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# RISKS AND THE DESIGN OF SUPPORT MECHANISMS

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# OUTLINE

1. SUPPORT MECHANISMS: RISKS AND INCENTIVES
   - Support schemes assessment criteria
   - Arbitrage between risks and incentives
   - Lessons from simulations of the future French “floating FIP”

2. MODELLING INVESTMENT IN POWER GENERATION
   - Integrated long term modelling of power systems
   - Taking risk into account in investment models
   - Efficiently reducing the optimization problem’s size

3. OPTIONS FOR POWER DECARBONISATION
   - RES support v. cap on $CO_2$ emissions
   - RES support with a price floor on $CO_2$ emissions
   - Conclusions and perspectives

# 1

# SUPPORT MECHANISMS: RISKS V. INCENTIVES

# SUPPORT SCHEMES: HOW DO THEY HELP?

**Revenues**
**Costs**

**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

**Revenues**
**Costs**

**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.

# DESIGNING EFFICIENT SUPPORT MECHANISMS: ASSESSMENT CRITERIA

## 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)

E.g. direct marketing + floating FIP ranks relatively well along all criteria

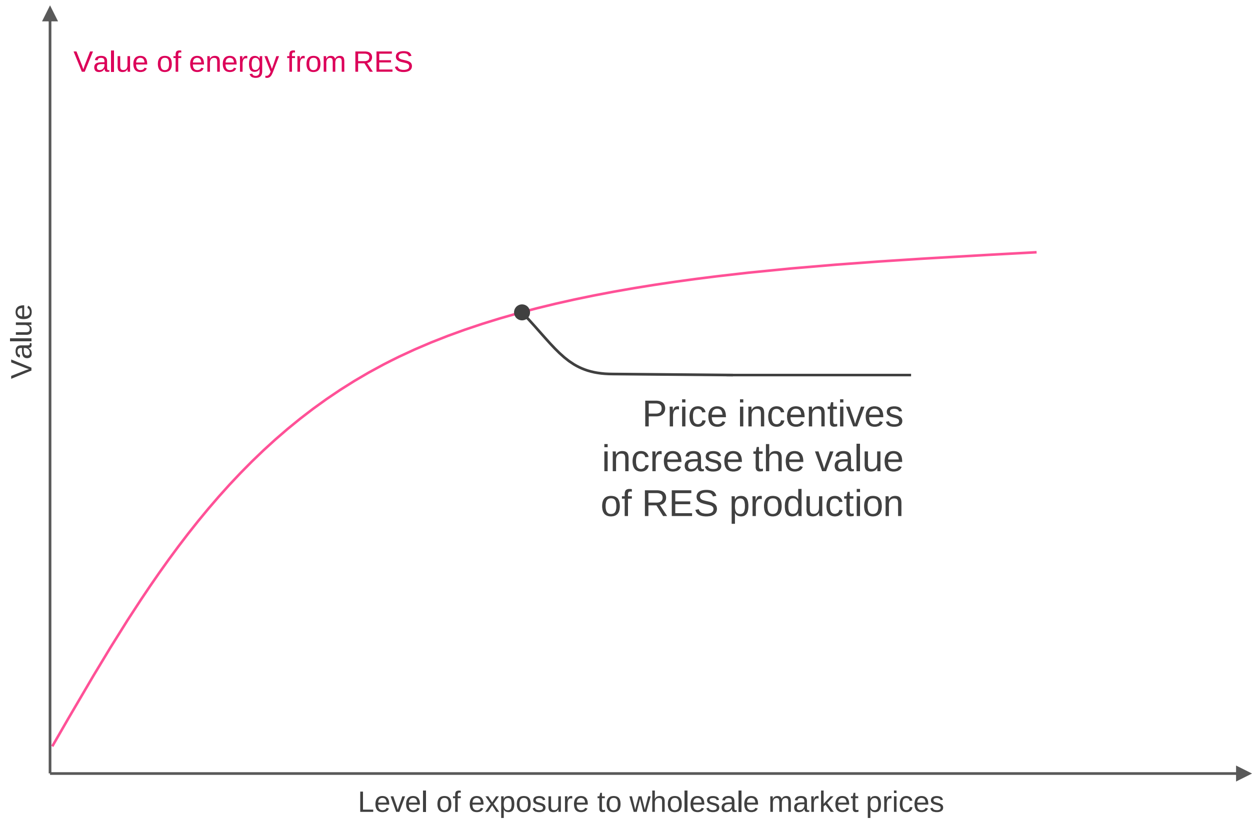
“Aid to electricity from renewable energy sources should in principle contribute to integrating renewable electricity in the market.”

EU Commission’s *Guidelines on State aid for environmental protection and energy 2014-2020*

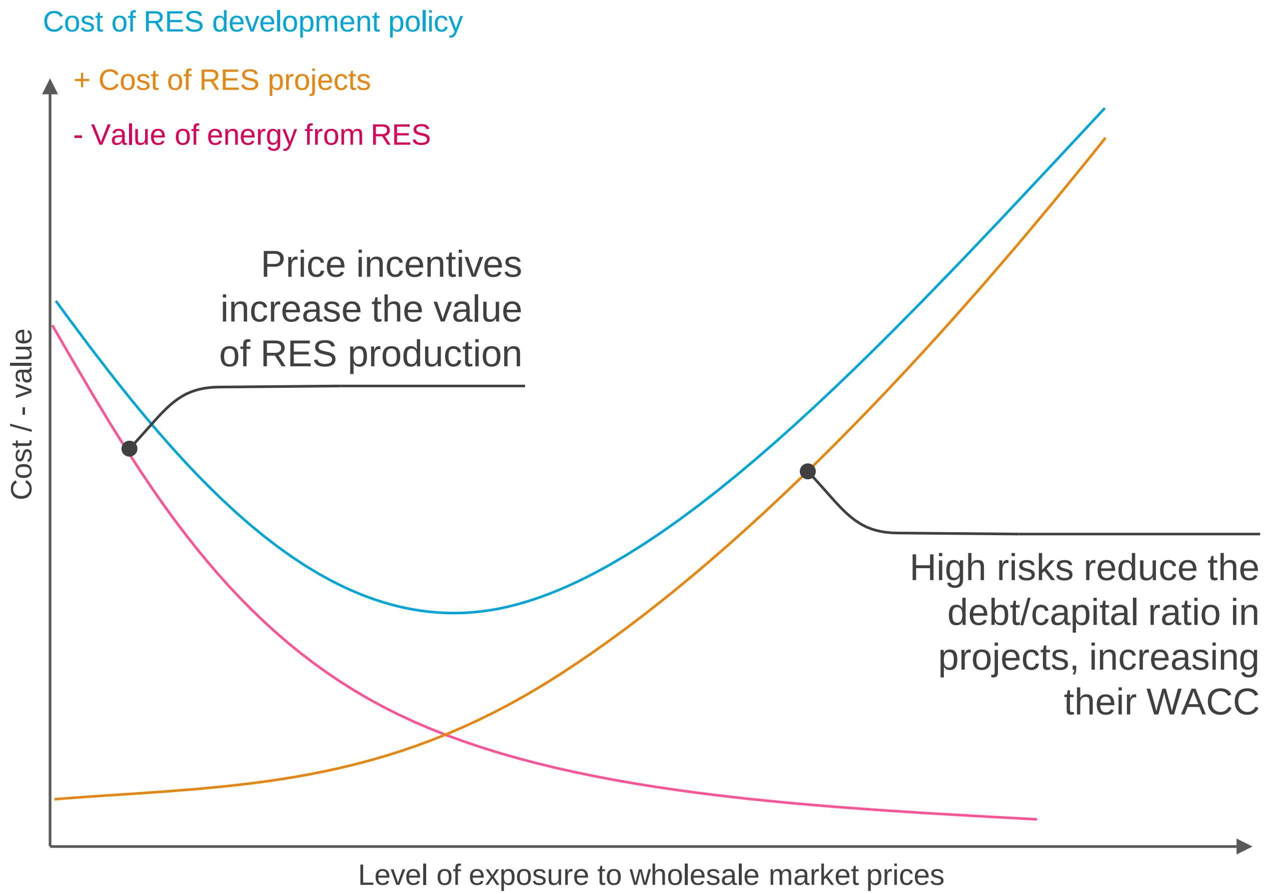
“Which obstacles, if any, would you see for the dispatching of energy from all generation sources including renewables on the basis of merit order principles?”

EU Commission’s consultation: *Preparation of a new renewable energy directive for the period after 2020*

# ARBITRAGE BETWEEN RISK AND INCENTIVES

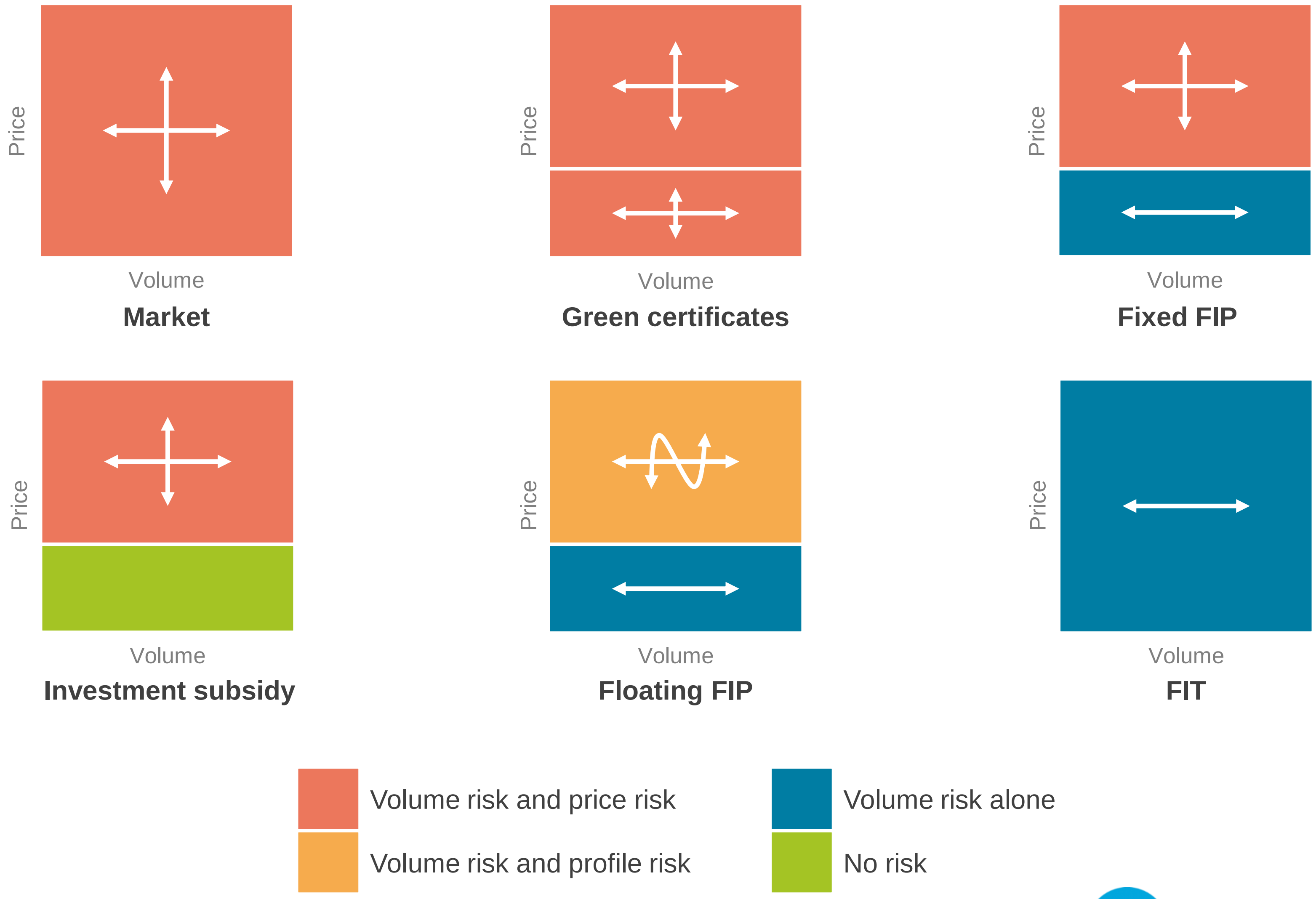


# ARBITRAGE BETWEEN RISK AND INCENTIVES

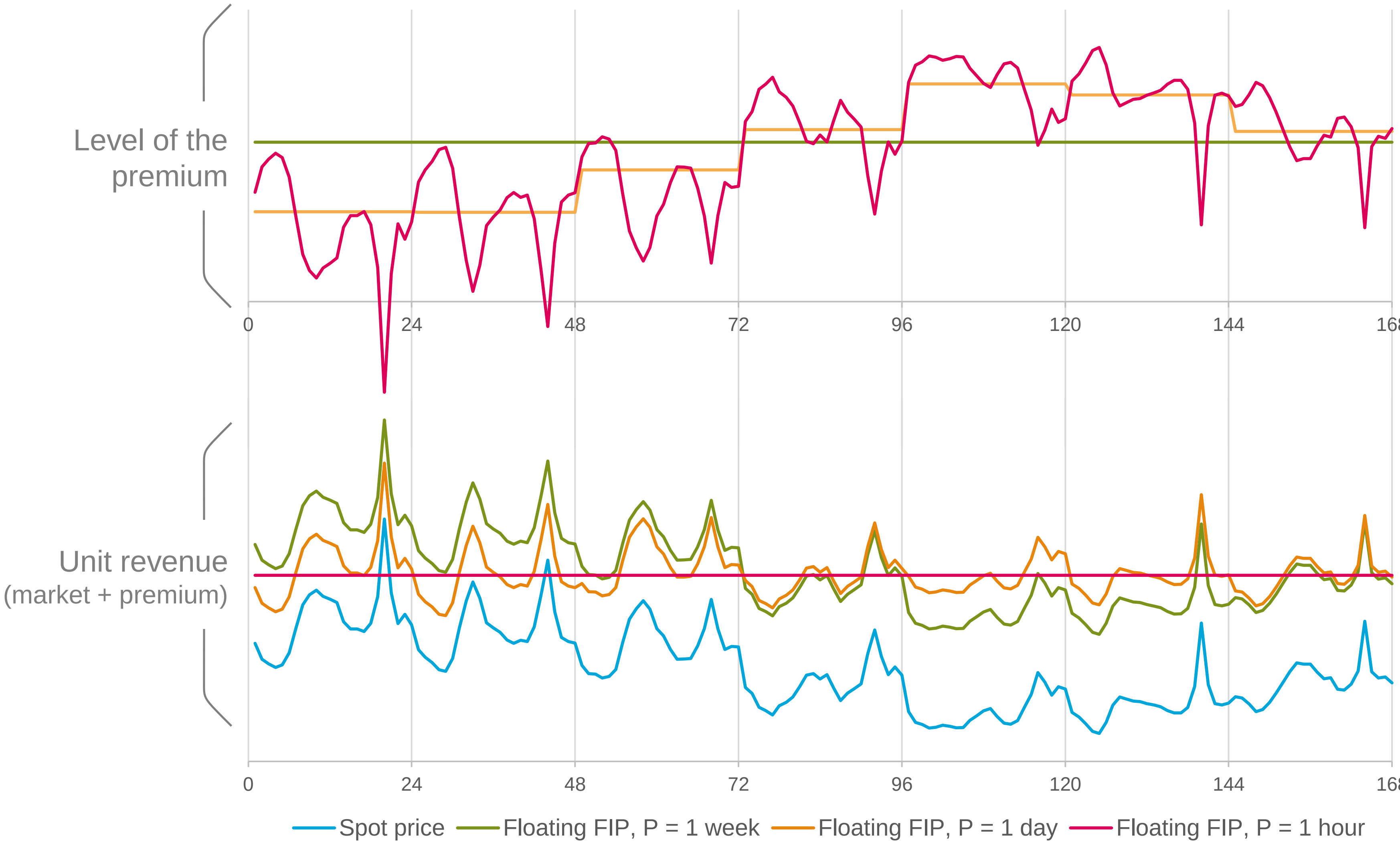



Here we focus on the **risk** part: the value of incentives is not explored

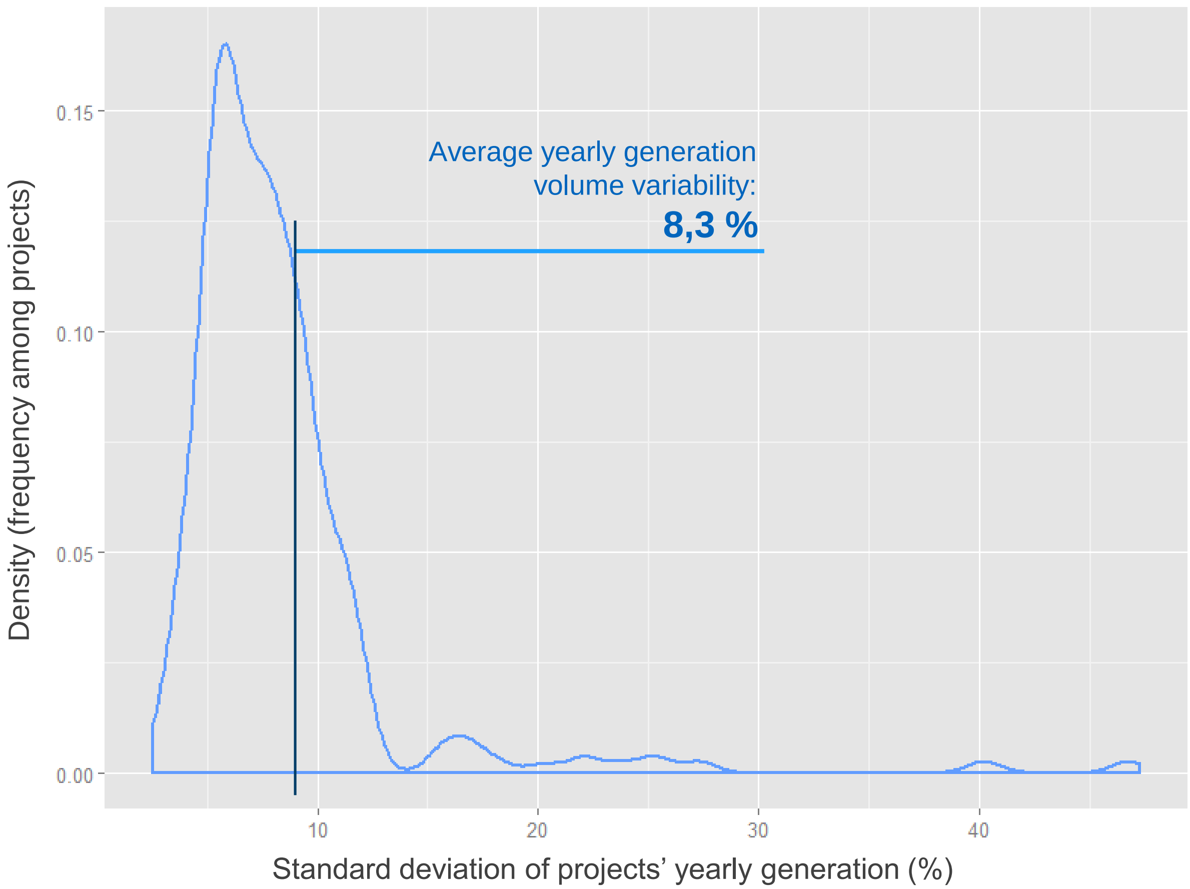
# MARKET RISKS IN RES PROJECTS, ACCORDING TO THE NATURE OF THE SUPPORT SCHEME



# FLOATING FEED-IN PREMIUM



# EXAMPLE OF THE FRENCH F.I.P
# *« COMPLÉMENT DE RÉMUNÉRATION »*




Producers already face a relatively large risk on the volume they generate

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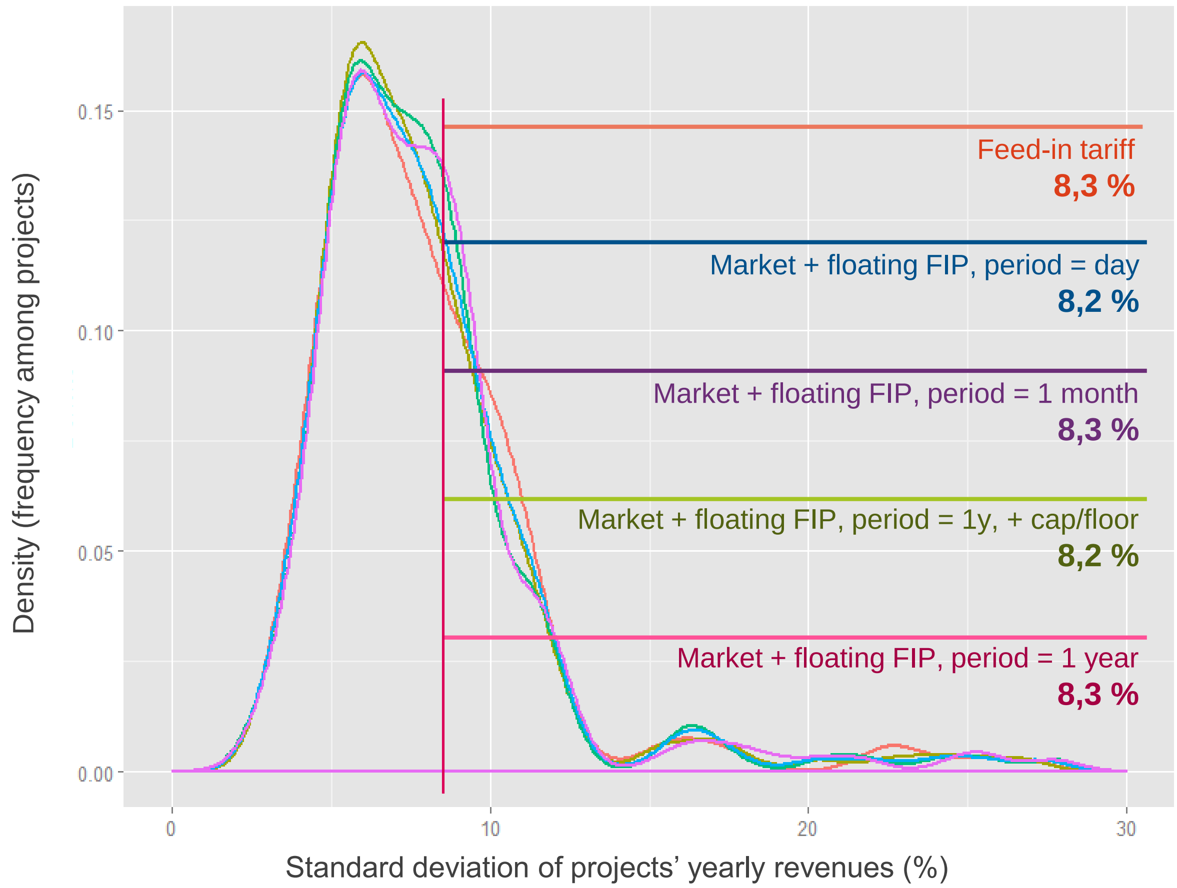



Floating FIP with a period ≤ 1 year → **no increase in risk** in comparison w/ FIT

# 2

# MODELLING INVESTMENT IN POWER GENERATION

Market4RES

Post-2020 framework for a liberalized electricity market
with a large share of renewable energy sources

http://market4res.eu/

- WP2 : Challenges for RES-E deployment in a market driven by the Target Models
- WP3 : Novel market designs & KPIs
- WP4 : Appropriate new market instruments for RES-E to meet the 20/20/20 targets
- **WP5 : Modelling of electricity market design & quantitative evaluation of policies for post-2020 RES-E targets**
- WP6 : Conclusions, recommendations, procedure Guidelines

## 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

# SHORT-TERM MODELLING OF POWER SYSTEMS

## 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*

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

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

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

## 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 in the short and long terms

*Variable* *Parameter*

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

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

**Additional mix constraints, e.g.:**

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

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

$$\sum_{p \in Plants,t} EF_p . Gen_{p,t} \leq Z\ MtCO_2$$ 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

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

$$Annual\ capital\ cost = \frac{\tau * I}{1-(1+\tau)^{-lifetime}} \qquad WACC:\ \tau = \tau_f + \beta\phi$$

Hypotheses for the discount rate including risk

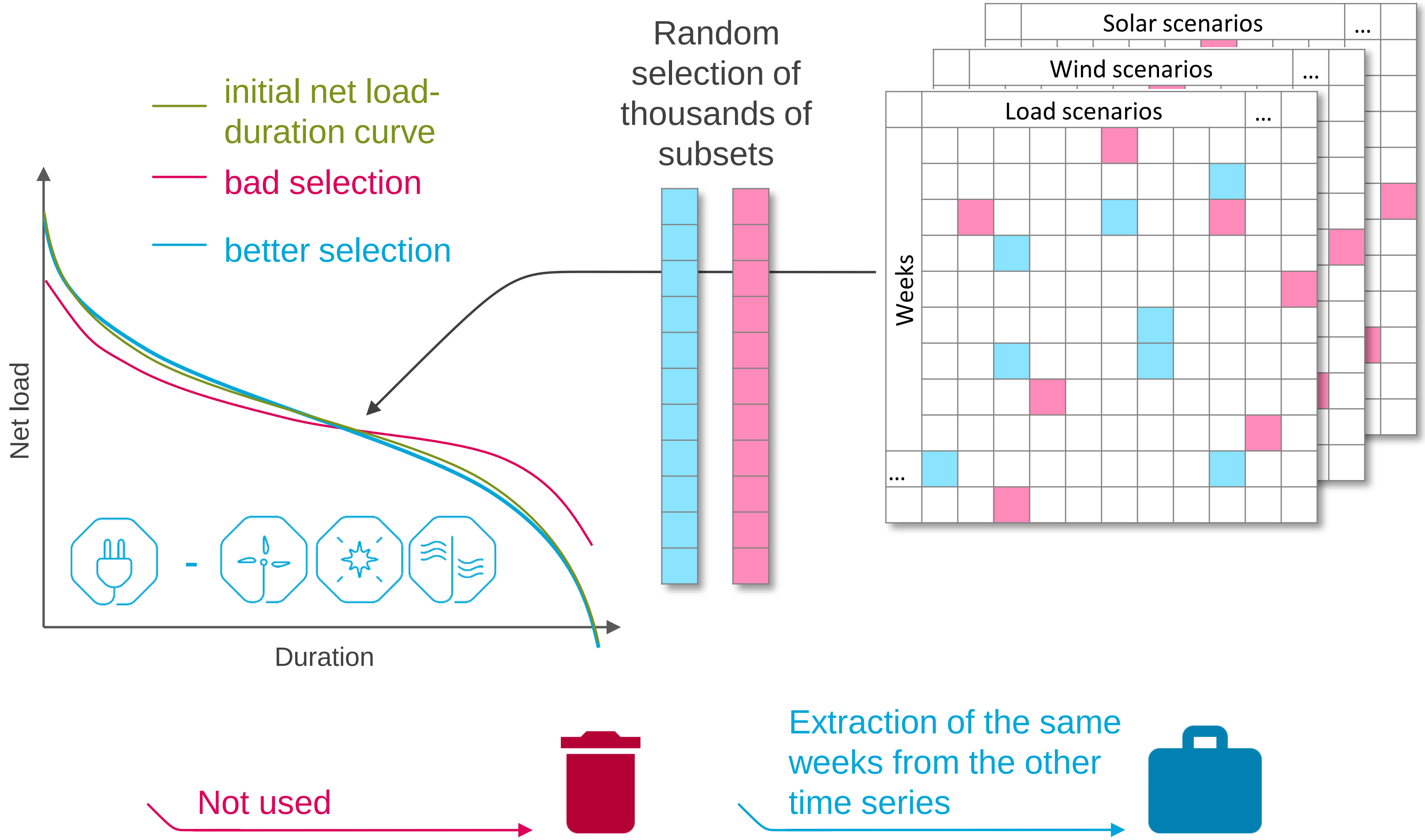
Conventional technologies: **8 %**

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 %** | FIP: 7,1 %

# OPTIMISATION PROBLEM SIZE REDUCTION

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



# 3 OPTIONS FOR POWER DECARBONISATION

# 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

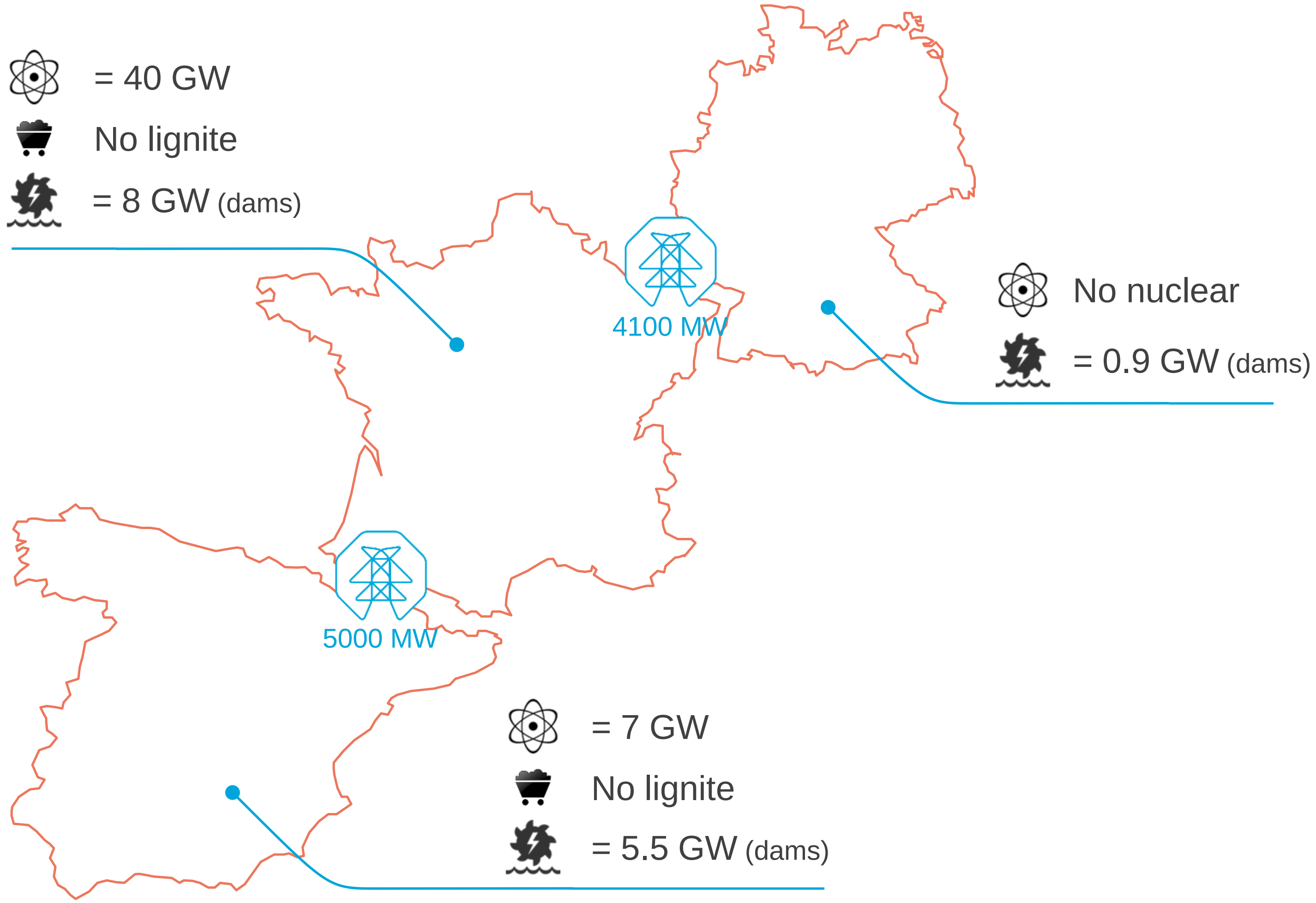
**ADEME, RTE ECO2Mix** $CO_2$ emissions from primary energies

## Fixed costs (excluding discount rates)

**IEA** Projected costs of generating electricity

**ADEME** *100 % ENR*, benchmark from many sources

# MODELLING ASSUMPTIONS: MIX CONSTRAINTS

# METHODOLOGY

Cheapest mix to reach
**250 $MtCO_2$** (~160 g/kWh) ?

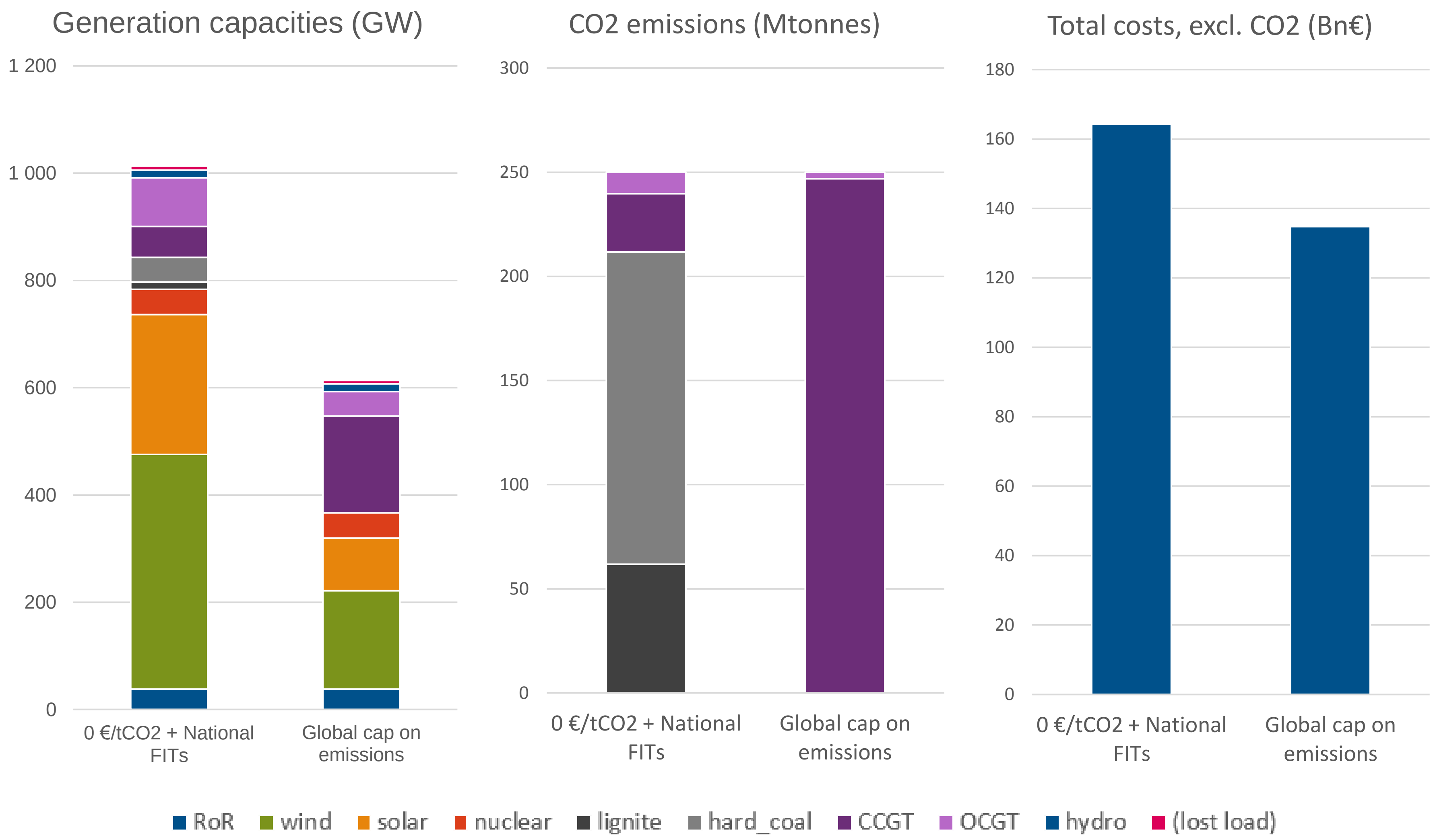
**Market + CO2 price from Cap & Trade**

**Floating FIP or FIT**

## Market design options and 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 or regional targets

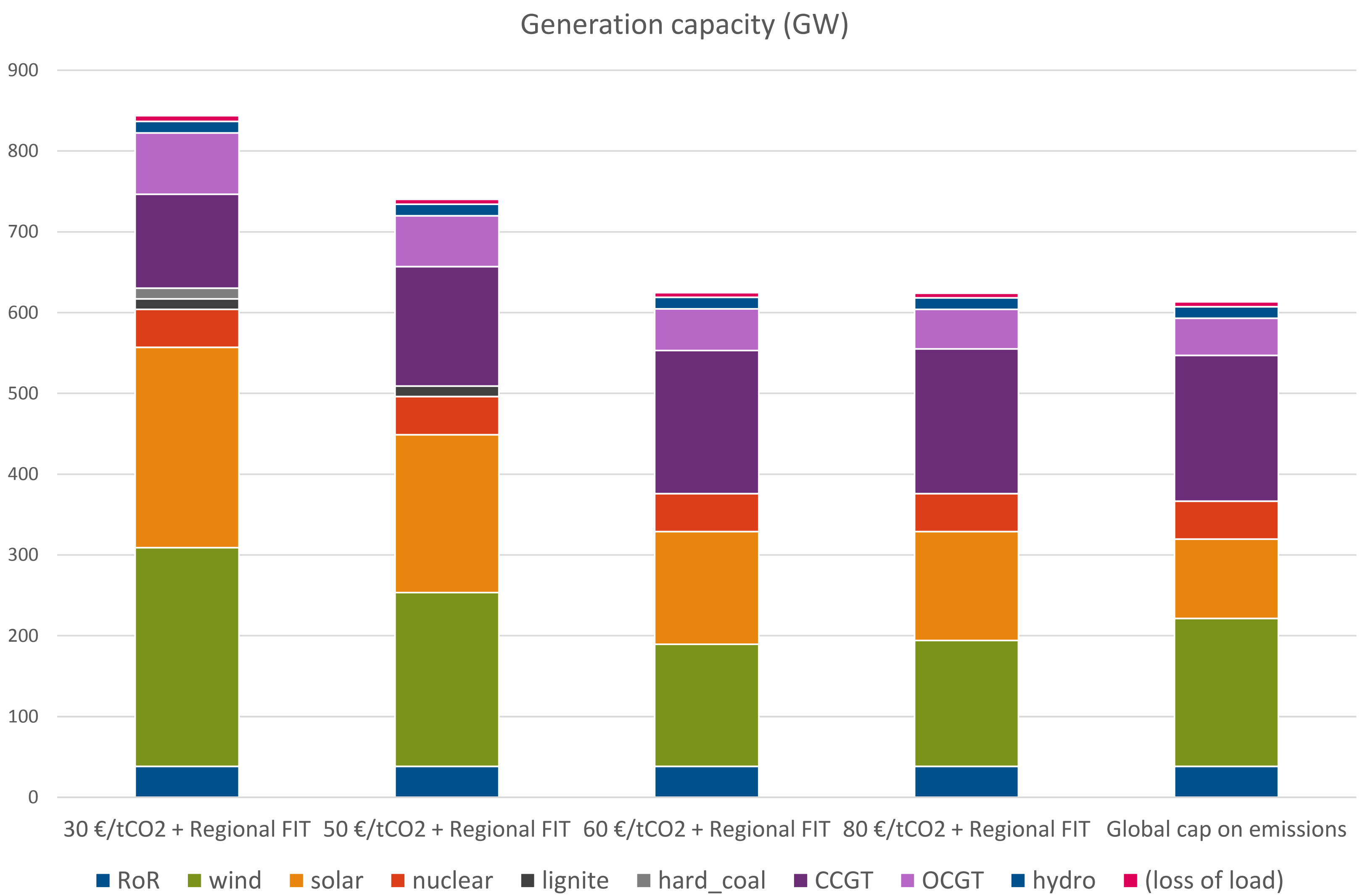
# RESULTS: SUPPORT SCHEME V. EMISSIONS CAP






*Important note: please regard as preliminary results of an ongoing study.*

# RESULTS: CARBON PRICE + **REGIONAL** SUPPORT

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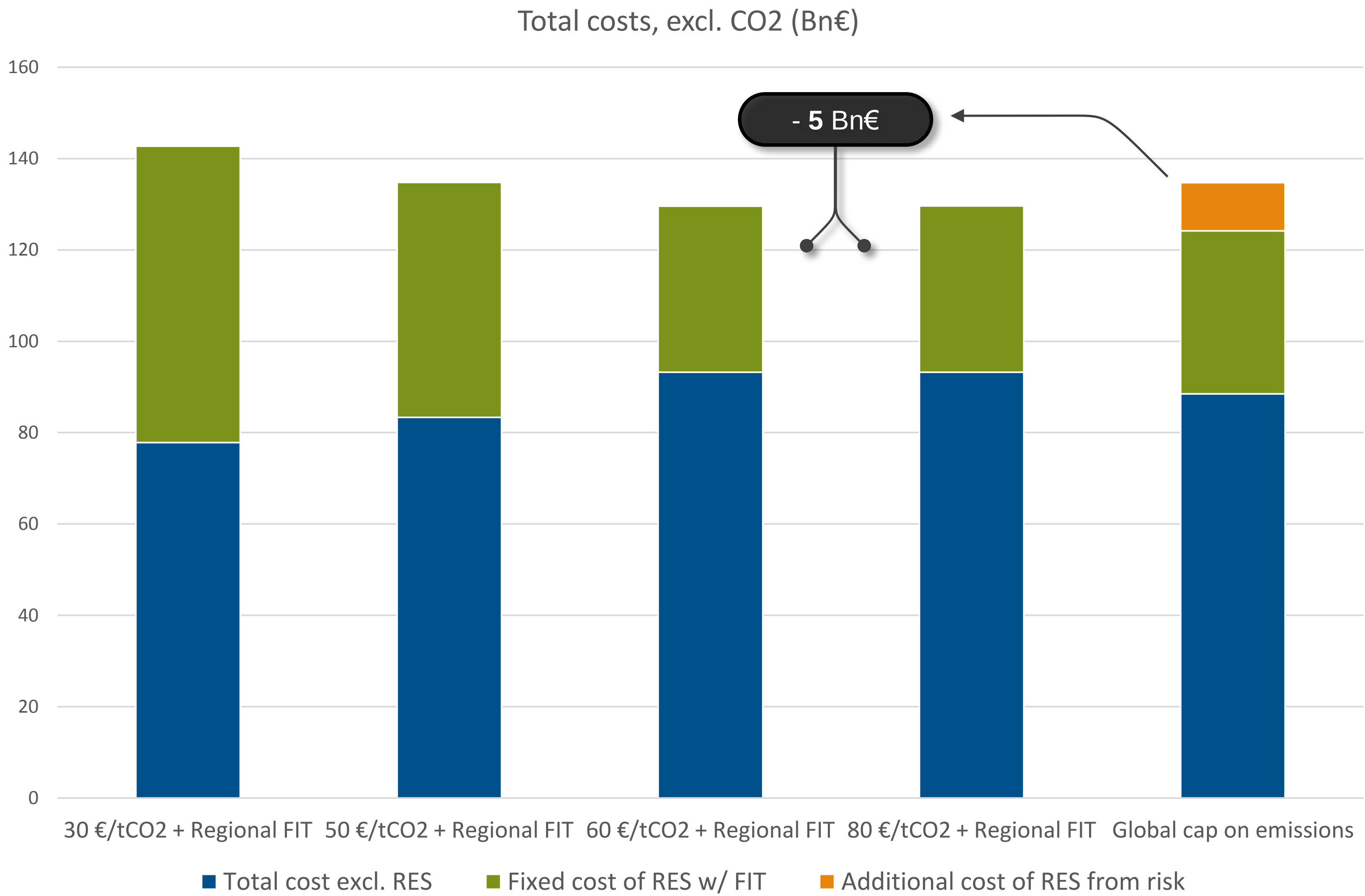




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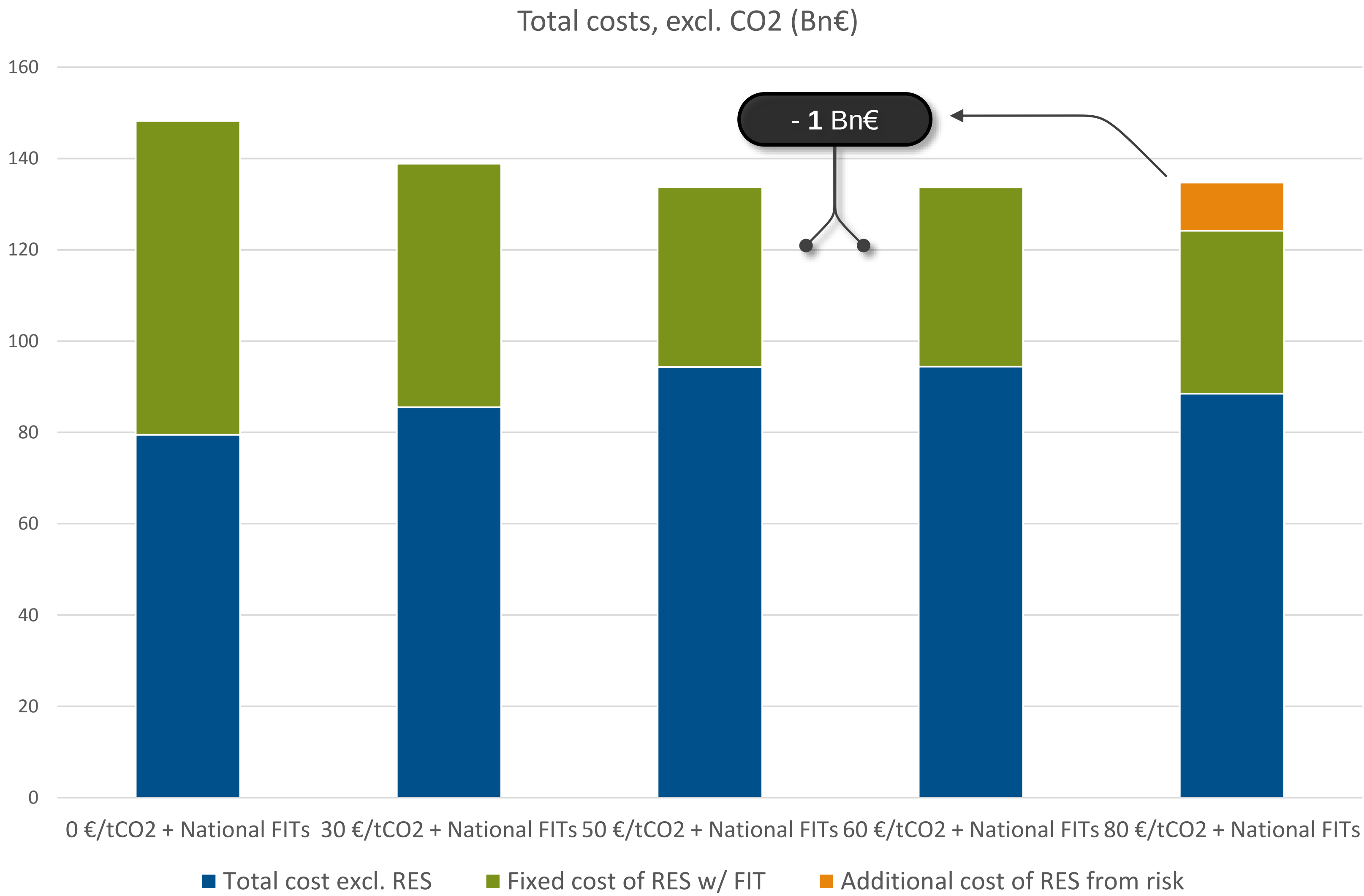
# RESULTS: CARBON PRICE + **NATIONAL** SUPPORT



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# 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

- Improving the **hypotheses on capital cost** as a function of the design of the support mechanism.

- What does it change if we consider the **socio-economic value** How to compute it: socioeconomic beta of low-carbon projects?

- Extend the **geographic perimeter** to explore the relative merits of national and regional RES targets and how they compare with $CO_2$ cap.