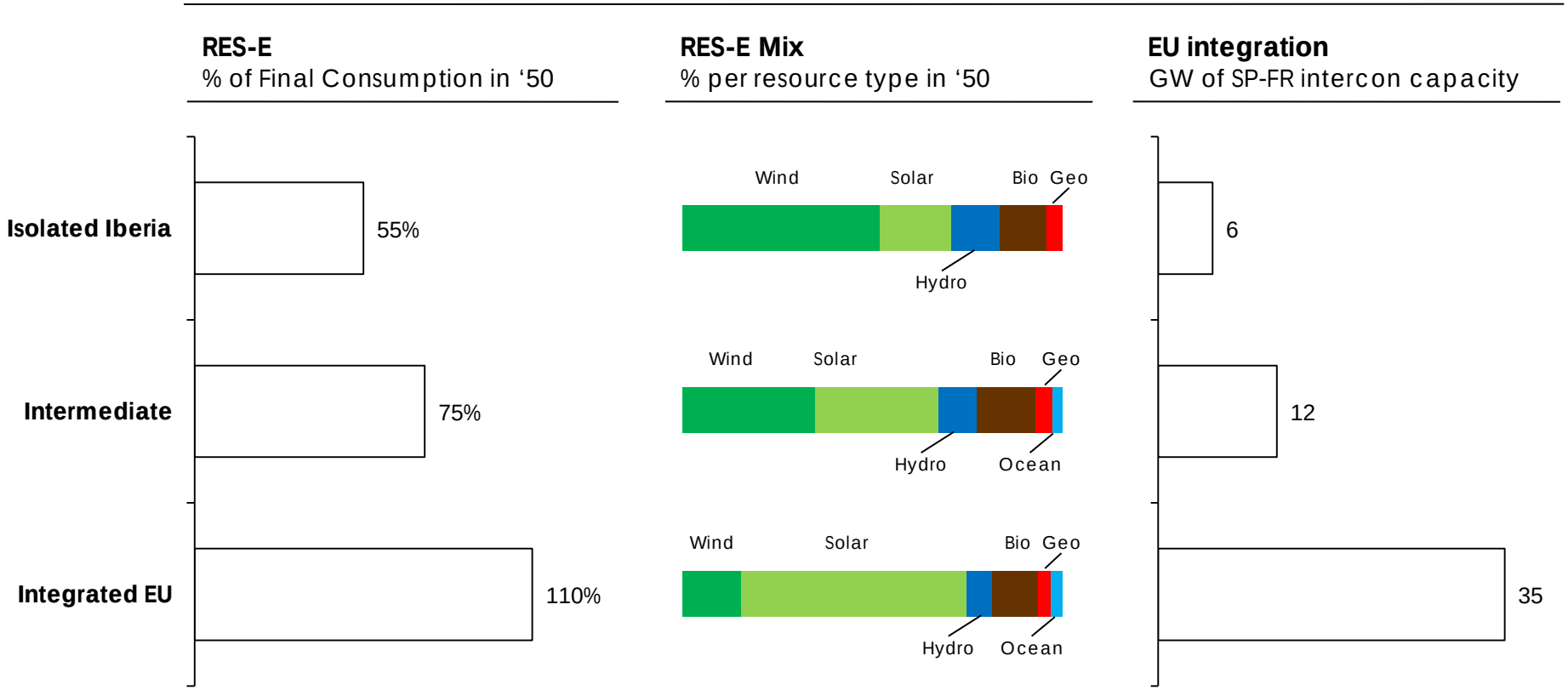
Instantaneous undispatchable generation	Key impacts on system volumes and installed capacity
Very High	• Curtailment likely to occur if intermittent renewables plus rigid thermal generation exceed instant demand • Implies loss of RES generation decreasing load factors and IRR
Very low	• Risk of instantaneous lack of capacity whenever renewable sources drop for a period of time • Implies having installed backup capacity solely to avoid potentials black-outs • Backup capacity not profitable in a marginal cost market

...implying high curtailment and requiring considerable flexible backup capacity



3 main policy scenarios can be envisaged assuming varying RES penetration and mixes and EU integration levels

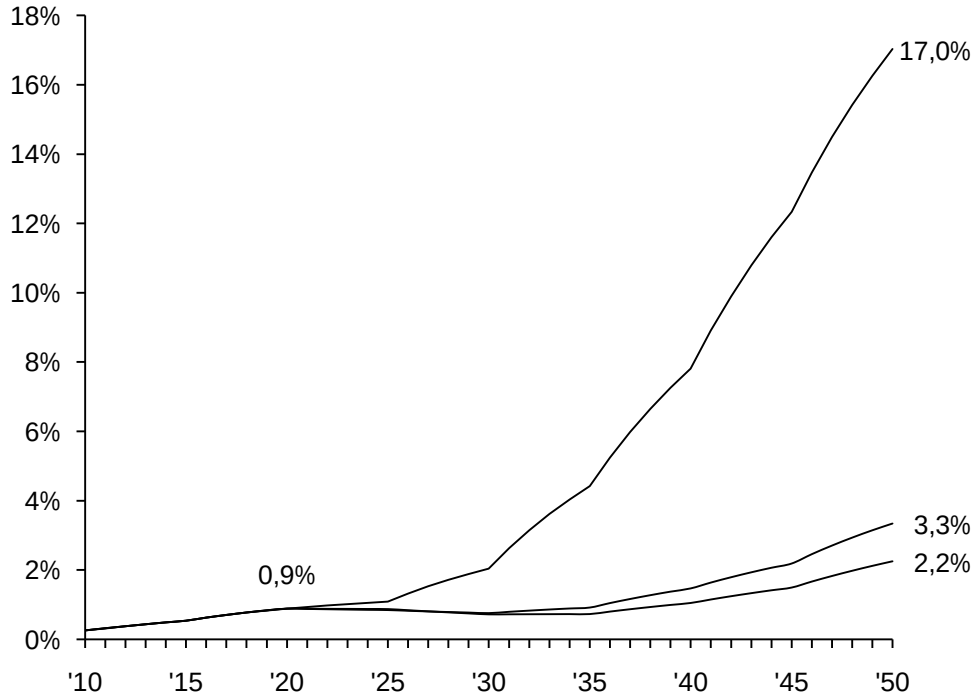
Key attributes of Iberian scenarios analyzed



Without flexibility measures, curtailment in Iberia by 2050 could be as low as 2% with 55% RES or as high as 17% with 110% RES

Curtailment in Iberia for varying scenarios

TWh generation curtailment, 2010-2050 (no flexibility measures[1])

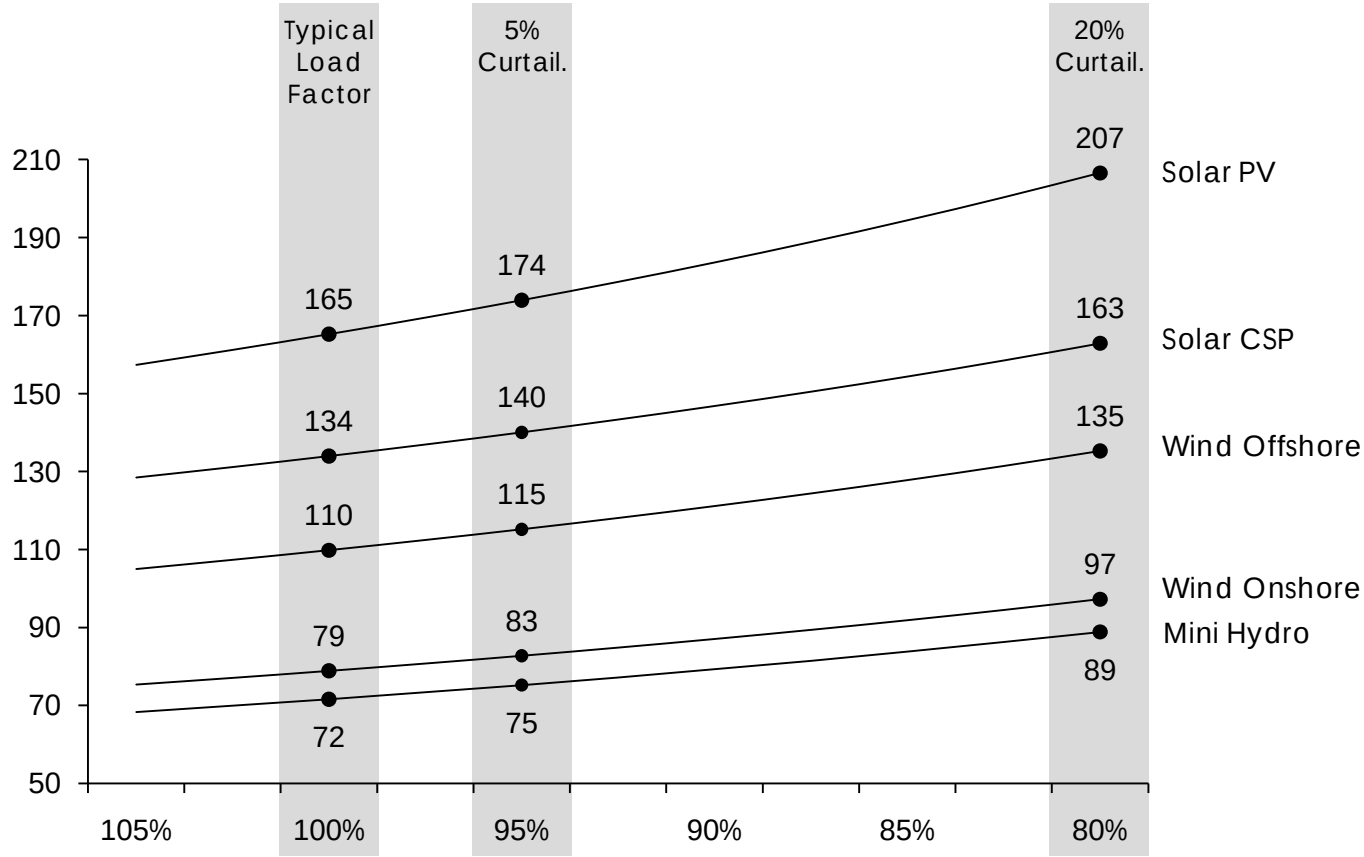


	RES			Curtailment	
Scenario	Mix type	%	TWh	% RES	TWh
Integrated EU	Solar focused	110%	735	17%	125
Intermediate	Diversified	75%	495	3%	17
Isolated Iberia	Wind focused	55%	371	2%	8

1. Assumes no off-peak management through hydro pumping or any other flexibility measure

At current tech costs, a 5% curtailment can imply an extra system cost of €40-100M/year to meet a 10 TWh RES target

Renewable tech LRR for varying load factors relative to base case
€/MWh, % load factor relative to typical operation regime



Incremental annual cost due to curtailment for 10 TWh of RES

Curtailment	5%	20%
Incremental €M / year	+108	+514
Solar CSP	+87	+413
Wind Offshore	+61	+289
Wind Onshore	+54	+255
Mini Hydro	+39	+184

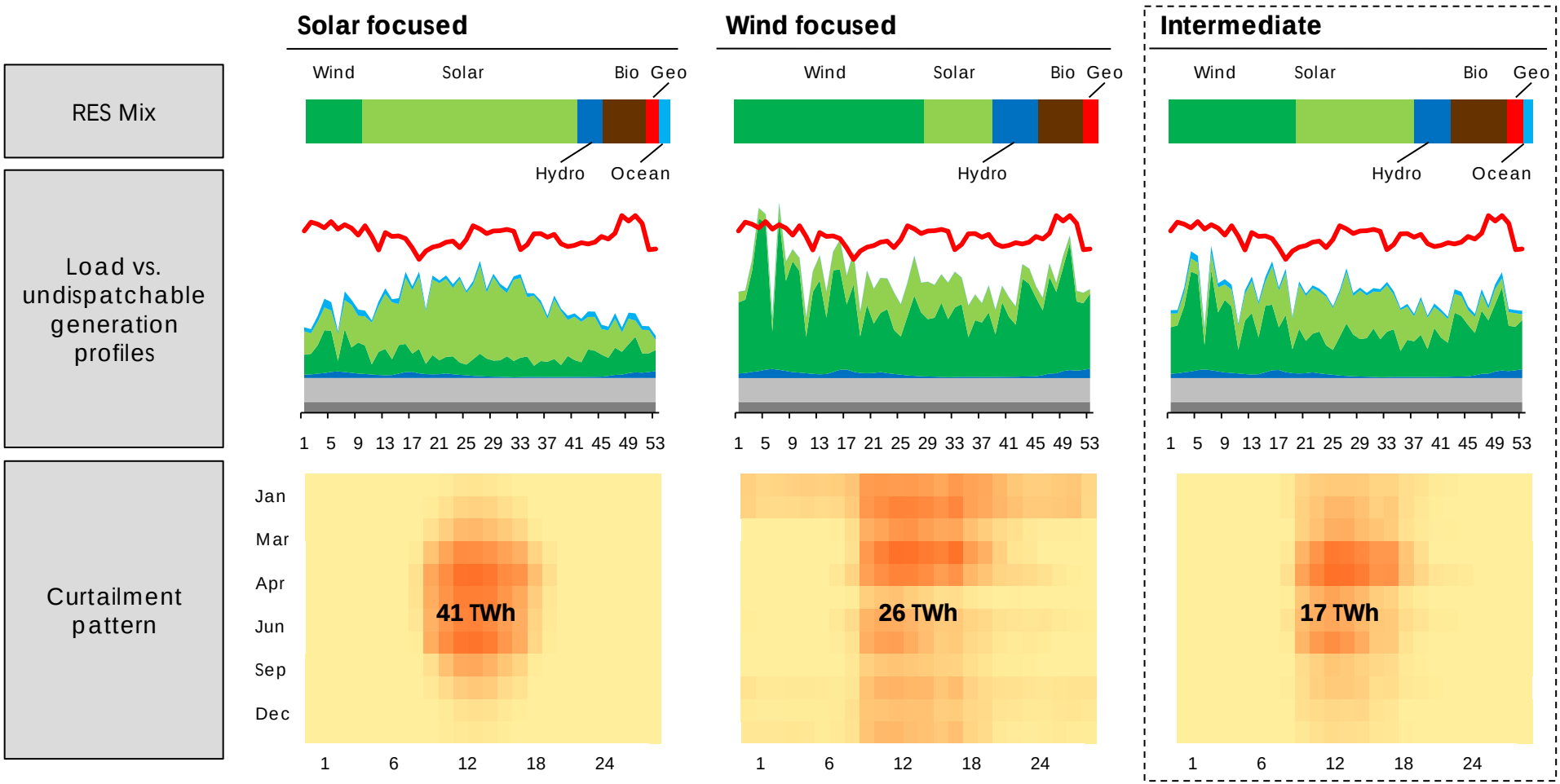
1. Levelized annual cost of additional CAPEX and OPEX over project lifetime for the additional capacity required by the system to meet renewable generation target due to curtailment

A set of technological options will allow for large-scale integration of intermittent RES

Intermittency is managed within different…	Available technologies
… technologies	• Complementary seasonalities of renewable technologies • Flexible thermal generation and hydro
… regions	• Cross-border interconnections
… time frames	• Demand-side management supported on smart grids • Distributed storage (e.g., electric vehicles) • Centralized storage (e.g., pumped hydro, other storage)

RES mix diversification, by itself, significantly lowers curtailment risk

Demand vs. undispatchable generation for varying RES mixes @ ~75% RES-E in Iberia by 2050
MW average hourly generation and load, 52 weeks, 2050 Iberia

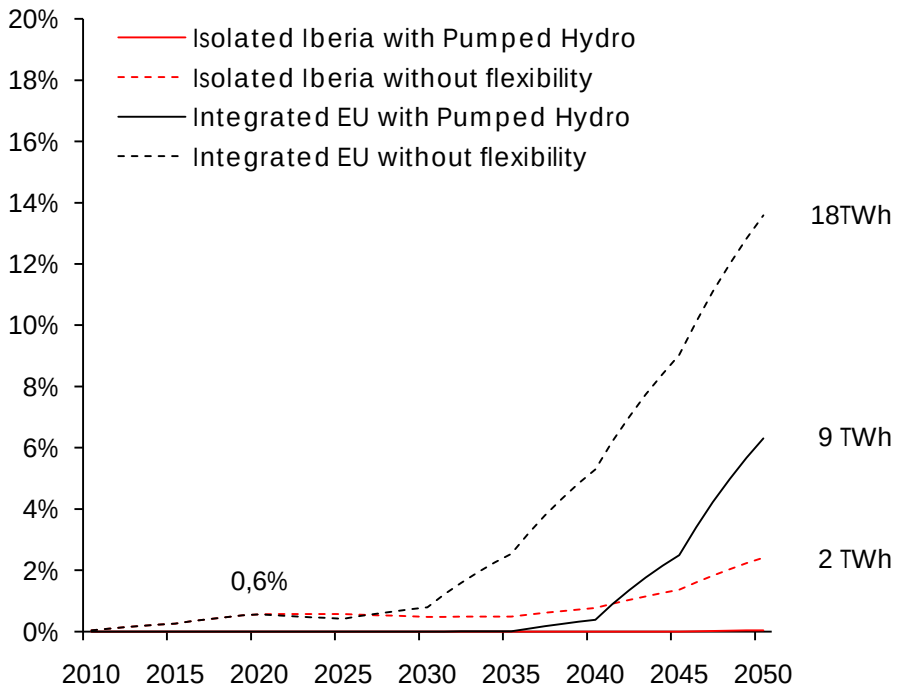


Note: Assuming no off-peak management through hydro pumping or any other flexibility measure

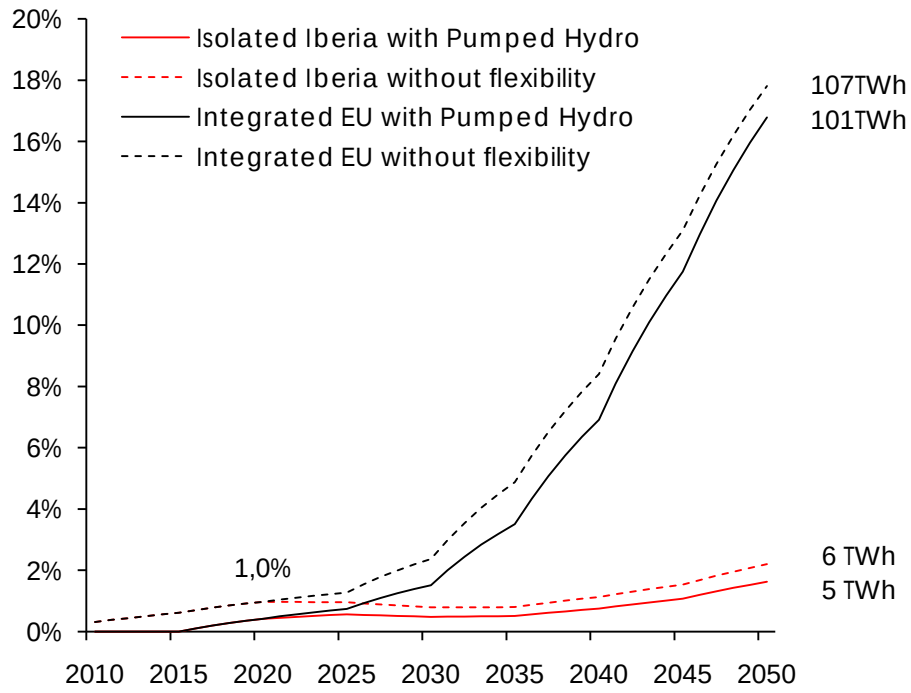
Current Pumped Hydro will by itself reduce potential curtailment significantly in Portugal

RES-E curtailment evolution
TWh and %

Portugal



Spain

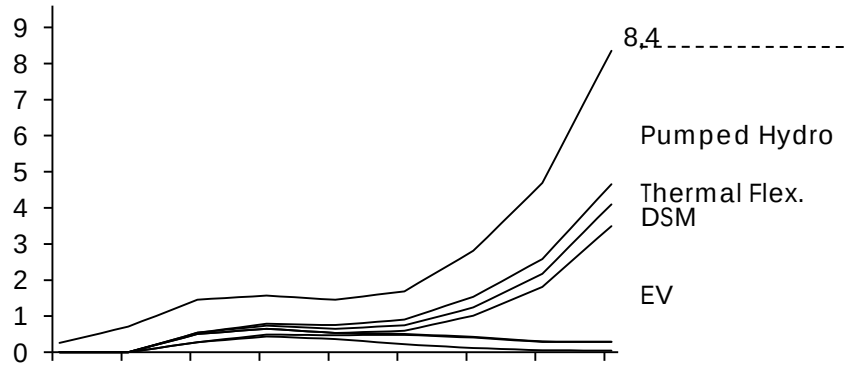


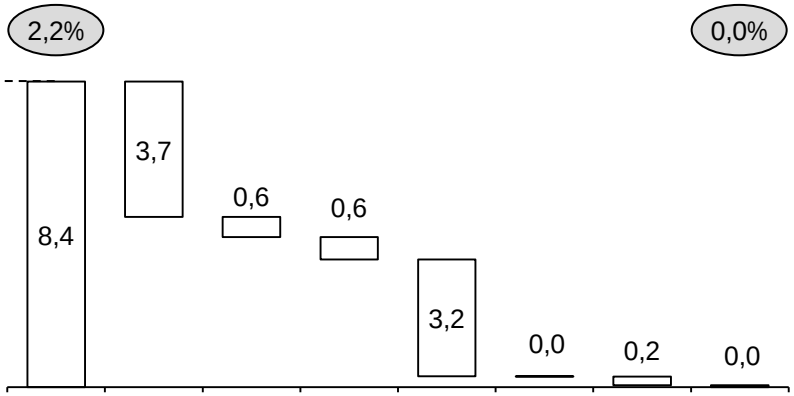
In tandem, flexibility measures have a combined effect capable of significantly reducing curtailment

Impact of flexibility measures adoption on curtailment in Iberia over time
TWh intermittent RES curtailment, 2010-2050

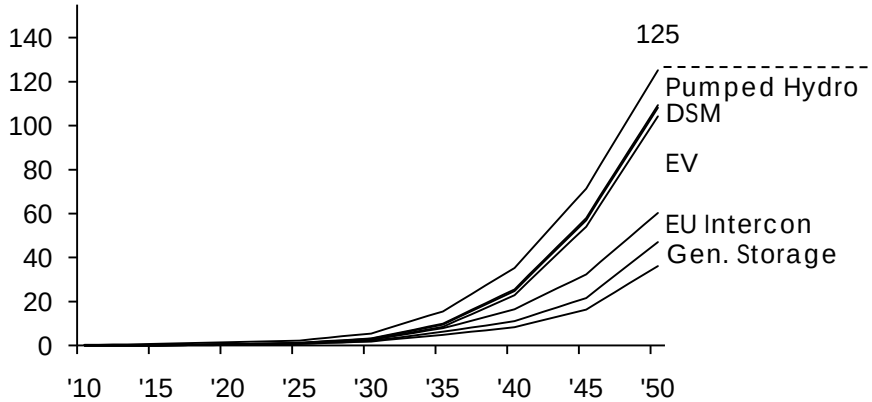
Overall impact of flexibility measures adoption on curtailment in Iberia
TWh intermittent RES curtailment, 2050

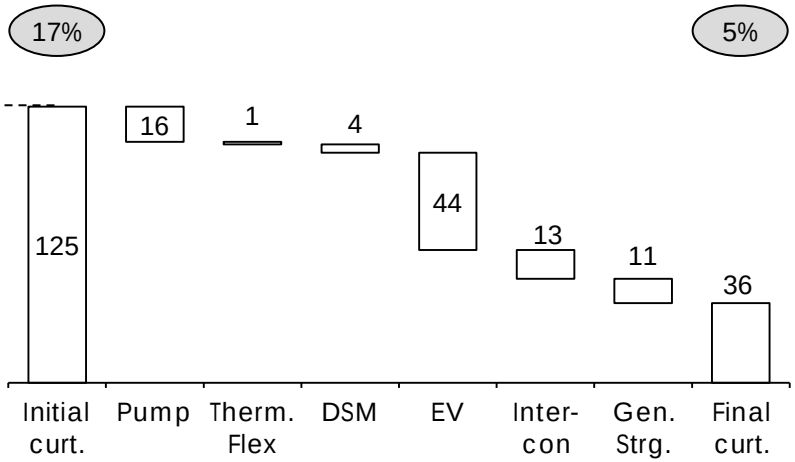
Isolated Iberia
Wind focused
(RES-E = 55%)





Integrated EU
- Solar
focused
(RES-E = 110%)





- % curtailment vs. RES volume