Market4RES

Low-carbon technologies, risks and support options

Market4RES WP5

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Support mechanisms: risks v. incentives

Support schemes: how do they help?

Investment support make projects more attractive by **reducing their costs**

Subsidy /MW upfront: only part of the cost remain at the expense of the producer

Financial guarantee: access to cheaper capital

Operating aid (/MWh) make projects more attractive **by increasing their expected revenues <u>and</u>** often also by **making future revenues more certain**, therefore granting access to cheaper capital.

What makes an efficient support mechanism?

Integration into the power system

→ Electricity from RES is welcomed in the power system at the lowest possible cost. RES producers can value their flexibility (balancing, voltage control…)

Financial risk for producers

→ The uncertainty on projects' future revenues is limited so as to enable high "gearing", *i.e.* access to relatively cheap capital.

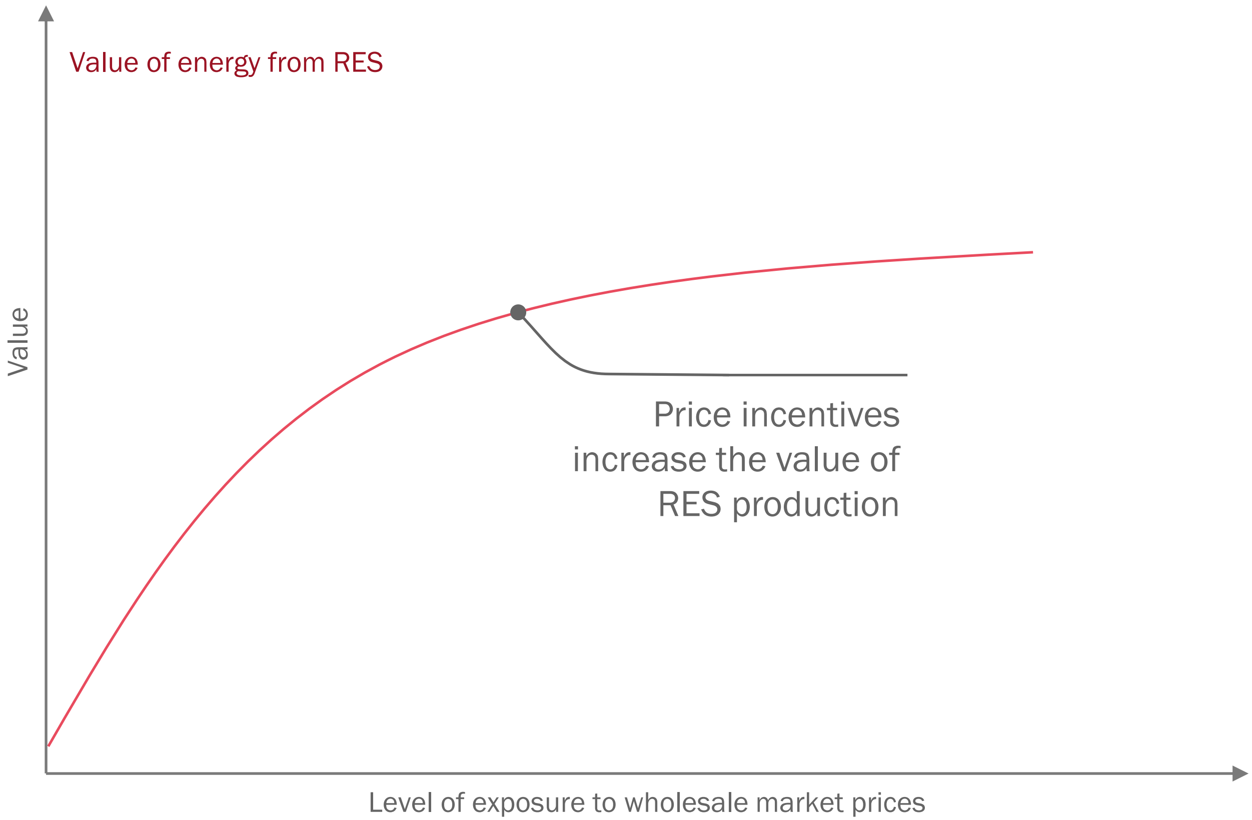
Short-term distortions

→ Short-term merit order is not altered by RES generation. Producers able to generate when the price is high are rewarded.

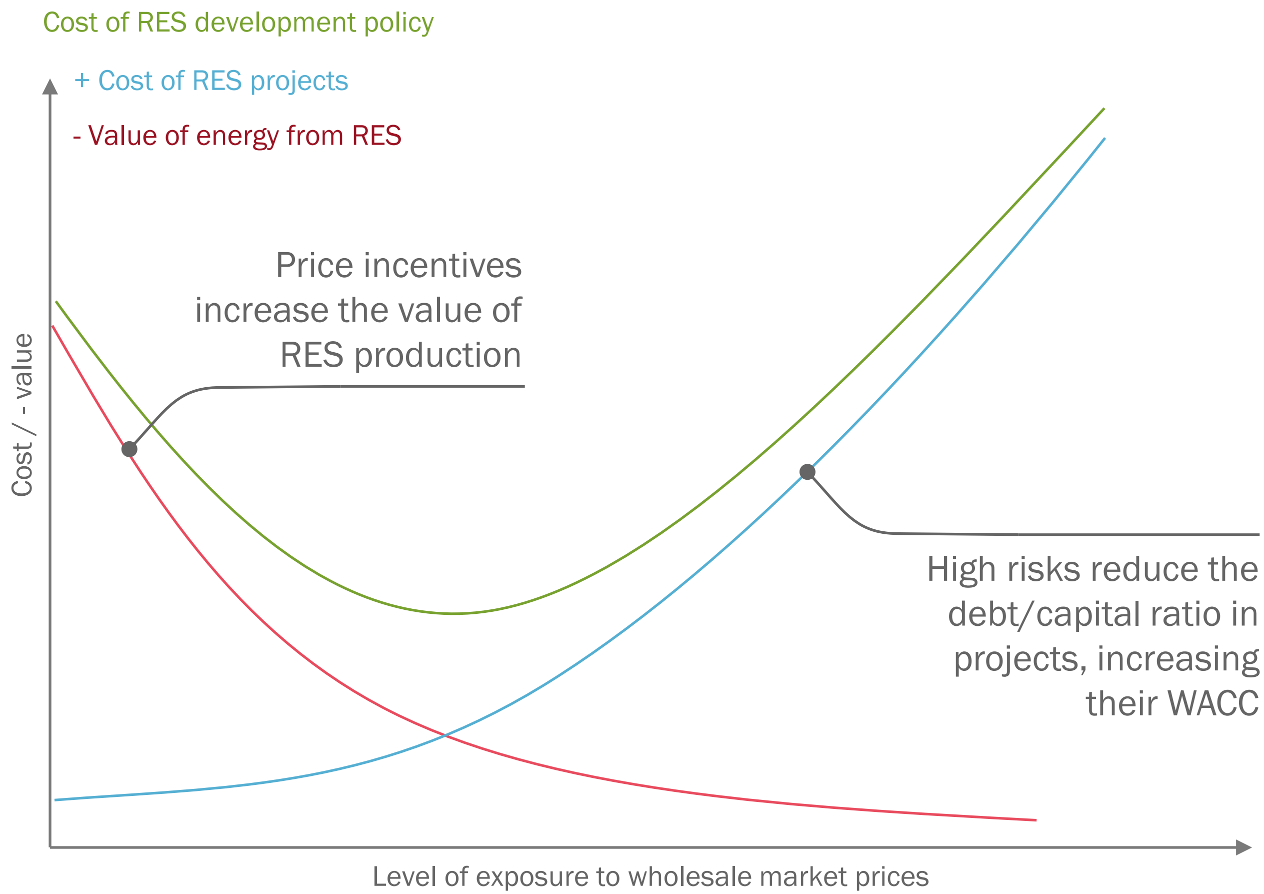
Long-term distortions

→ Private investment decisions leads to the best collective choices (no investment bias due to the subsidy)

Arbitrage between risk and incentives

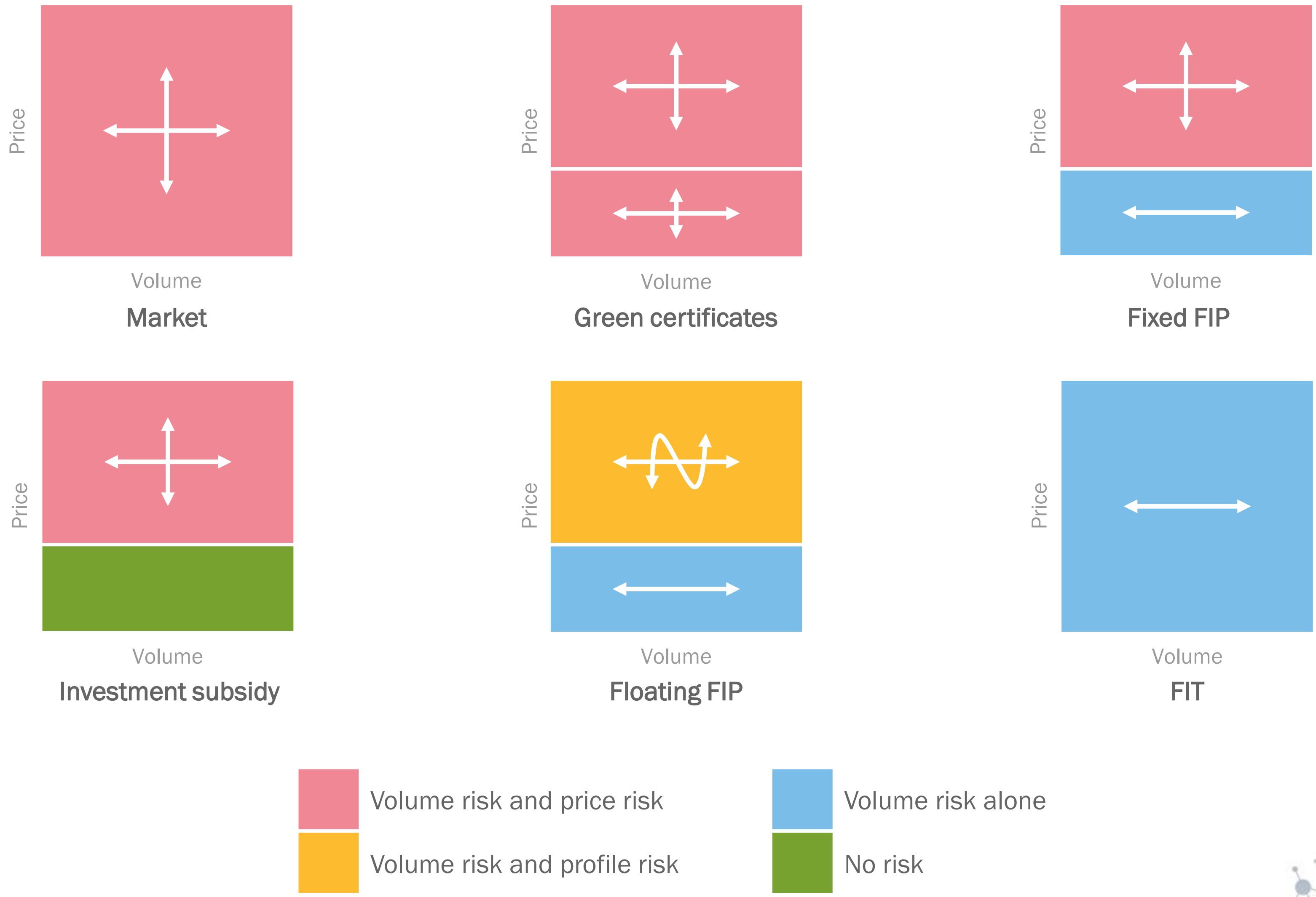


Arbitrage between risk and incentives



→ Here we focus on the **risk** part: the value of incentives is not explored ←

Market risks in RES projects,
according to the nature of the support scheme



Modelling investment in power generation

Short-term modelling of power systems
based on optimization programmes

Short-term module: optimal dispatch

Principle:

Min variable cost

Under constraints of P=C, max generation, interconnections

Inputs:

- Generation mix
- Network model
- Demand, availability of generation units

Assumption:

Perfect competition in the short term (market outcome is optimal)

Variable *Parameter*

$$Variable\ cost = \sum_{p \in Plants, t} VC_p . Gen_{p,t}$$

$$\forall p, \forall t, 0 \leq Gen_{p,t} \leq GenCap_p$$

VC_p is the cost of primary energy + cost of CO_2 if applicable

Optimal investment in power systems
based on a short-term dispatch module

Short-term module: optimal dispatch

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Min variable cost

Under constraints of P=C, max generation, interconnections

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Generation mix

Cost of dispatch

Long-term module: optimal investment

Min **total** cost (variable + fixed)

Under mix technical (potential) and political mix constraints

Various investment decision techniques

Optimal investment in power systems

as integrated optimization programme

Co-optimization of investment and dispatch

Principle:

Min **total cost** (= variable + fixed)

Under constraints of P=C, max generation, interconnections, mix constraints

Inputs:

- **Mix constraints**
- Network model
- Demand, availability of generation units

Assumption:

Perfect competition over the short and long terms

Variable *Parameter*

$$Total\ cost = \sum_{p \in plants} FC_p . GenCap_p + \sum_{p \in Plants,t} VC_p . Gen_{p,t}$$

$$\forall p, \forall t, 0 \le Gen_{p,t} \le GenCap_p$$

Additional mix constraints, e.g.:

$$GenCap_{RES} \ge X\ GW$$ Min RES generation capacity

$$\sum_{p \in RES\ plants,t} Gen_{p,t} \ge Y\ TWh$$ Min RES generation

$$\sum_{p \in Plants,t} EF_p . Gen_{p,t} \le Z\ MtCO_2$$ CO2 emissions cap

Taking risk into account
in long-terms models of the power system

Numerator / certainty equivalent method

$$NPV = -I + \sum_{t=1}^{lifetime} \frac{Certainty\ equiv.of\ income\ distribution}{(1+\tau_f)^t}$$

Denominator / beta method

$$NPV = -I + \sum_{t=1}^{lifetime} \frac{E[income(t)]}{(1+\tau_f+\beta\phi)^t}$$

→ Under normal hypotheses on the distribution of incomes, the two methods are equivalent

In practice : static optimization based on an annualized vision of costs

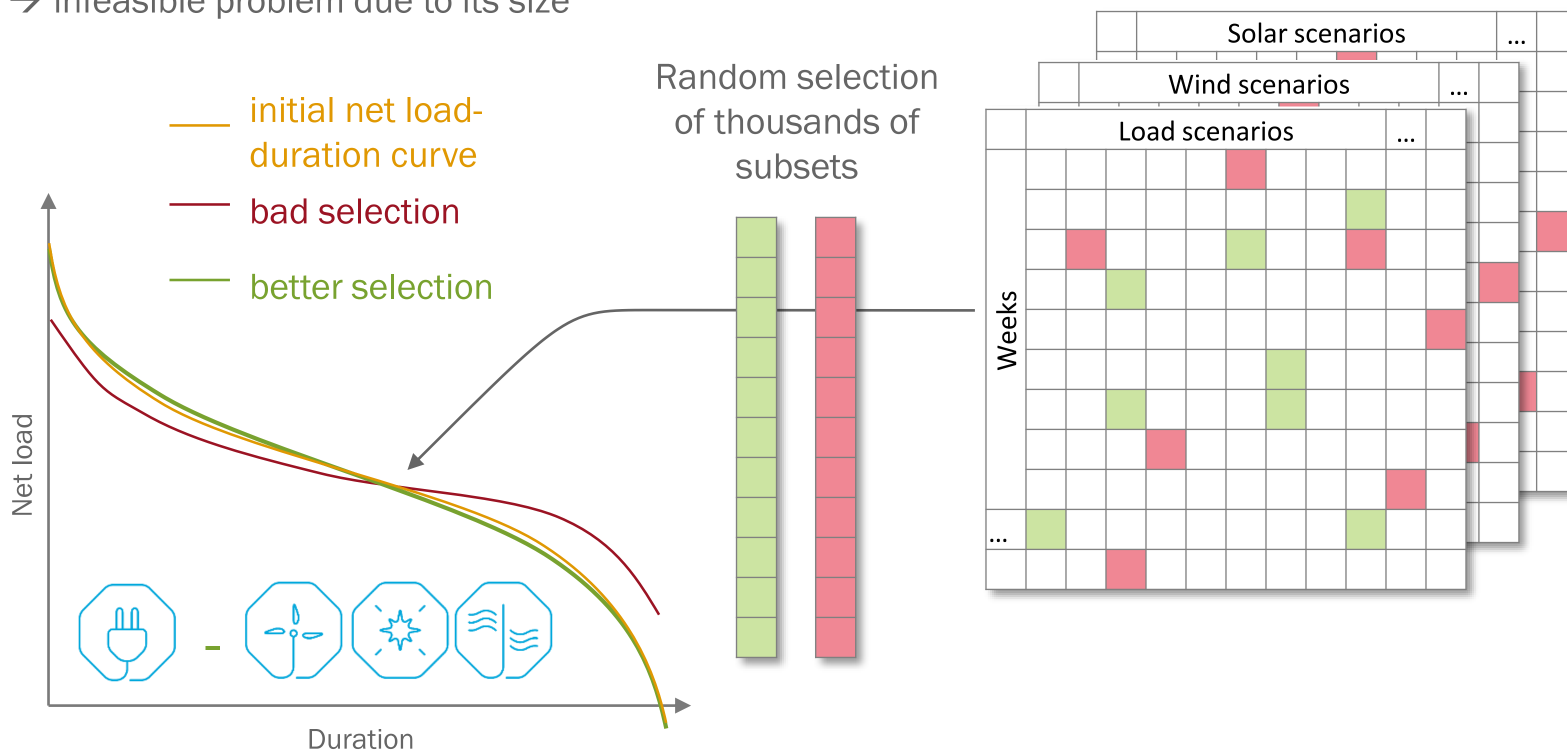
$$Annual\ capital\ cost = \frac{\tau * I}{1-(1+\tau)^{-lifetime}}$$

$$WACC : \tau = \tau_f + \beta\phi$$

$$Annual\ fixed\ cost = Annual\ capital\ cost + annual\ O\&M\ cost$$

Reduction of the optimisation problem size

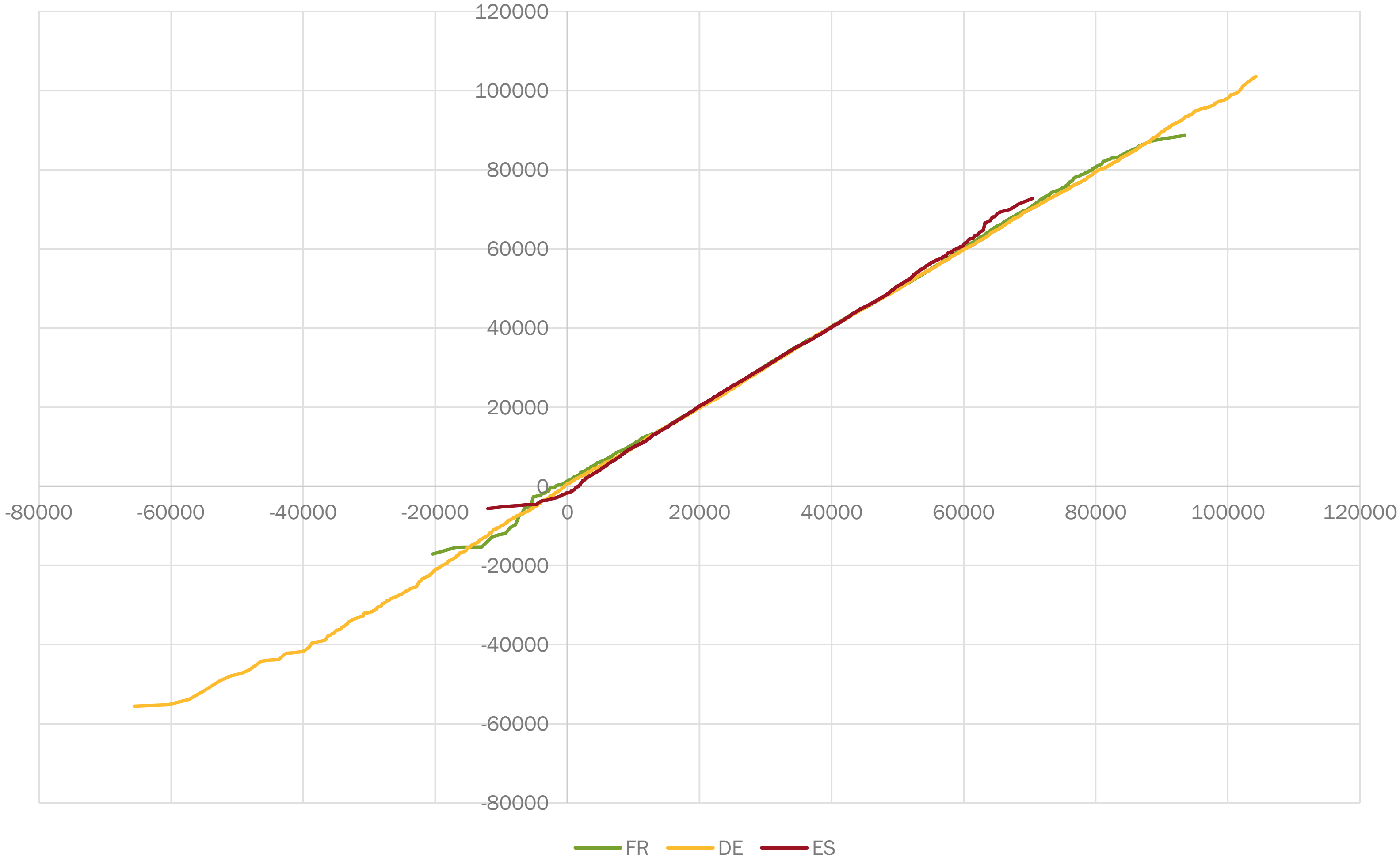
Monte-Carlo simulation and / or difficult constraints
→ infeasible problem due to its size



Not used

Extraction of the same weeks from the other time series

Reduction of the optimisation problem size



Result: approximate load-duration curve plotted against actual
(y=x means ideal fit)

Exploring decarbonization options

Modelling assumptions – data sources

Consumption, RES profiles and NTCs

ENTSO-E TYNDP

historical time series 2000-2011 adjusted to 2030 in Vision 4 scenario + projected NTCs

Other availability profiles, hydro stocks

Generated with ANTARES (RTE's main tool for adequacy studies) based on a "New mix 2030" situation

Variable costs

IEA / ENTSO-E Fuel prices projections to 2030

ADEME, RTE ECO2Mix CO_2 emissions from primary energies

Fixed costs (excluding discount rates)

IEA Projected costs of generating electricity

ADEME *100 % ENR*, benchmark from many sources

Taking risk into account
WACC hypotheses used in this study

WP5 'reference' and 'high' scenario hypotheses

Conventional technologies: **8 %**

RES technologies, computed based on conclusions from the Beyond 2020 European project
- **8 %** if all revenues come from the market (including ETS)
- **FIT: 6,2 %**

Beyond2020 unmodified hypotheses

Conventional technologies: **9,8 %**

- **9,8 %** if all revenues come from the market (including ETS)
- **FIT: 7,5 %**

For sensibility analysis: "optimistic" hypotheses

Conventional technologies: 10 **%**

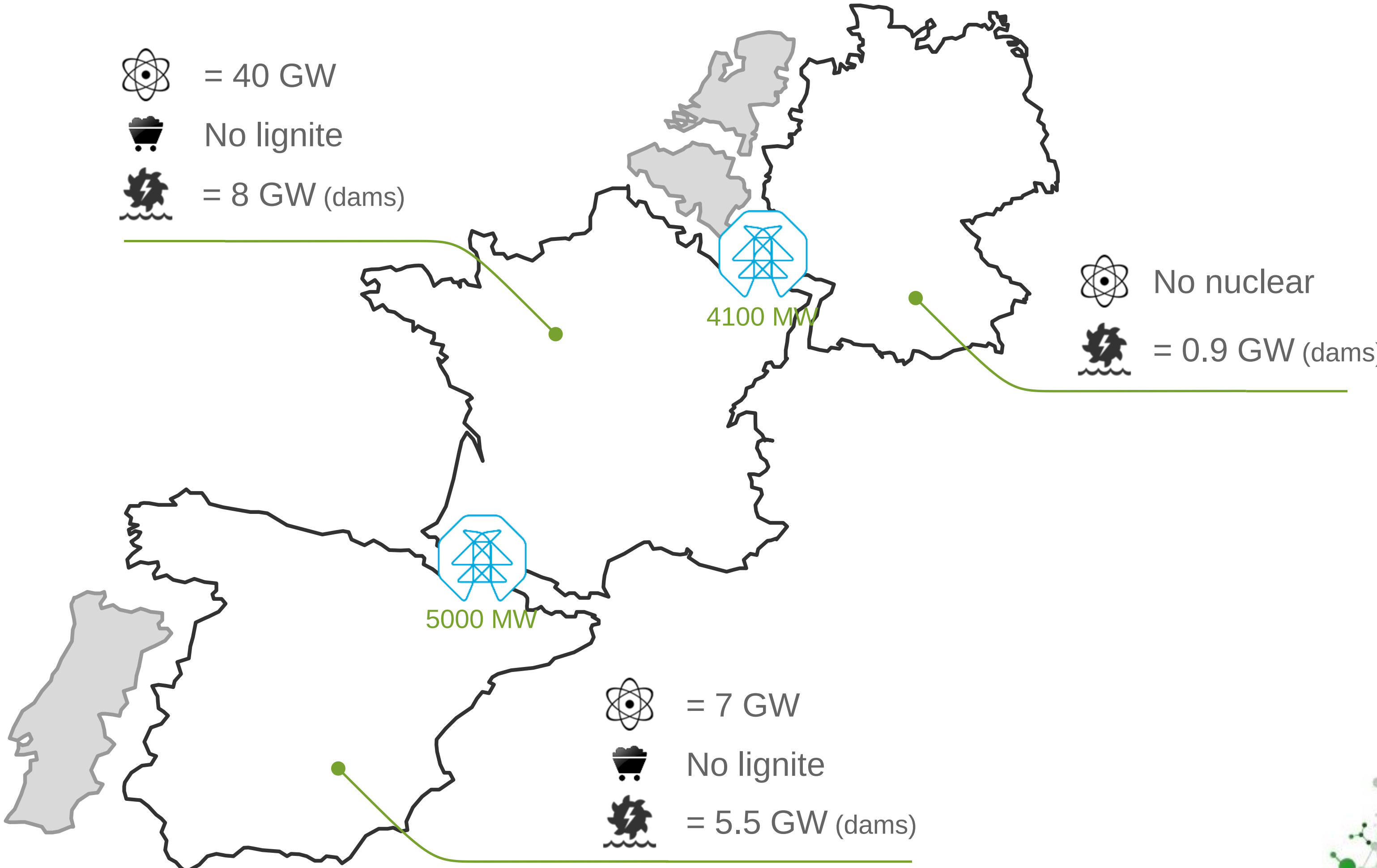
- **10 %** if all revenues come from the market (including ETS)
- **FIT: 5 %**

Modelling assumptions: mix constraints

Lignite
Hard coal

CCGT
OCGT

RoR
Dams



These countries will also be taken into account in the final version

Methodology

Reference

WP5 **High RES** scenario:
95 €/tCO_2 + RES capacities
~ 250 MtCO_2 (= 150 g/kWh)

- Cheapest mix to reach 250 MtCO_2 ?

Support scheme options

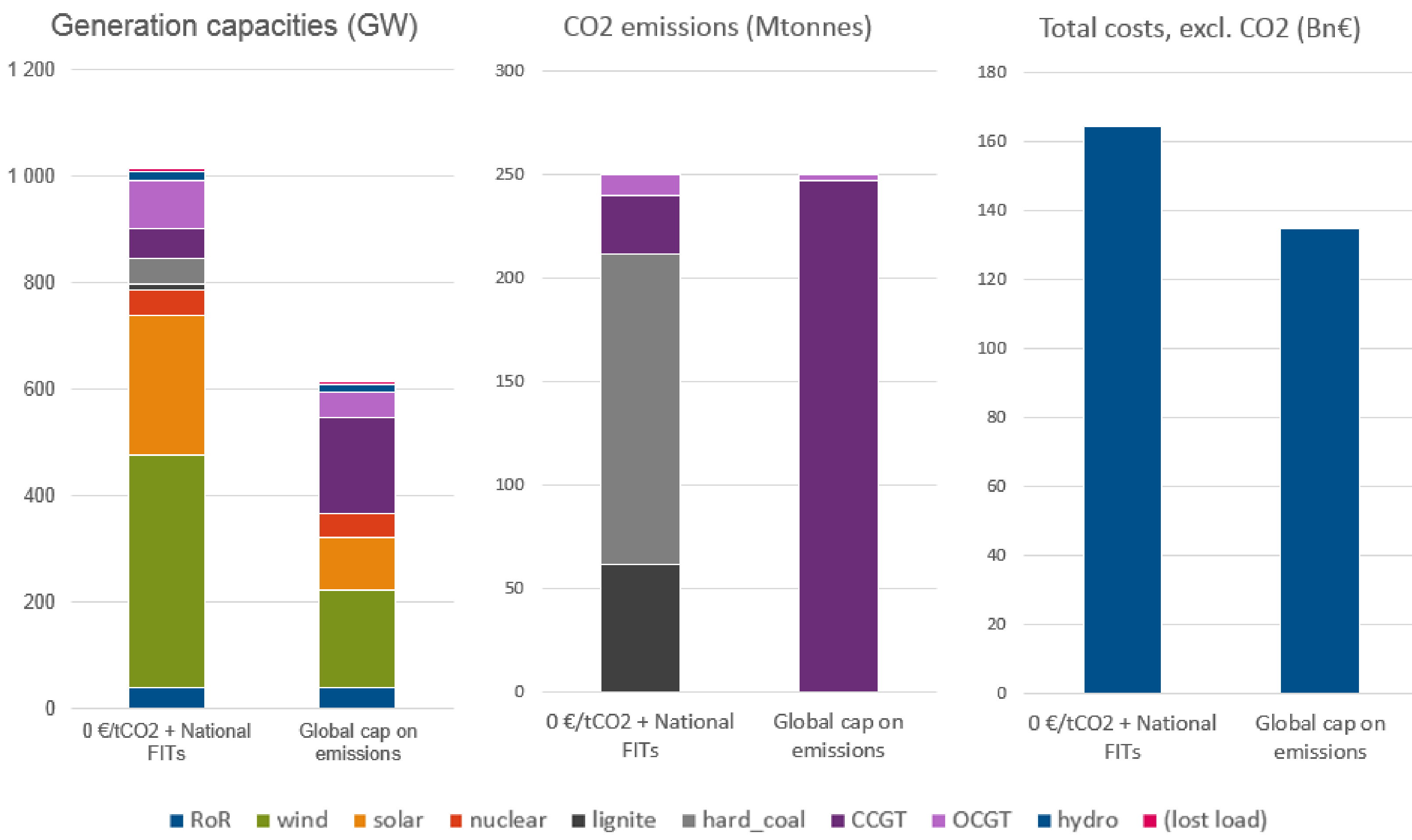
Market + CO2 price from Cap & Trade

Floating FIP or FIT

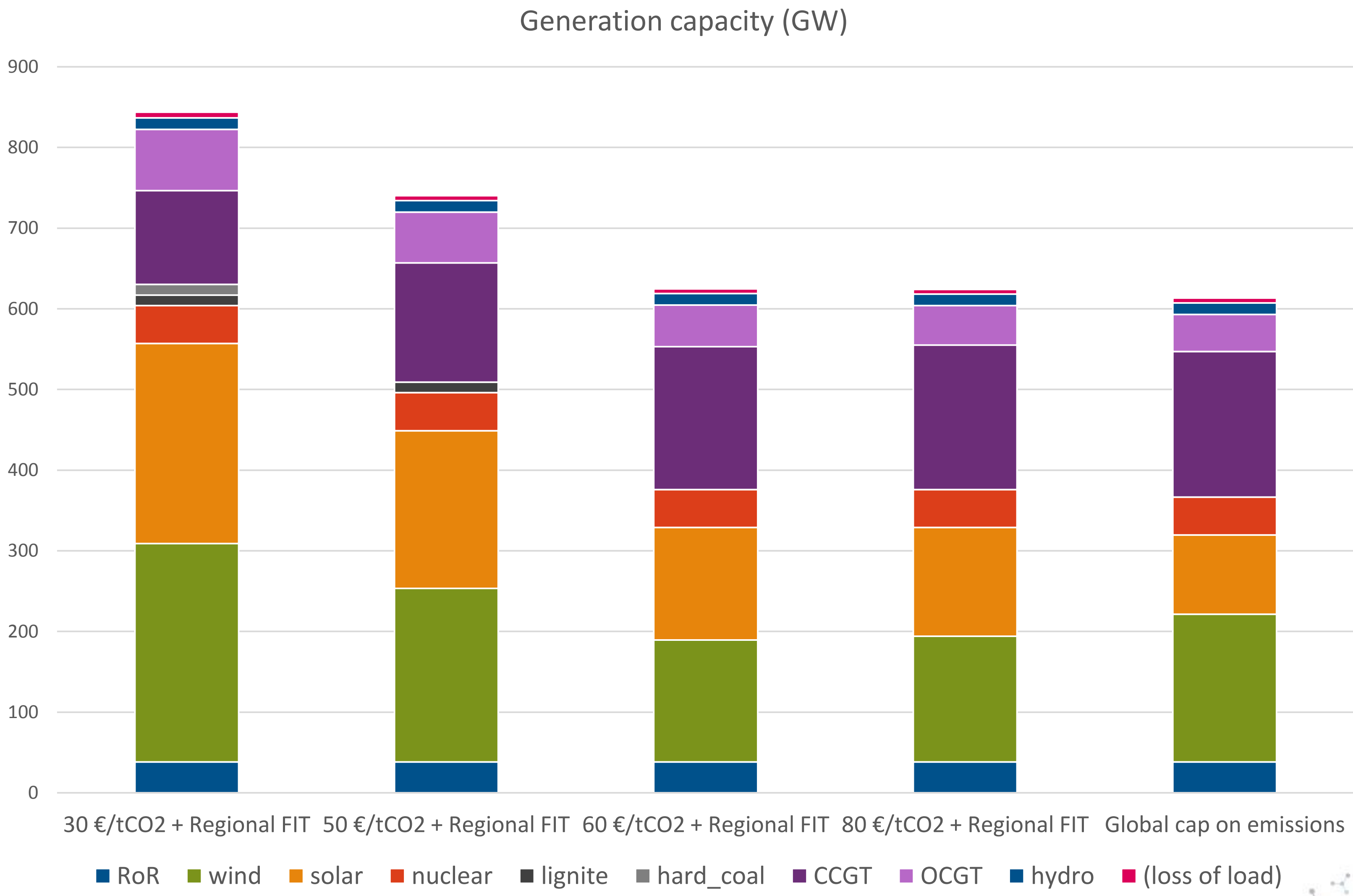
Market design variants

- CO2 price from cap & trade (ETS) and no RES target
- RES targets and support, no CO_2 price
- RES targets and support + CO_2 cost from a tax or a price floor on the ETS
  - Different CO_2 cost levels
  - National targets, technology-specific v. regional targets, technology-neutral

Results:
Support scheme v. emissions cap & trade



Results:
Carbon price + Regional, technology neutral target and support



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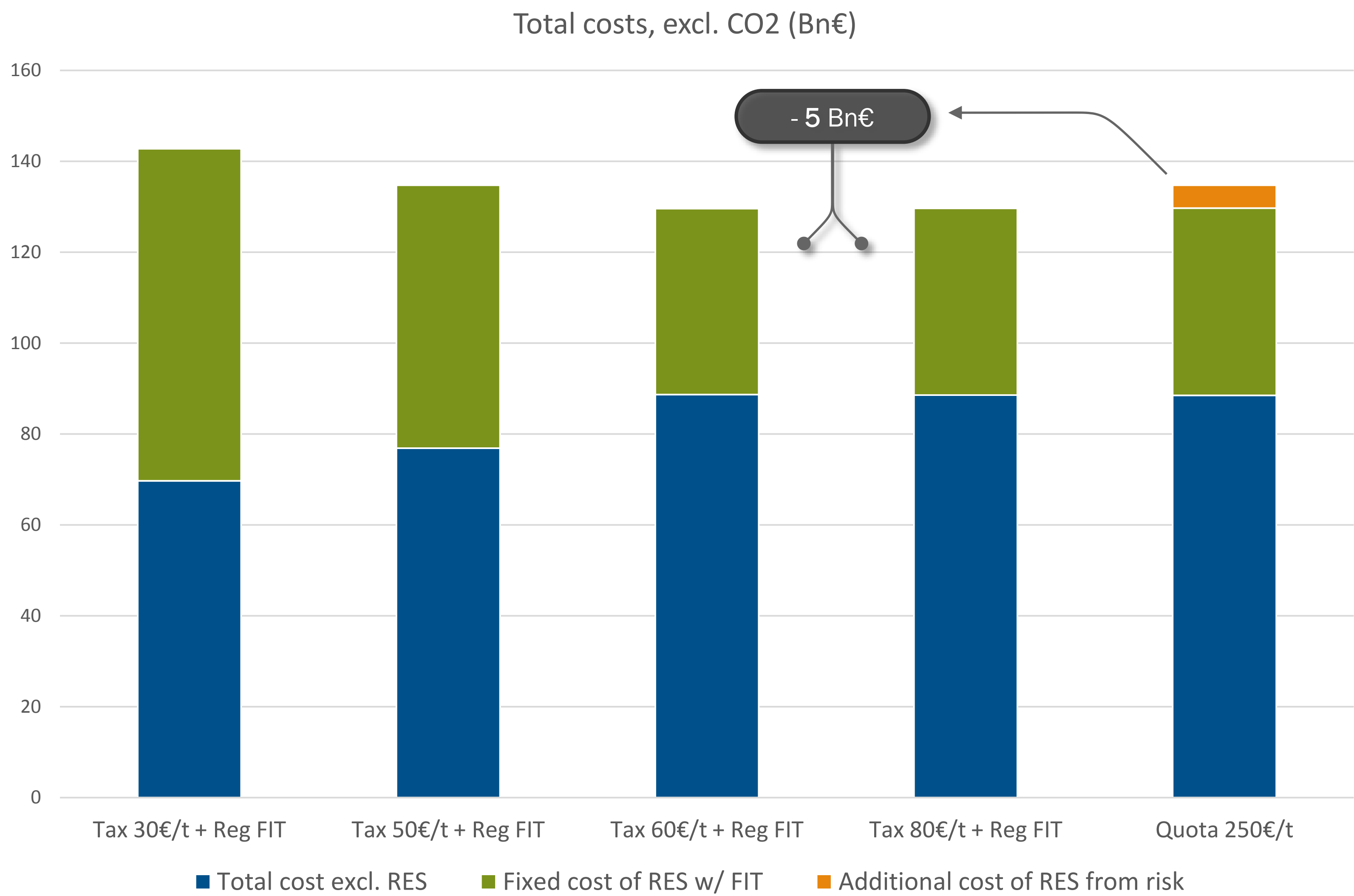

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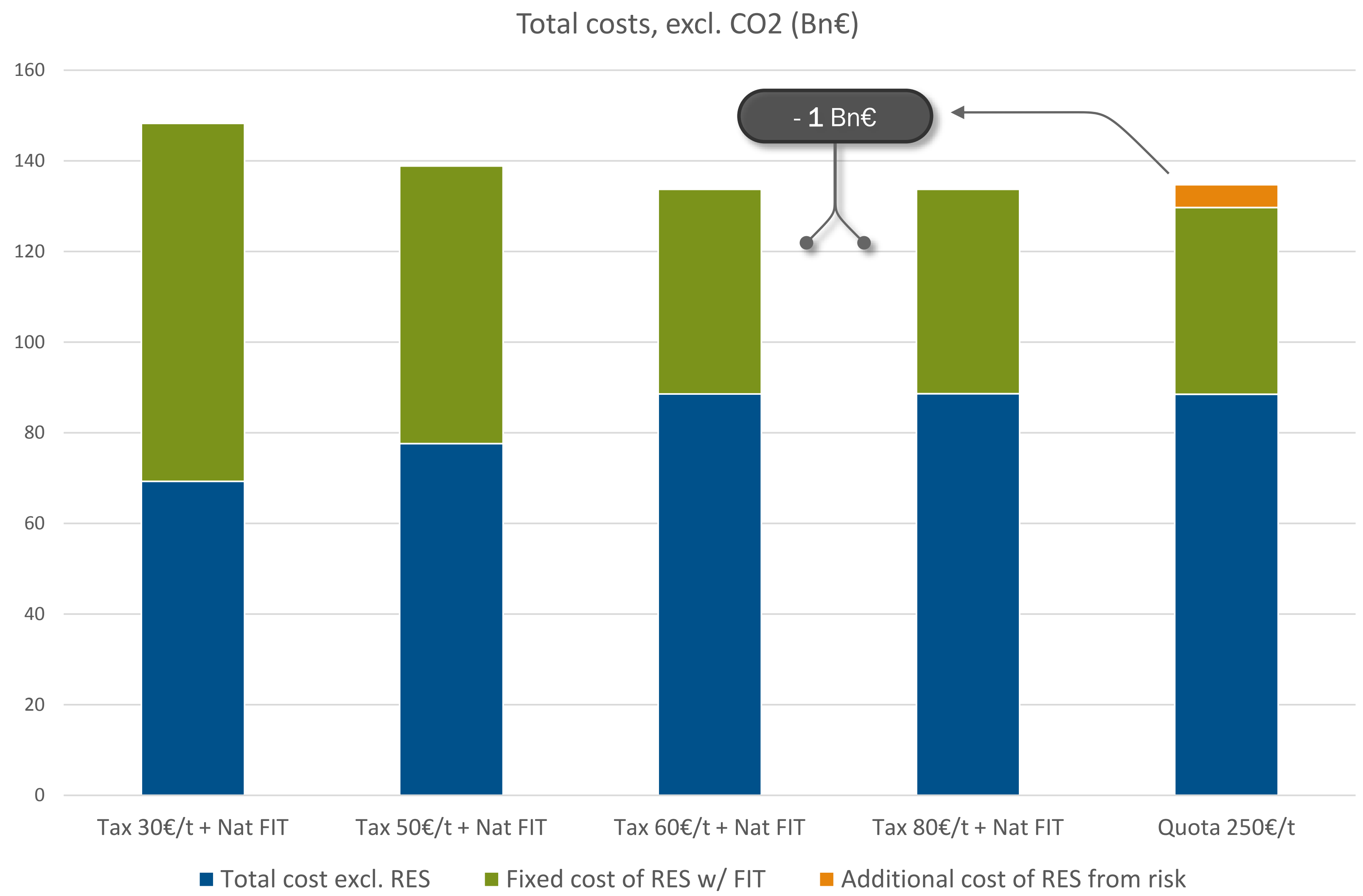

Market RES

Results:
Comparison of unit cost of electricity

Unit cost of electricity as a function of the support mechanism's design

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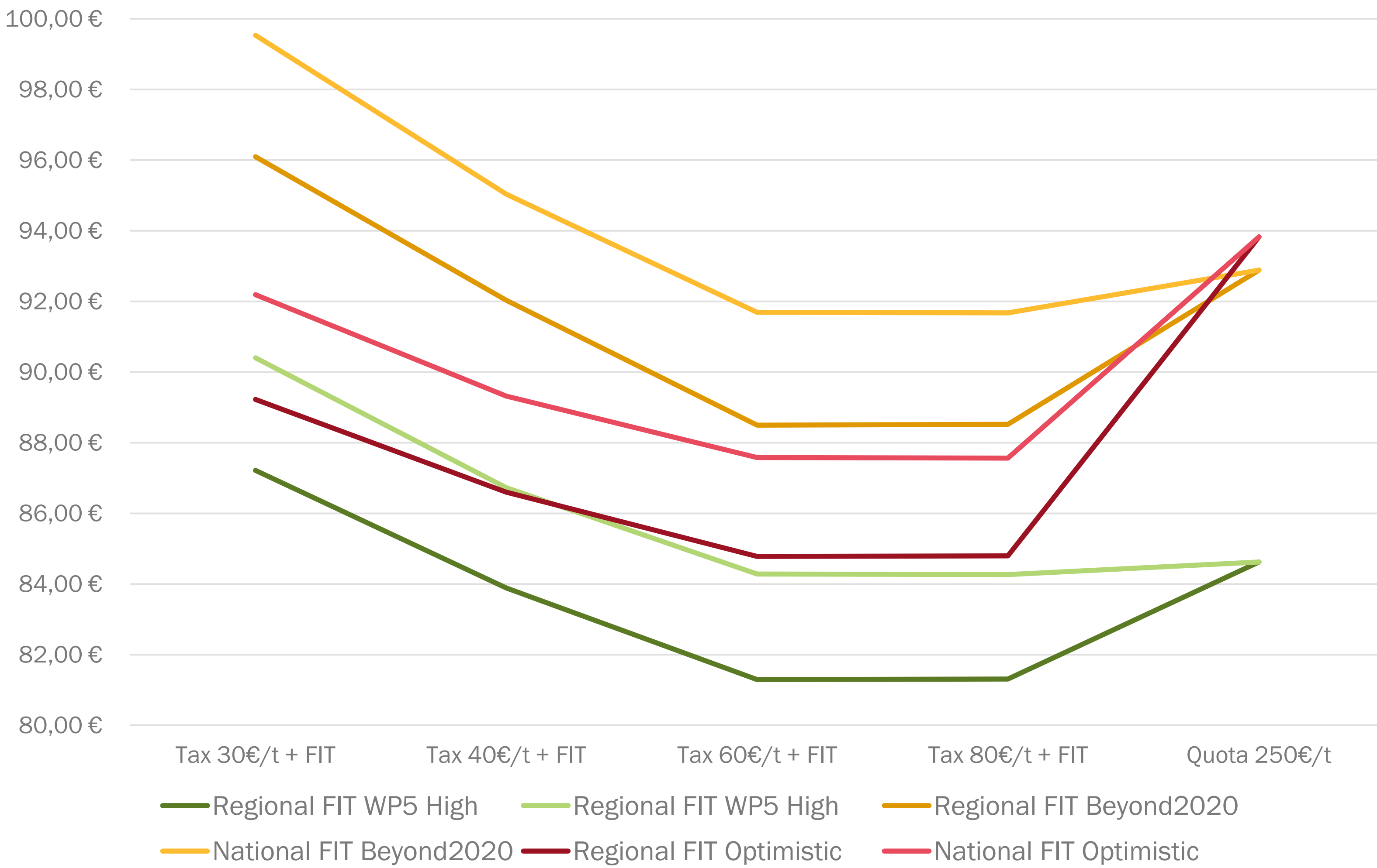
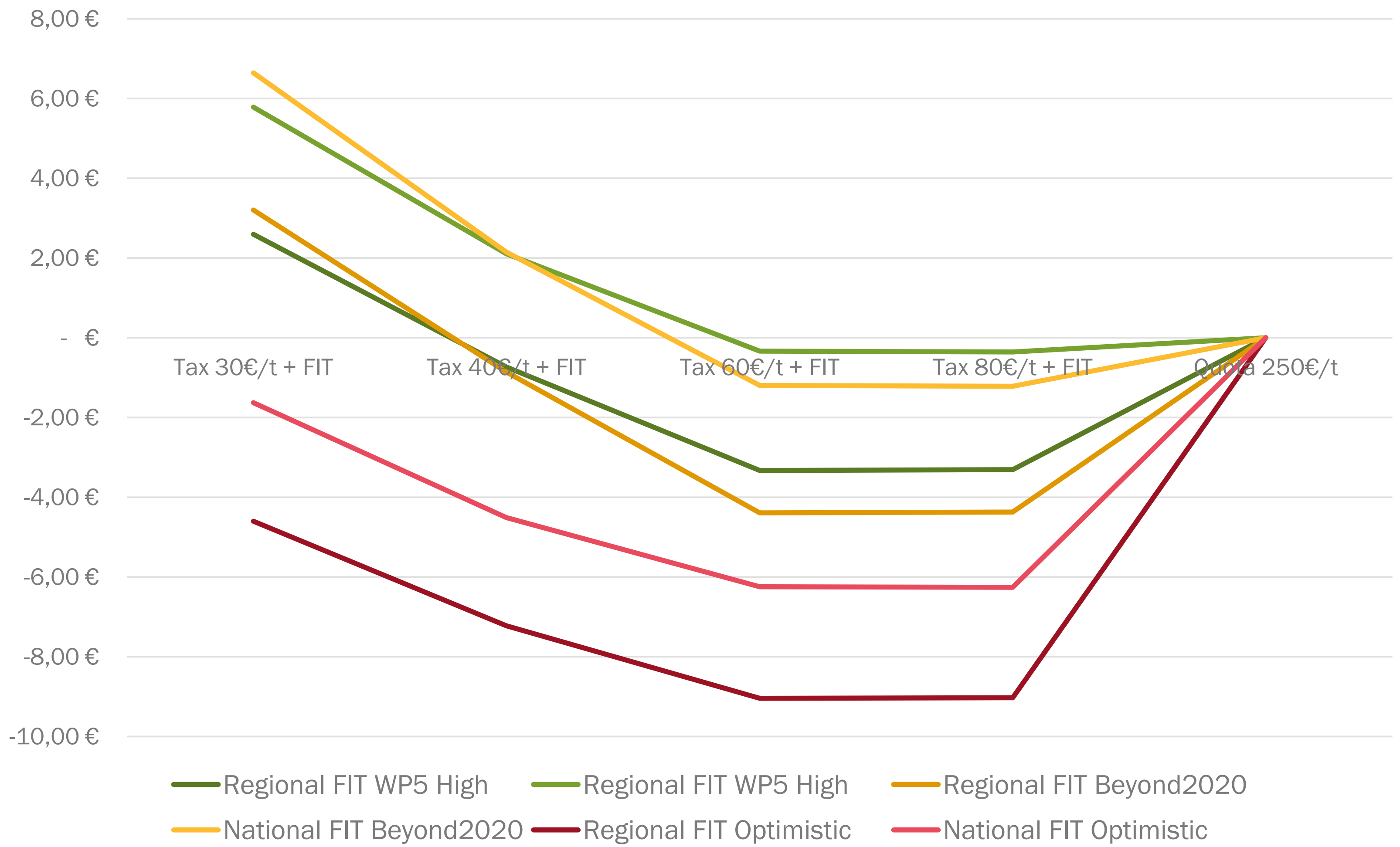
Comparison of unit cost of electricity



Unit cost of electricity as a function of the support mechanism's design

Results:
Comparison of unit cost of electricity



Unit cost of electricity as a function of the support mechanism's design, compared with the unit cost in the case of quotas

Conclusions

CO_2 pricing through a global cap is a more efficient tool to reach emissions targets than direct support to RES (or low carbon technologies in general)

Without carbon pricing, cheap decarbonisation (switch from coal to gas) options **remain untapped**.

Without support scheme, capital-intensive low-carbon technologies **remain very expensive**.

Combining **a moderate but certain CO2 price** and an **explicit support scheme** allows to benefit from both cheap decarbonisation options low-carbon technologies at a reasonable cost

Homework to go further

- Include **missing countries** (Belgium, the Netherlands and Portugal)
- Improving the **hypotheses on capital cost** as a function of
  - the design of the support mechanism
  - the domestic context of each country
- Test the robustness of the conclusion to **alternative long-term scenarios** (two other long-term scenarios described in WP5 will be assessed)
- What does it change if we consider the **socio-economic value** How to compute it: socioeconomic beta of low-carbon projects?

Coordinated by SINTEF

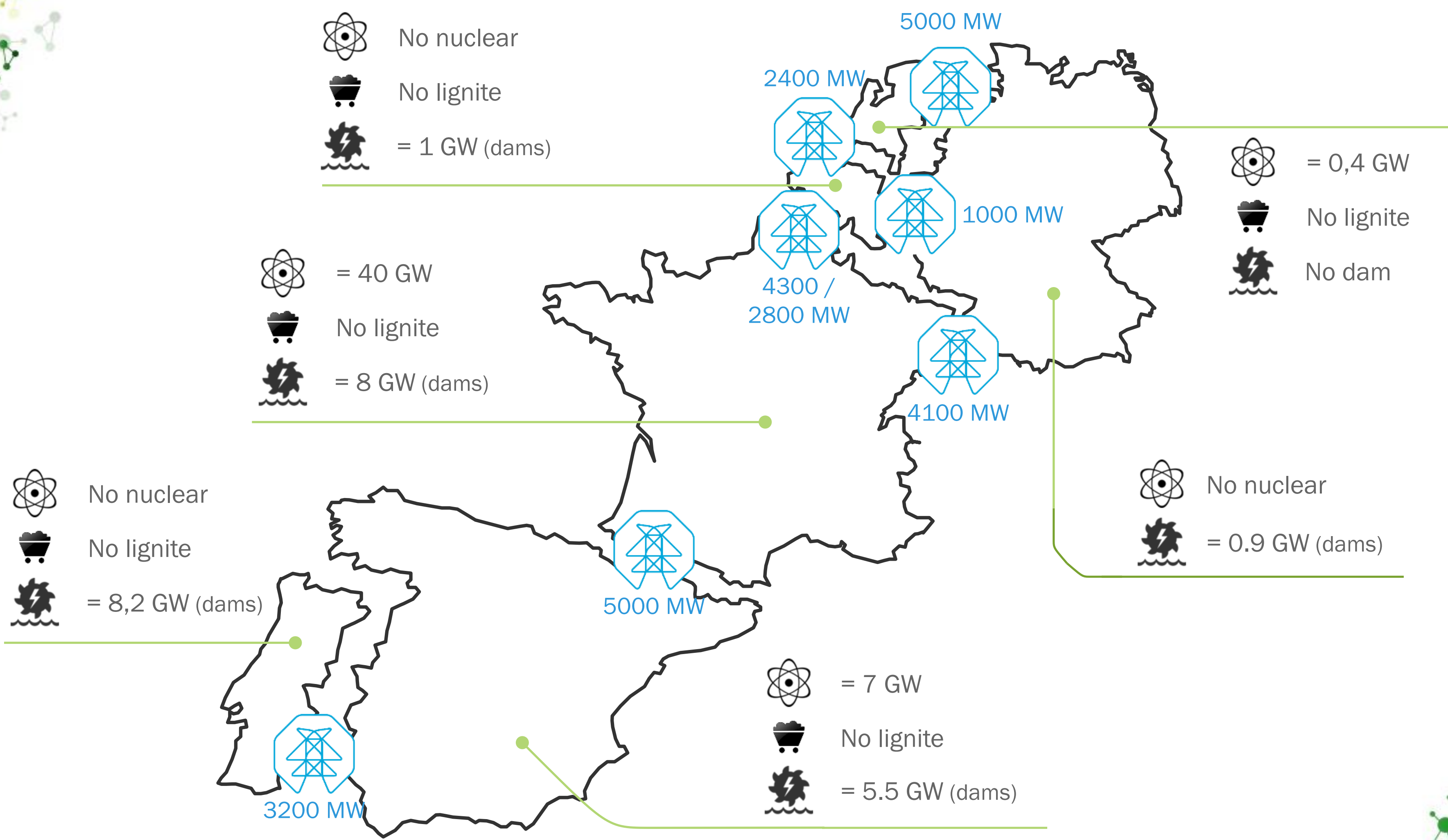
Contact: Market4RES@sintef.no

Results, event calendar and all related news can be found on www.market4RES.eu

Co-funded by the Intelligent Energy Europe
Programme of the European Union

Thank you very much for your attention

Modelling assumptions: mix constraints
(complete set of countries)



Lignite Hard coal | CCGT OCGT | RoR Dams

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