



Energy Economics and Policy

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Agenda for today

▪ **Motivation**

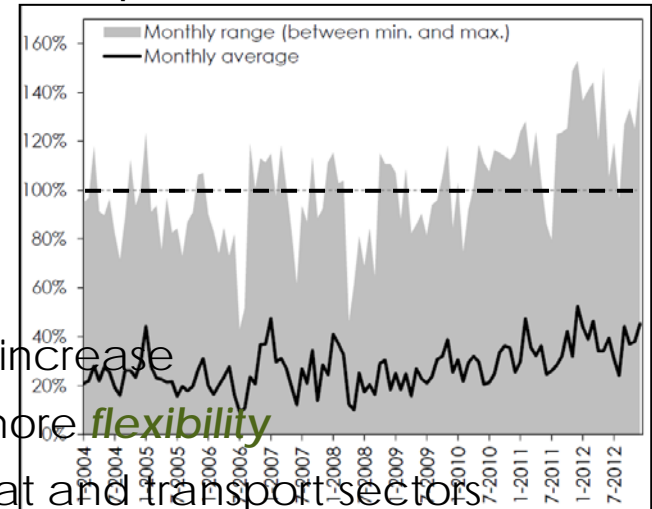
- **Prices at power markets**
- **Challenges in future energy markets**
- **Energy Systems Integration**

- **Introduction to Renewable Energy Support**
 - **Major Types of Support Schemes**

Motivation

- The new electricity systems: From centralised and fossil-intensive systems to sustainable and integrated
 - Increasing shares of variable renewable energies (VRE)
 - Total support and integration costs expected to increase
 - Trend to more **market integration** and need of more **flexibility**
 - Market integration with electrification of gas, heat and transport sectors
 - Technological solutions exist. Need for **REthinking the framework conditions** to support these + **business cases**
- ⇒ Research is needed for analysing the effects of different policy and regulatory framework conditions, both qualitatively and quantitatively
- Wind power provided a world record
42% of Danish electricity consumption in 2015

Wind production share in DK-West



The night of Friday, July 10 2015 wind produced 140 per cent of Denmark's electricity consumption

Rationale for EU energy policy

- Reduction of market power
- Diversity in production



**ENERGY
Policy
of the EU**

- 600,000 MW new capacity
- Import dependency of 2/3



- 20% Renewables
- 20% Greenhouse gas reductions

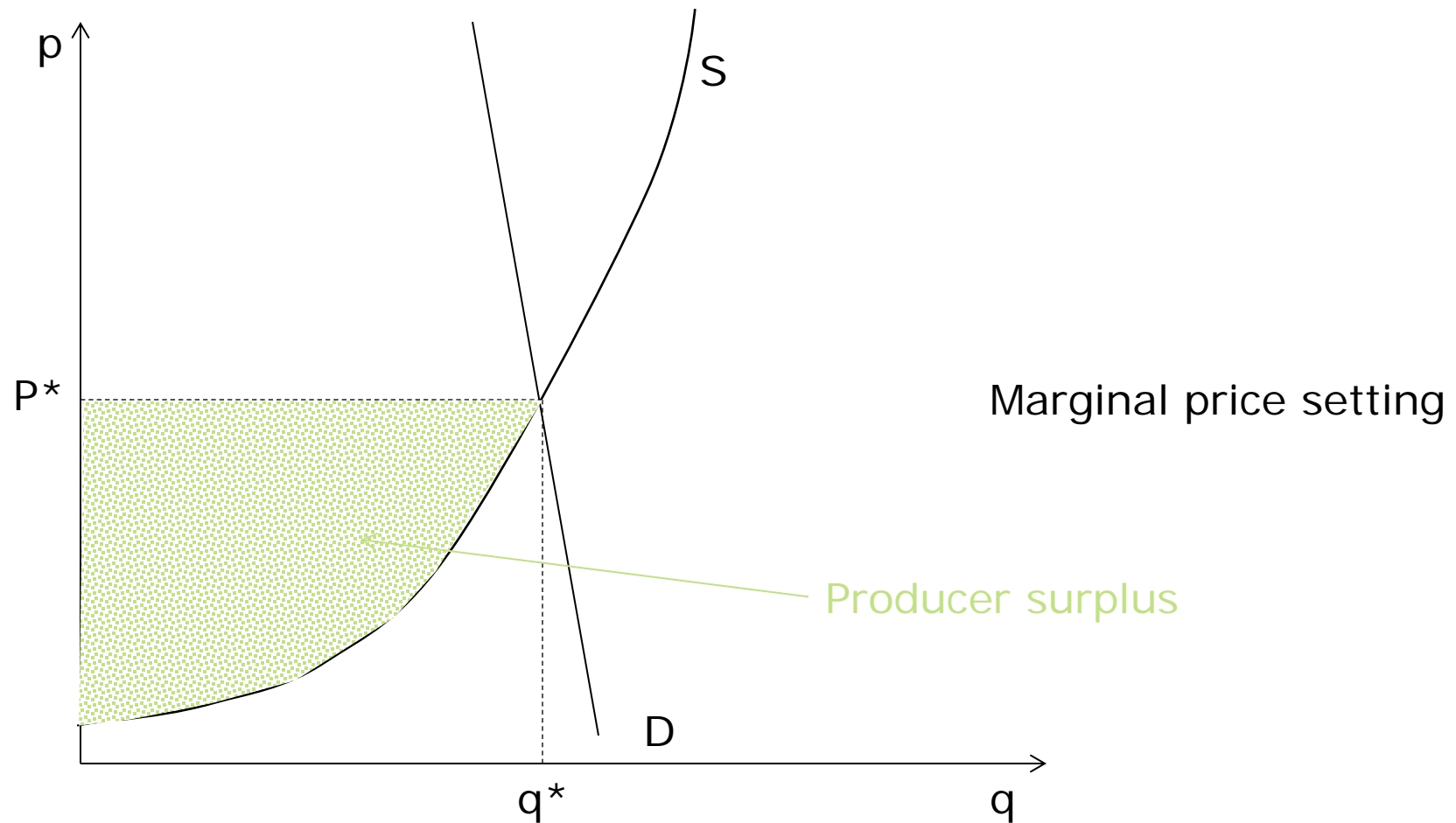
2030 targets!

- 27% Renewables

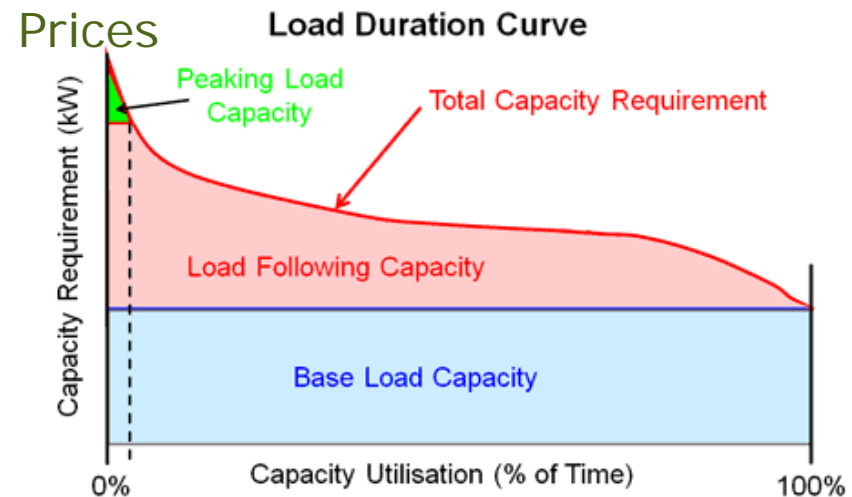
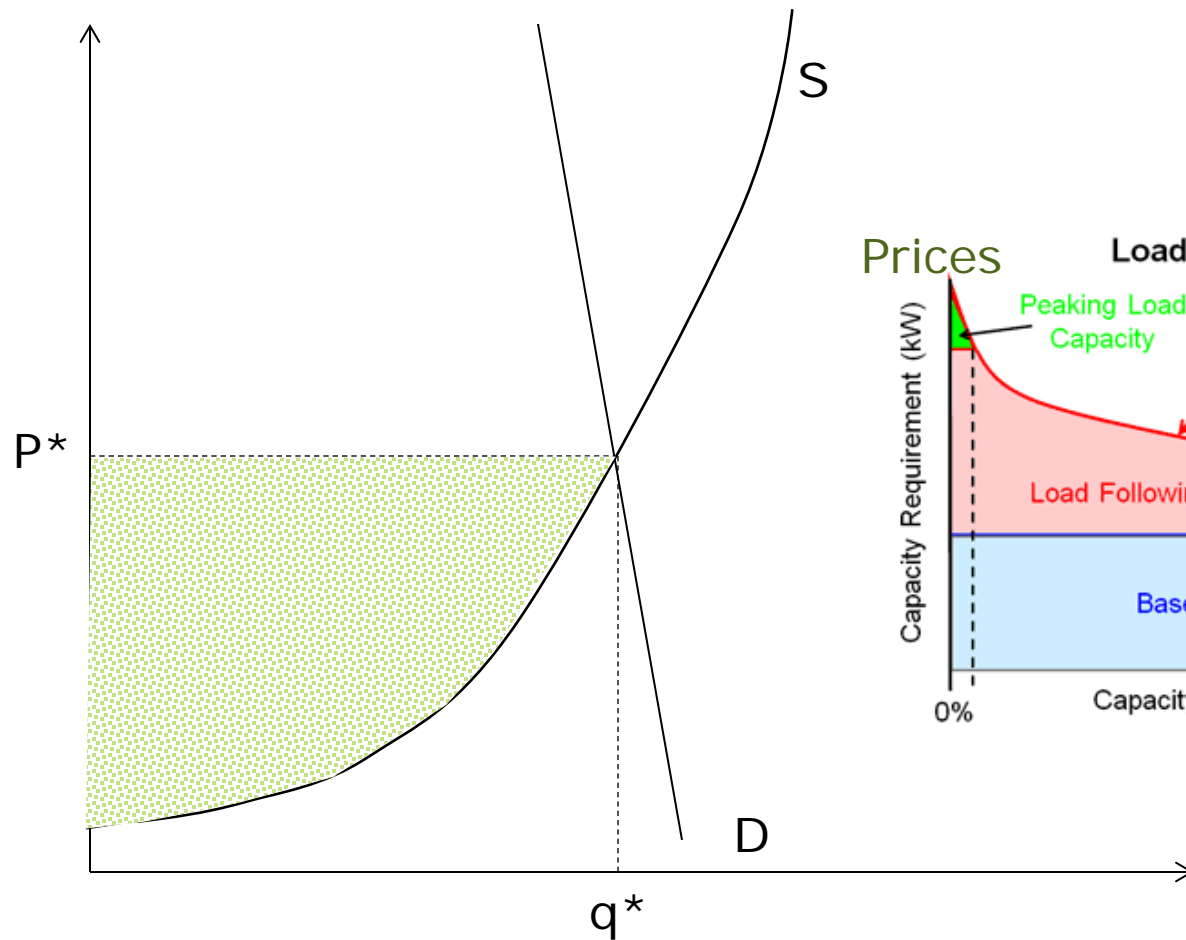
European Policy on Renewables

- **Renewables Directive 2009/28/EC**
 - ***Mandatory target*** of a 20% renewable share in overall Community energy consumption (2020)
 - Support schemes (national) and ***priority access & priority dispatch***
 - Measures of cooperation among Member States: statistical transfers, joint projects & joint support schemes

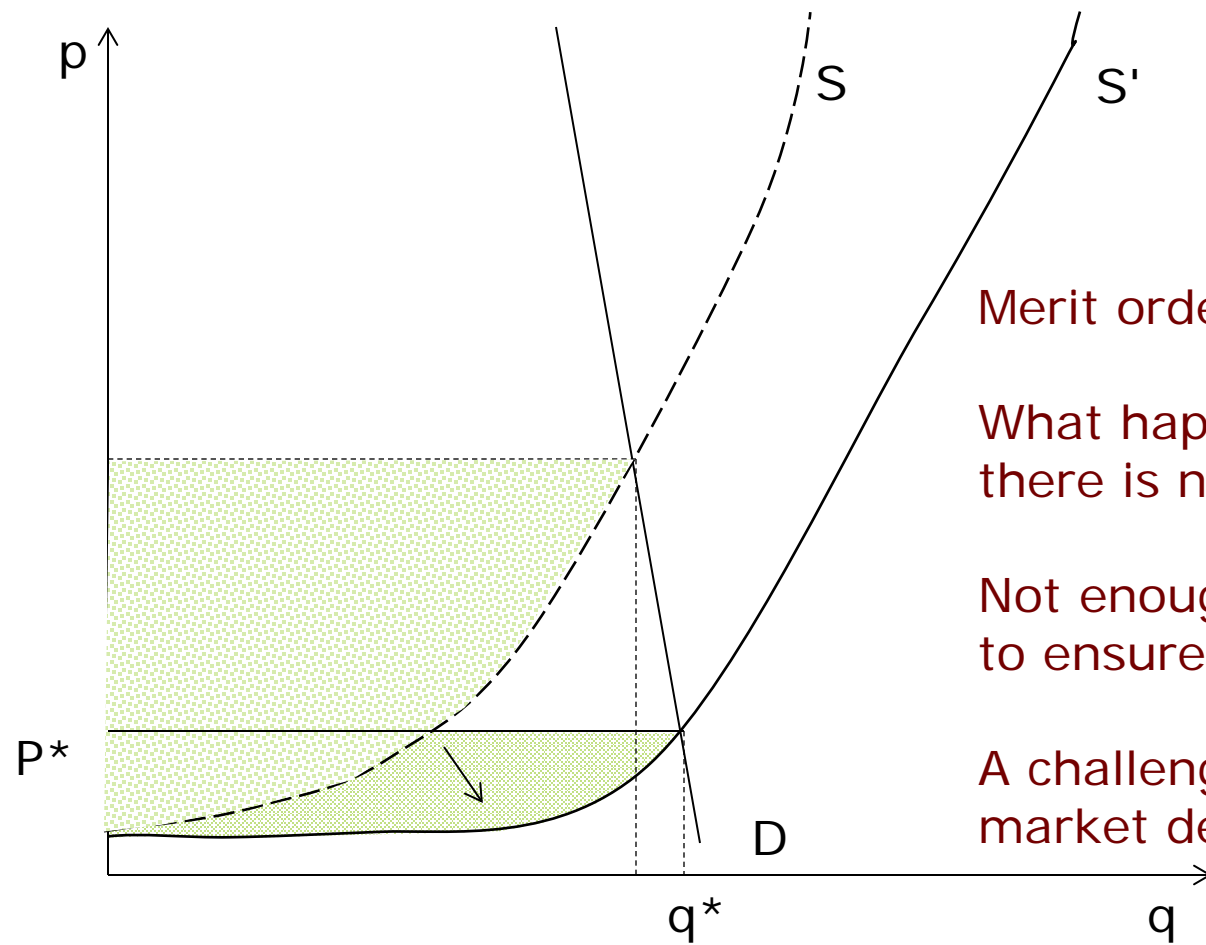
Market price at the power market



Market price at the power market



Market price with high share of RES



Merit order effect

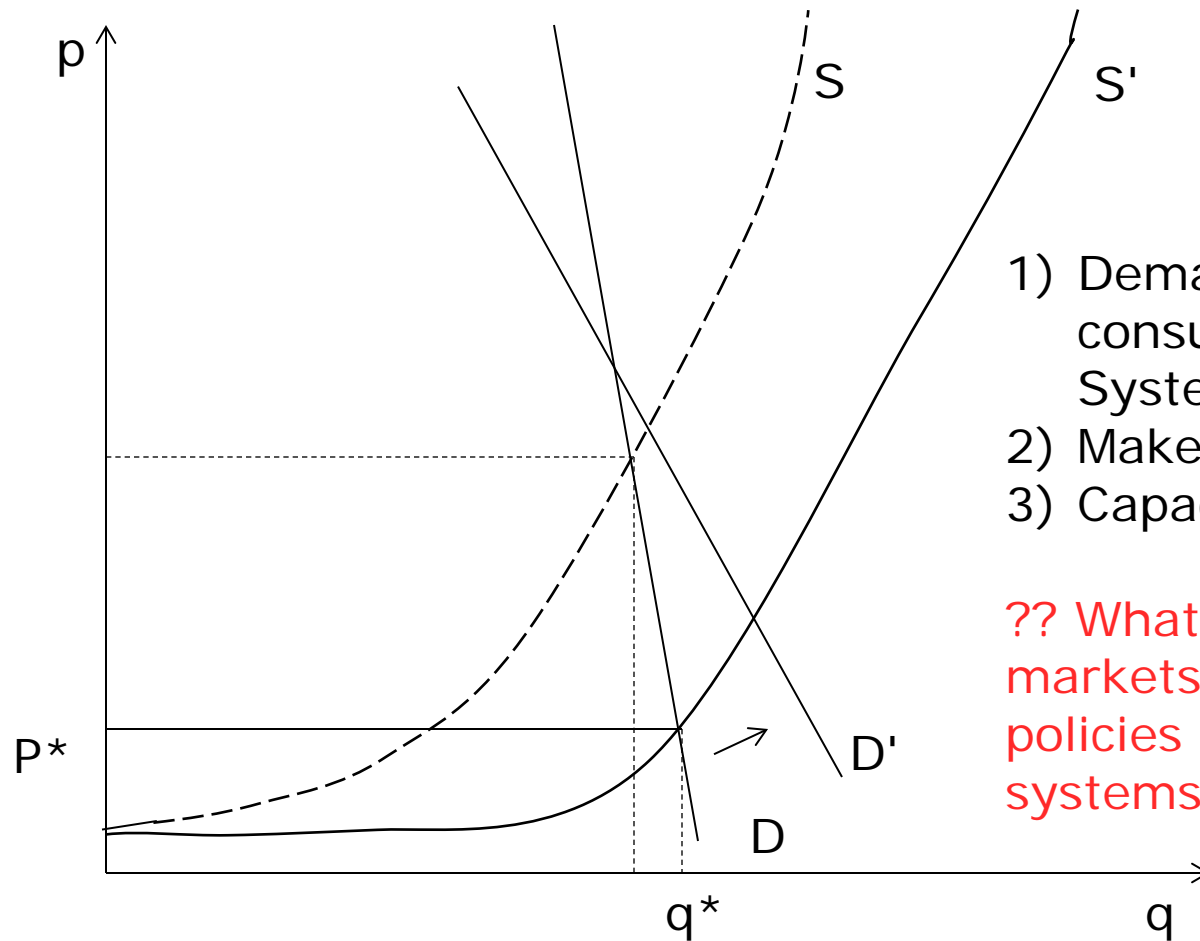
What happens when there is no wind?

Not enough producer surplus to ensure new investments

A challenge for the future market designs

What to do?

What to do?

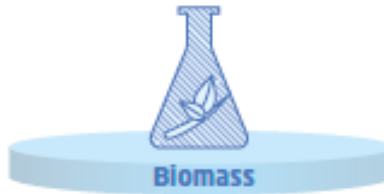


- 1) Demand responds/
consumer behaviour/
Systems integration
- 2) Make RE active actors
- 3) Capacity markets

?? What is the role of
markets/consumers/finance/
policies in integrated energy
systems of the future?

Energy Systems Integration

Ressource

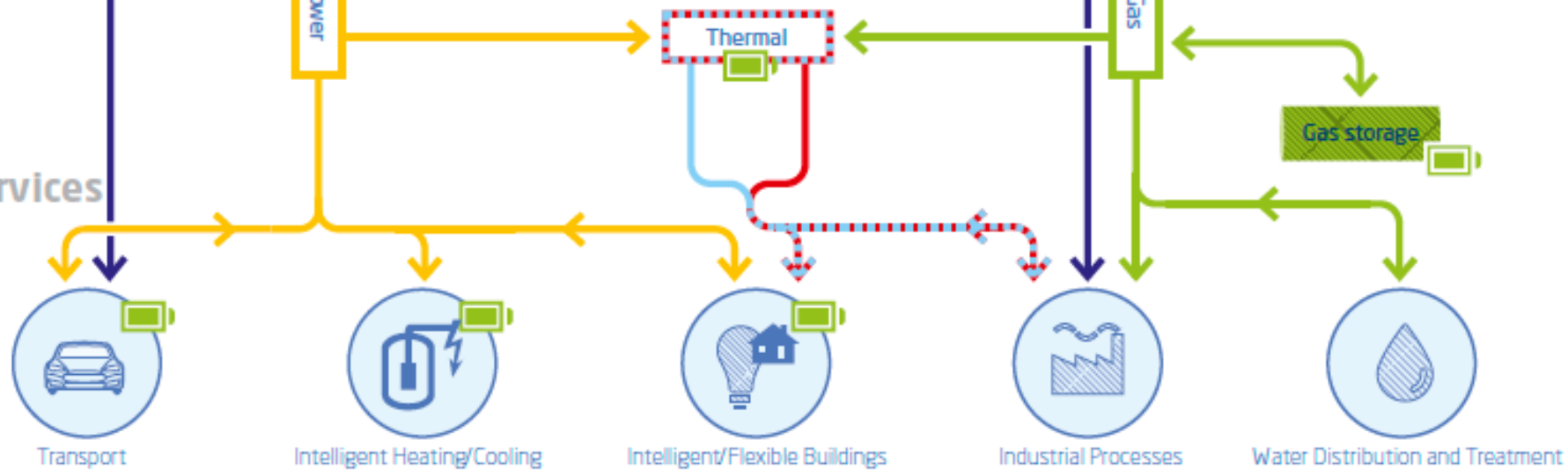


The green battery icons  indicate storage capabilities.

System

International Denmark

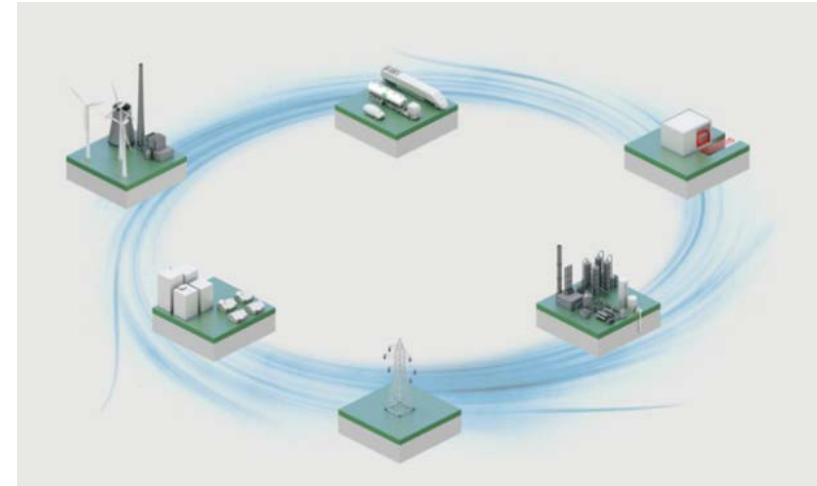
Services



Hypotheses - Systems integration

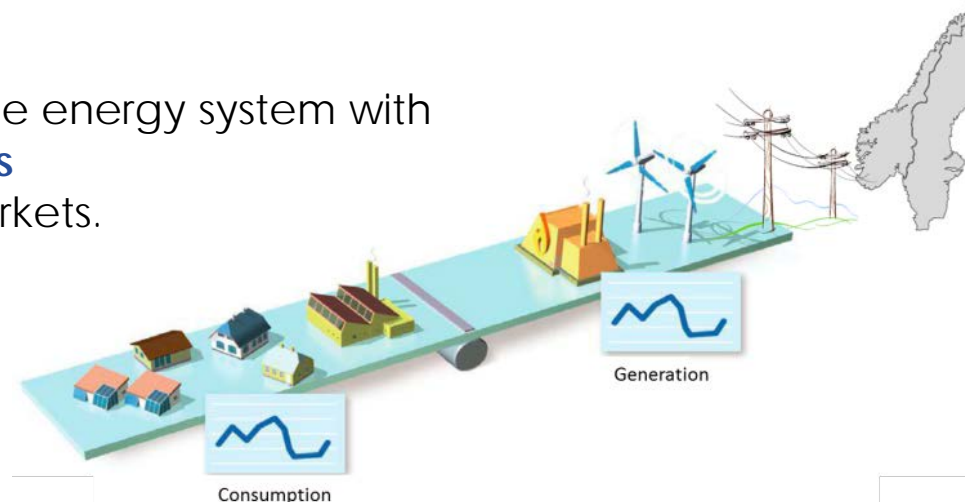
There is a **comparative advantage of combining different energy markets**, both with respect to flexibility, but also with respect to synergy and economics.

The power market is well functioning despite a few technical challenges.

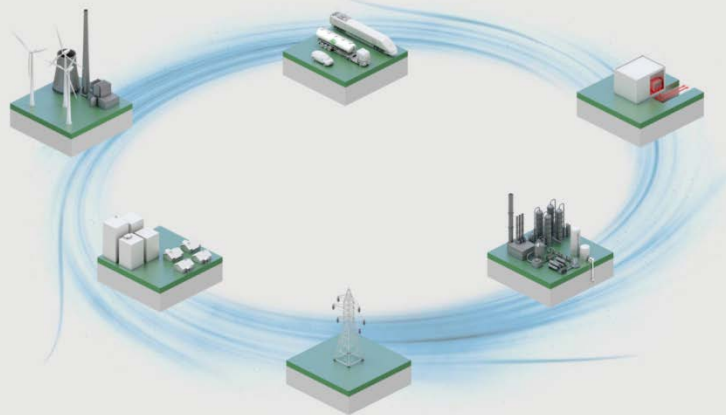


With the right coupling to the underlying national and local energy markets for heat, gas, and transport fuels, enough flexibility can be generated in a cost efficient way and so embrace a larger amount of VRE.

Need for a holistic system approach to the energy system with **flexibility obtained across energy markets** with respect to flexibility at the power markets.



Key Challenges



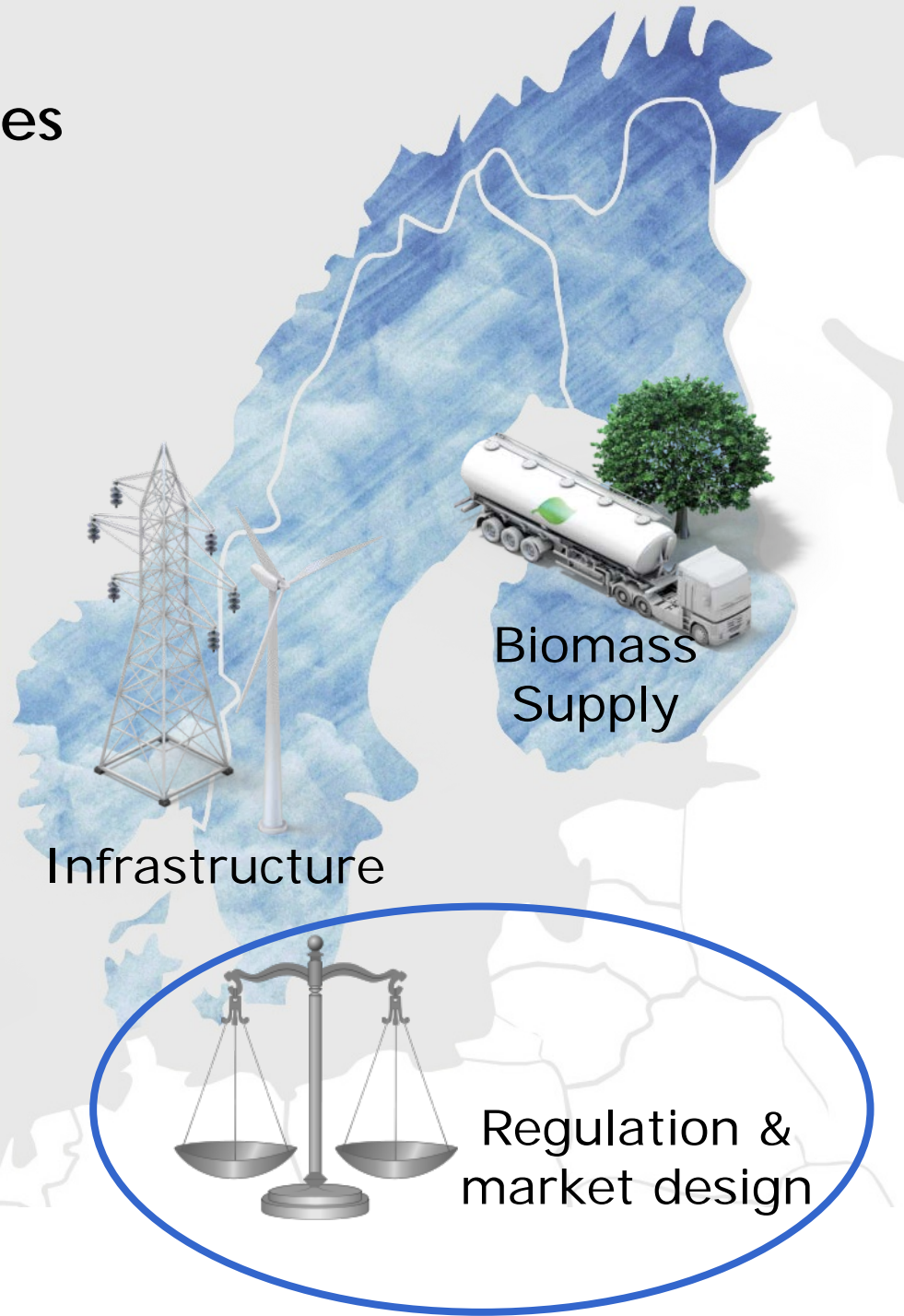
Energy system integration



Energy Efficiency



CCS



Biomass Supply

Infrastructure



Regulation & market design

Regulatory Frameworks

- Flexible technologies and large potentials for systems integration exist
- Regulatory barriers may hinder the potential benefits from systems integration and lower the realisable potentials of e.g. flexibility options.

Regulatory RE-thinking:
Make RE market ready
VS
Make markets RE ready

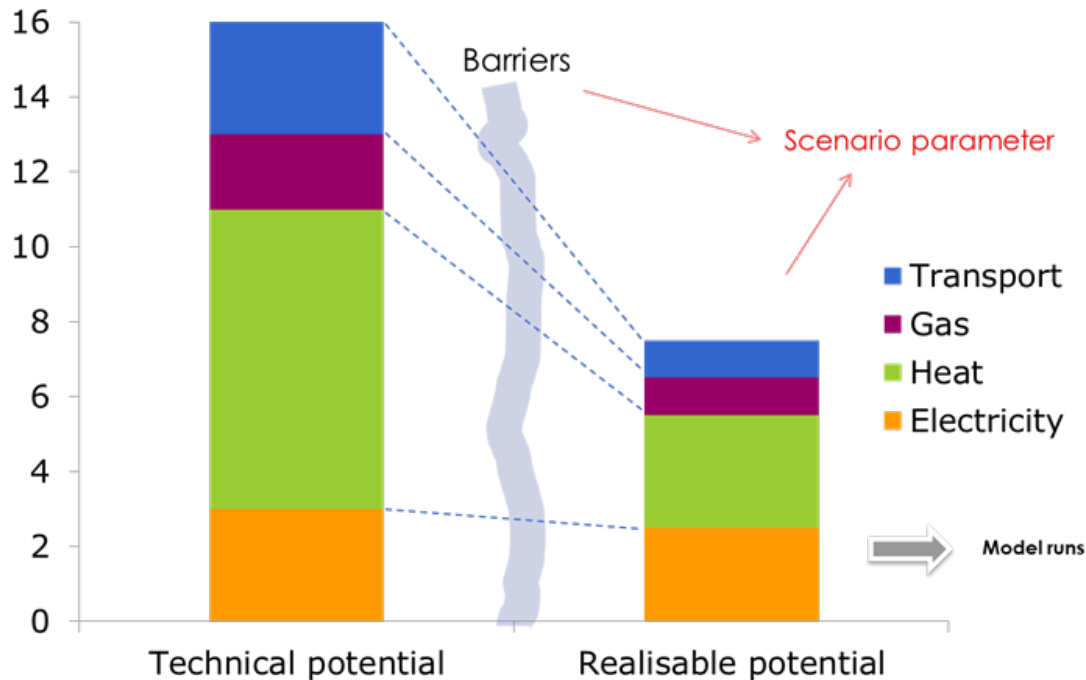
more **market integration** and
need of more **flexibility**

Regulation of the future energy markets must take into account the changes in technology mix, market designs, framework condition, and coupling of markets

Regulatory barriers and drivers

Flexibility options

From technical to realisable potential



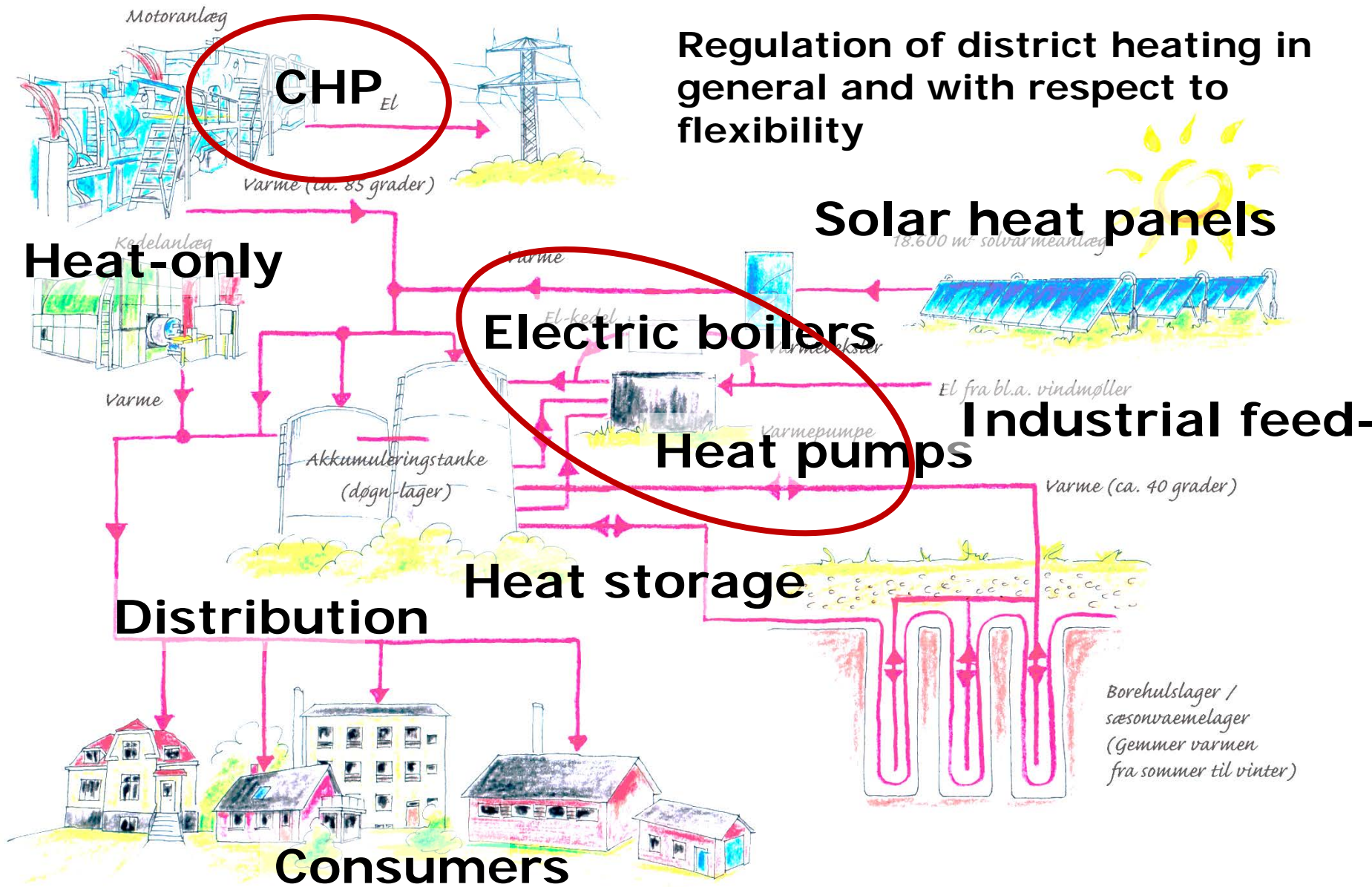
Framework category:
Political/jurisdictional,
financial, market
control,
behavioural/organizational.

Political level: EU,
national, local

Effect on flexibility:
Driver or barrier for
investment and
operation.

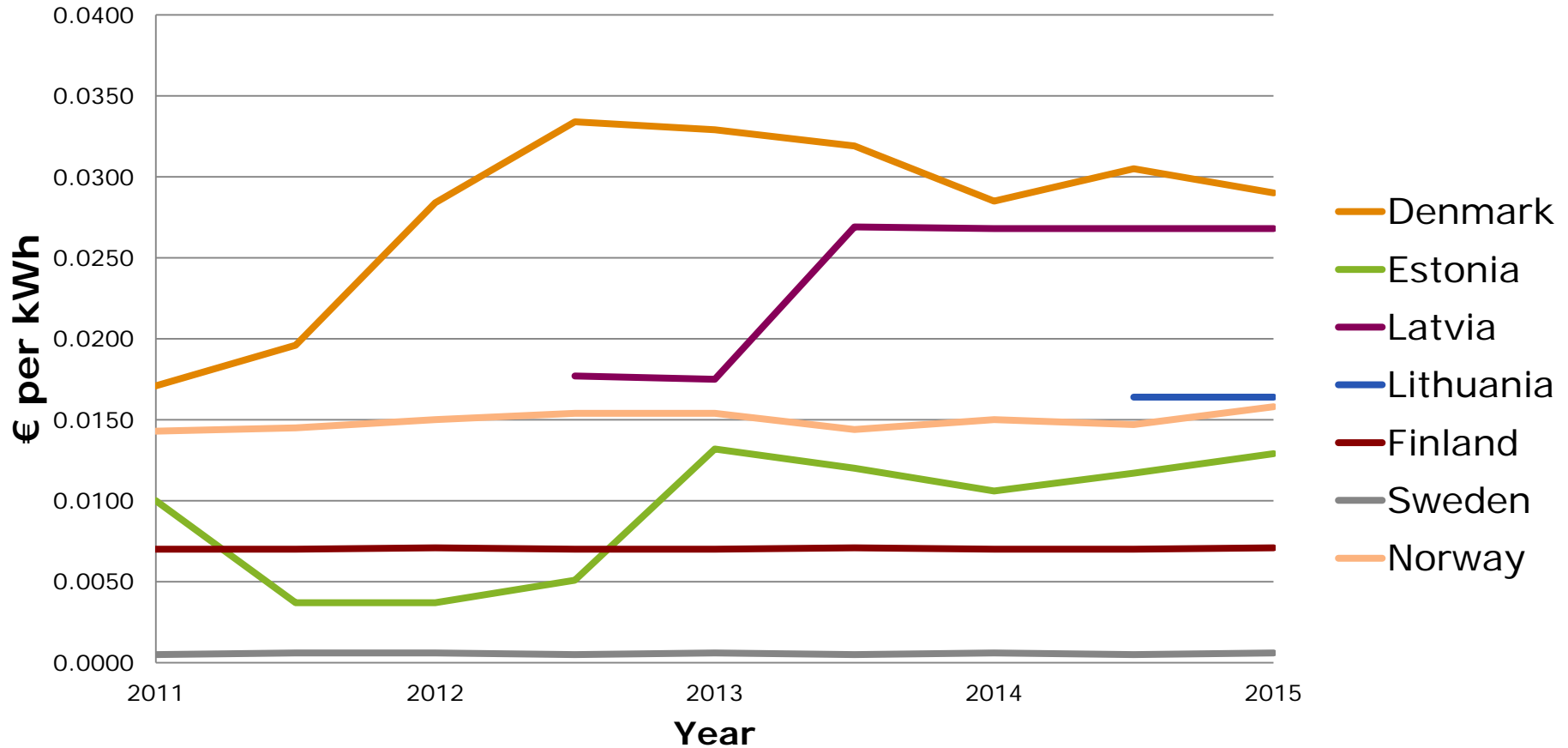
Incentive: Direct or
indirect, strong or
weak
incentives

Systems integration



Consumer incentives

Non-recoverable electricity taxes and levies (large industries)

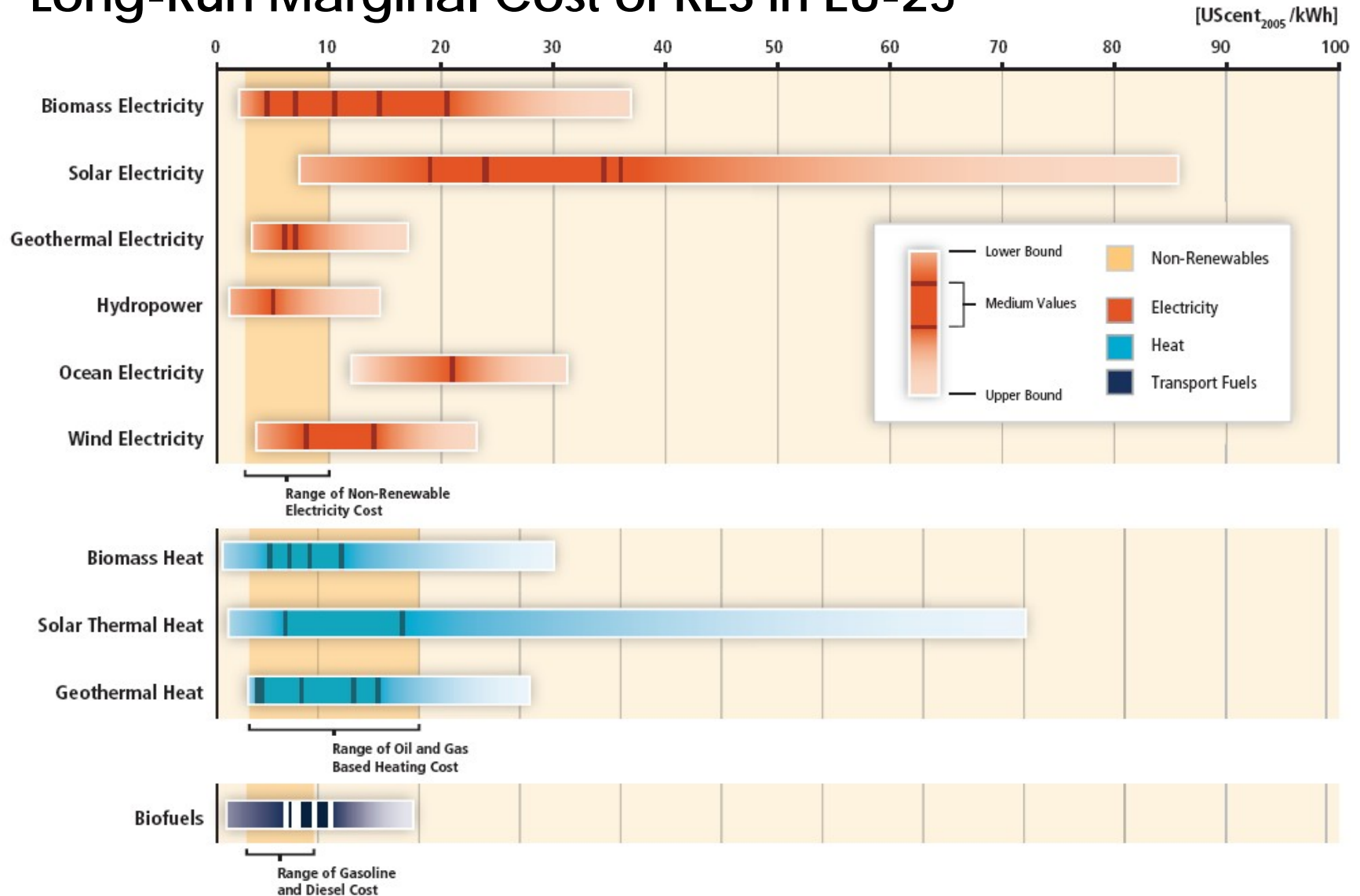


Source: Eurostat

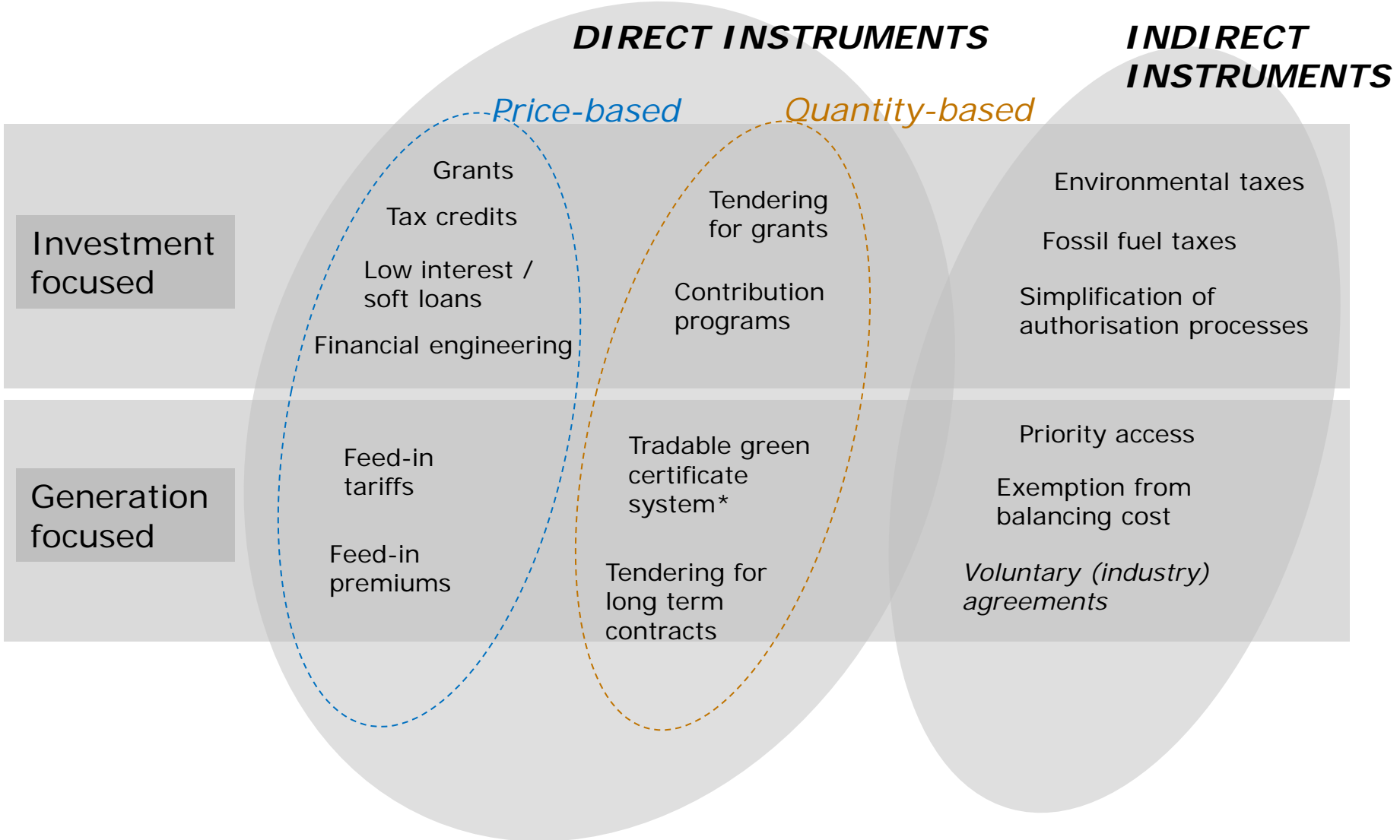
<http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do>

RE support is still needed

Long-Run Marginal Cost of RES in EU-25

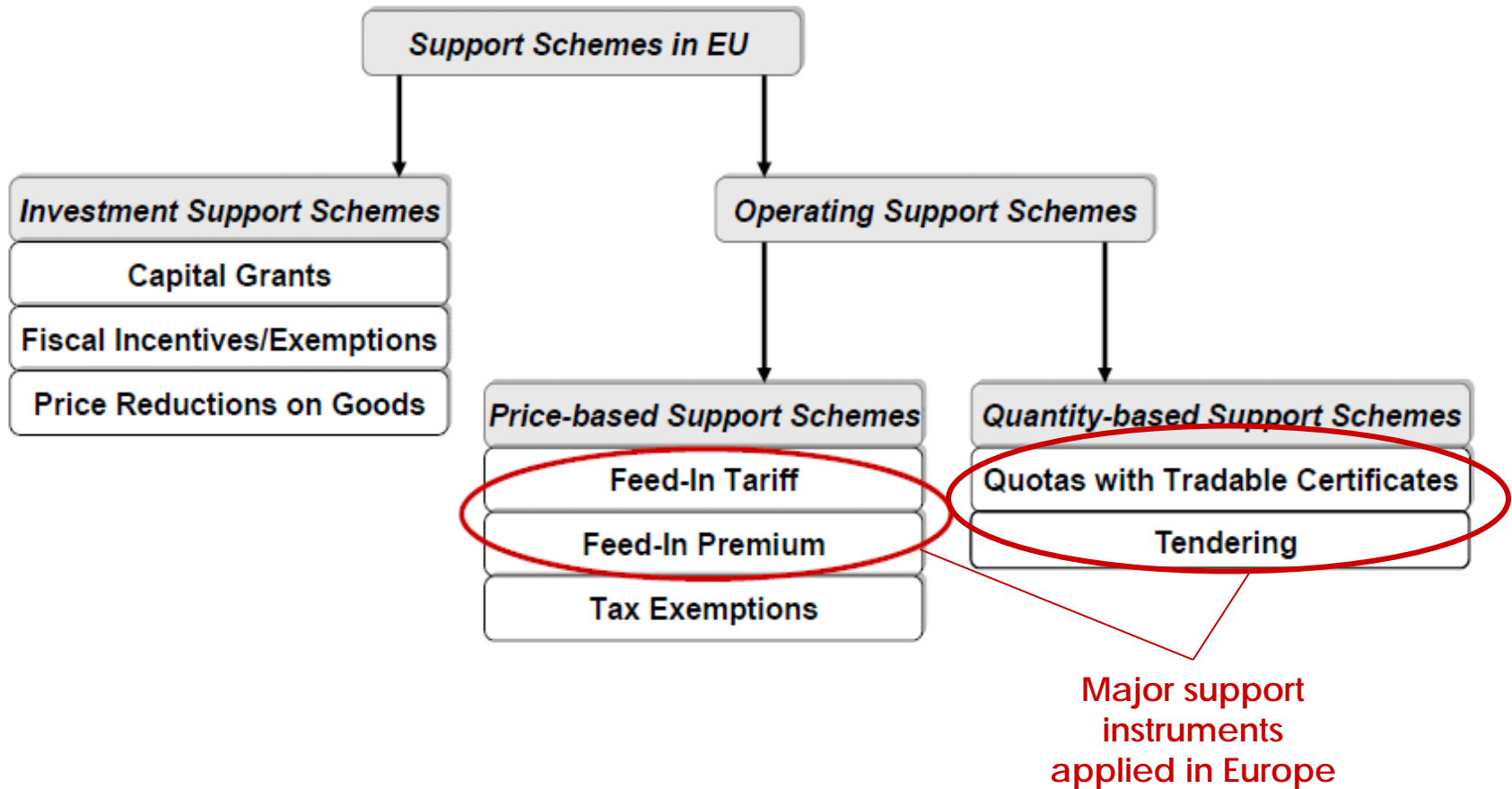


What kind of support?



* equal to Renewable Portfolio Standards /Renewables Obligation

Overview Support Schemes

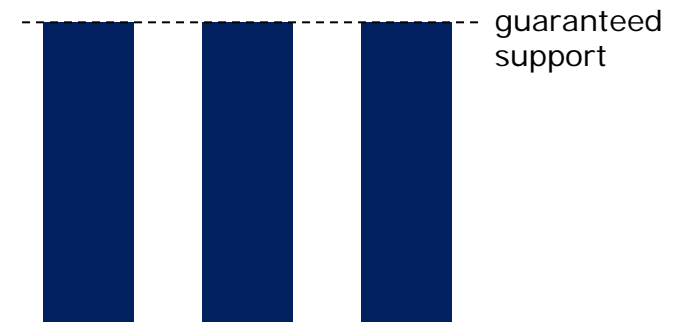


Source: modified, based on IMPROGRES Report (Cali *et al.*, 2009)

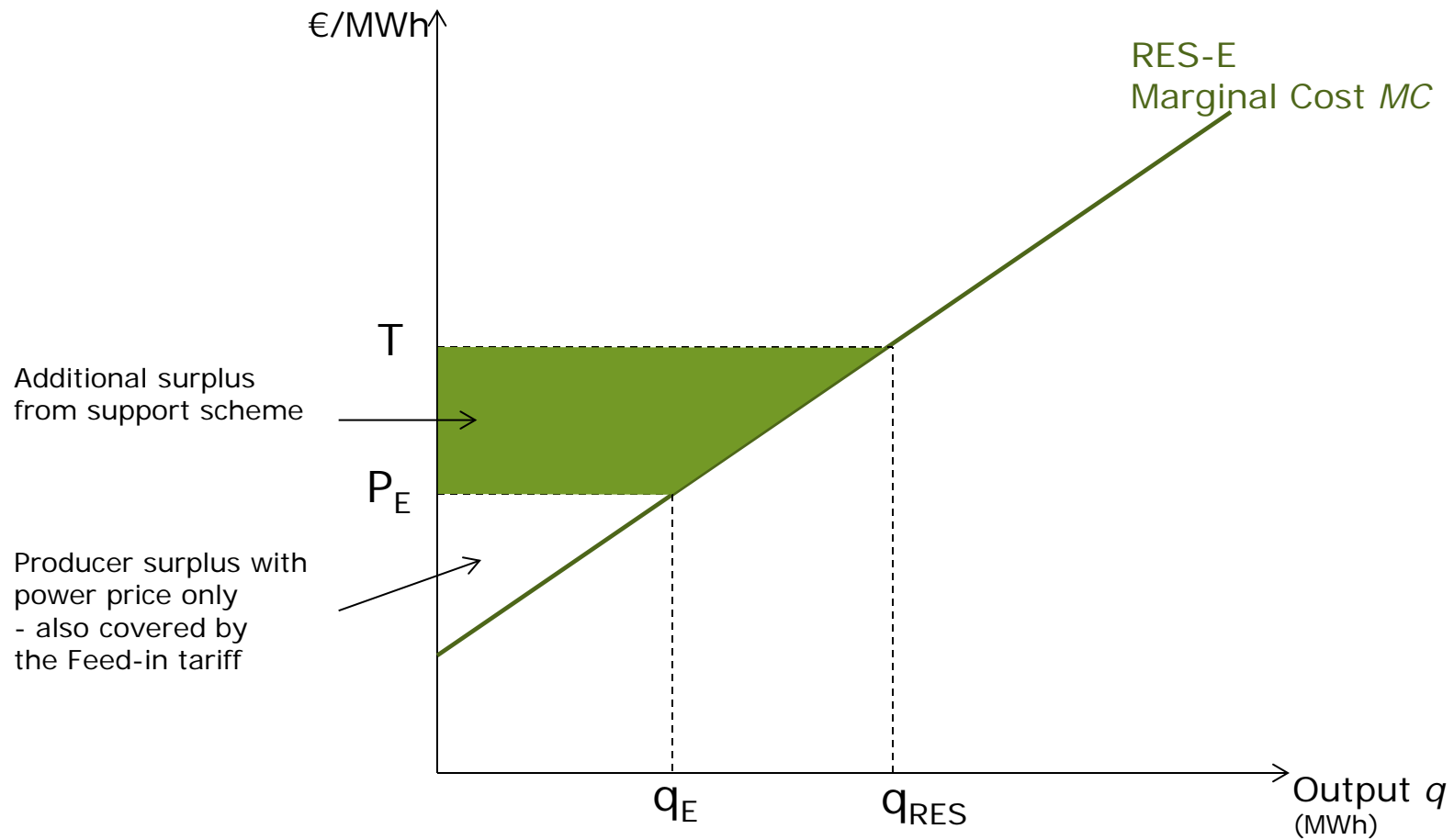
Feed-in tariff – *the simple one*

Guaranteed price paid per kWh of electricity production to qualified electricity producers

- Frequently coupled with obligation on system operators to purchase renewable output (**priority dispatch**)
- Fixed price typically guaranteed for a **long duration** (e.g., 20 years)
- Feed-in tariff is typically financed via the electricity bill of all consumers, utility with purchase obligation, taxpayers, or combination of the systems
- Where does all the purchased wind power go? – an agent (usually the transmission system operator) sells it on the power market.



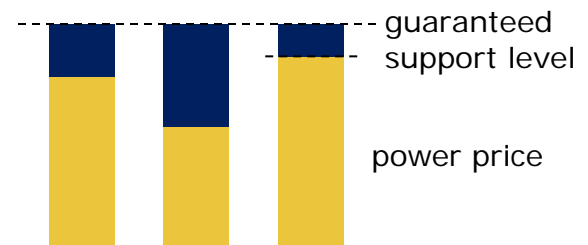
Feed-In Tariff - profit to RES-E producers



Feed-in tariff / Sliding premium – *Contracts for Difference*

Guaranteed price paid per kWh of electricity production
to qualified electricity producers

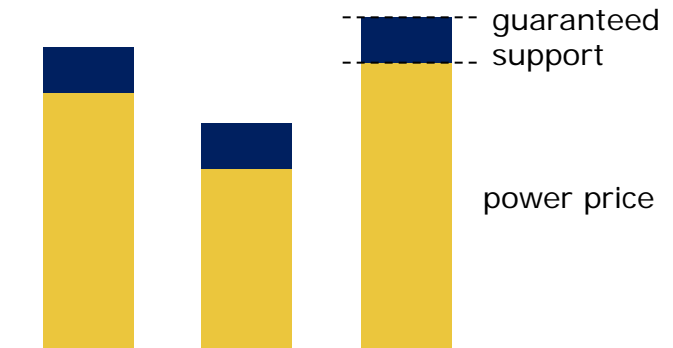
- A bit more market integration than a simple feed-in tariff - as producer has to sell on power markets
- Also, producers are balancing responsible
- Still, they do not see market incentives for e.g. down-regulation at zero prices (although this is sometimes added as special design feature)
- Complies with EU understanding of "premiums" which are to be used in new schemes, according to current state aid guidelines



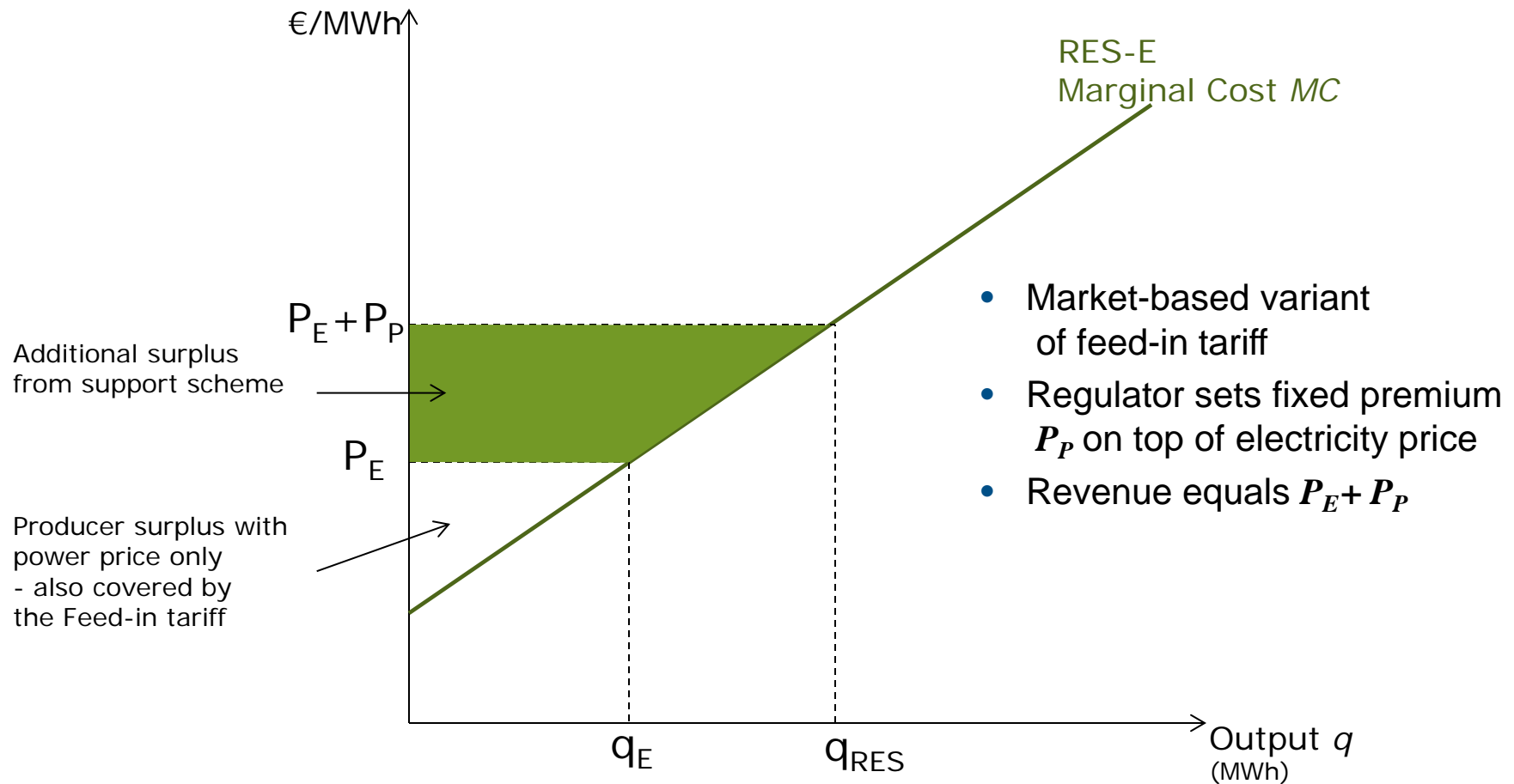
Price premium – *more advanced*

Fixed premium per kWh paid on top of wholesale market price to qualified electricity producers

- Higher exposure of electricity producers to fluctuations of wholesale market price
- Revenue of qualified generators consists of wholesale market price (P_E) and price premium (P_P)
- Serves to incentivise electricity producers to follow load patterns (less market distortion, stronger demand orientation)
- No purchase guarantee
- Consumer cost may be higher due to risk on total revenue



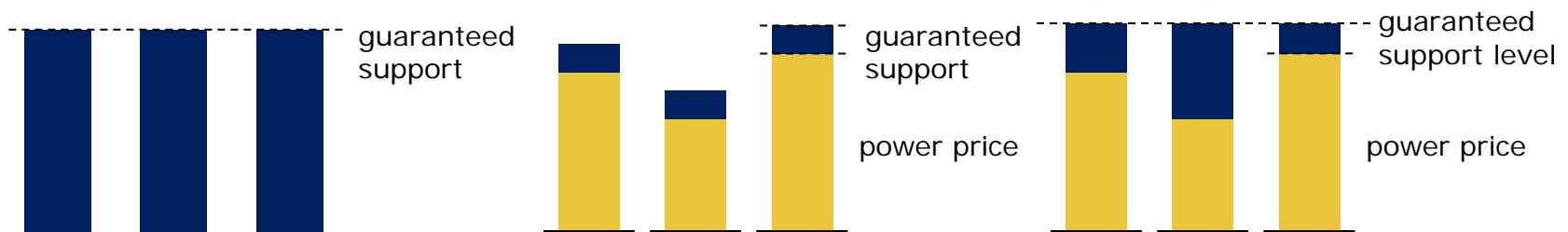
Price Premium - profit to RES-E producers



Tendering / auctions – *increasingly relevant!*

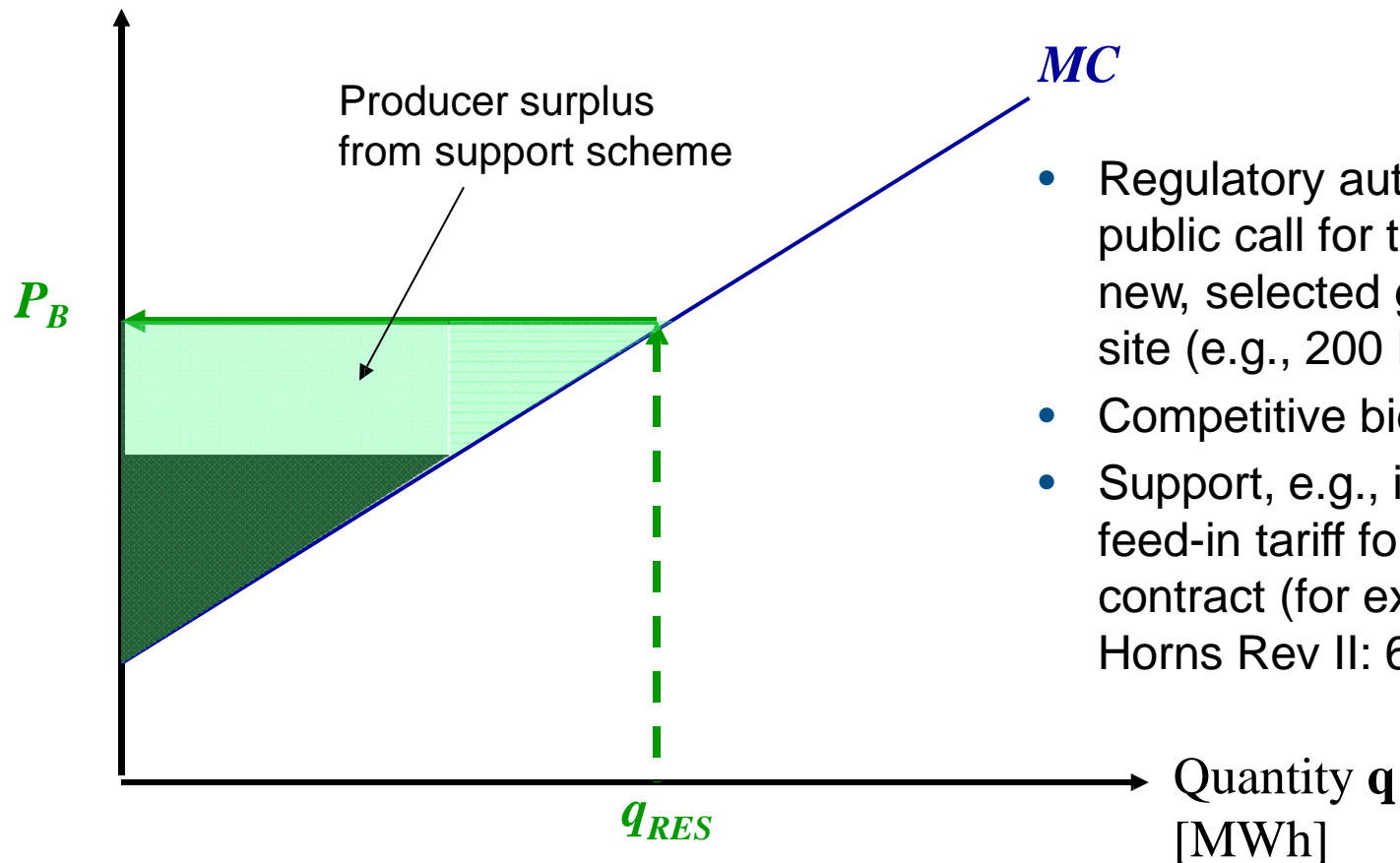
Governments tender out concessions for support payment for certain eligible production.

- **Public call for tenders** => Competitive bidding process
- **Tendering schemes:** invitation to companies to submit bids to regulatory authority for RES-E project
- Contract awarded based on certain criteria (e.g. lowest cost)
- Support scheme financed through levy (general tax) or via electricity bill by all consumers
- "Pay-as-bid"-price (mostly) but other designs are possible too
- Enables better control of amount of installed capacity



Tendering Schemes: Bidding for One Site

Price paid to awarded contract, P_B
[€MWh]



- Regulatory authority issues public call for tender for a new, selected generation site (e.g., 200 MW offshore)
- Competitive bidding
- Support, e.g., in form of feed-in tariff for awarded contract (for example Horns Rev II: 6.9 ct/kWh)

Quota System with Tradable Green Certificates /Renewables Obligation

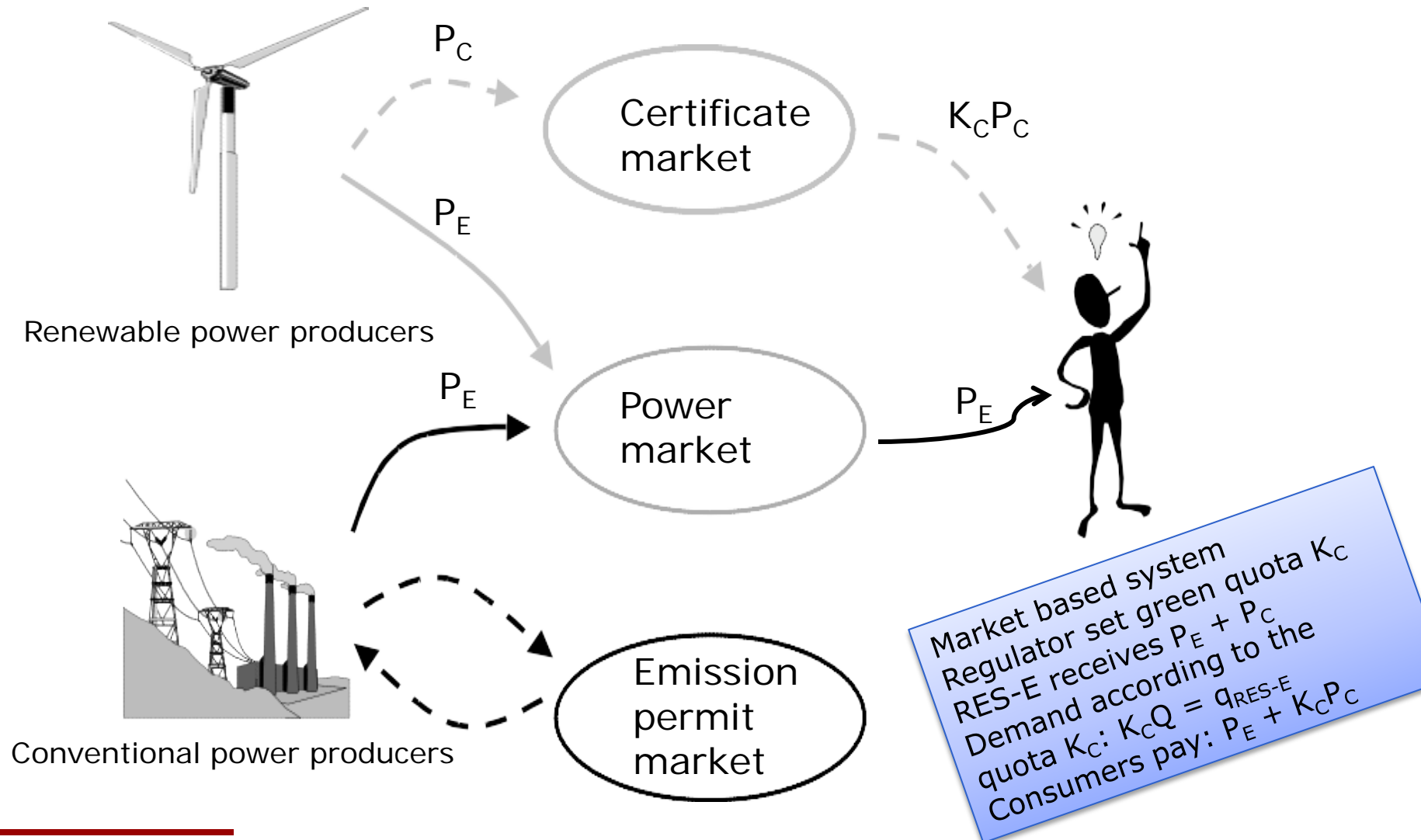
Green Certificates are stipulated as a percentage share (quota) of renewables in total electricity consumption or generation

- Green certificate is issued for specified unit of RES-E produced (e.g., for one MWh)
- **Two systems / political determined target:**
 - Quota imposed on *retailers/consumers* (e.g Sweden/Norway)
 - Quota imposed on *producers* (e.g. Italy)
- **Fulfillment** of quota obligation:
 - Purchasing/producing green electricity or
 - Buying corresponding amount of green certificates
- **Competitive prices:** Tradable on markets in order to insure competition / marginal price setting
- Can be aligned with the EU Guarantee of Origin for RES (EU Directive 2009/28/EC)

Green certificate schemes

- **Certificates are financial assets and tradable.** In addition to the physical power market, they can be sold in an organised, financial market established for green certificates and thereby realise an additional payment to the producer for his/her green power.
- The price obtainable to the producer for the renewably based electricity will be the sum of the market-based settling price for physical power and the price of the tradable green certificates.
- **Price setting on the power market might be based on short-run marginal costs.**
- Need for additional deployment of RES-E compared to the certificate demand, implies a **certificate price setting on long-run marginal costs including investments.**
- Competition between RES-E producers on the certificate market ensures that the supply price for green certificates reflects the actual cost differential (on long- and short-run) between renewably based and thermally based power, i.e. the marginal subsidy (certificate price) needed in order to ensure the desired deployment.
- The market for green certificates gives key policy makers, industrial stakeholders, and consumers a price signal from the actual marginal renewable energy technology on the market.
In addition, the green certificate system remunerates only the most efficient renewably based power producers.

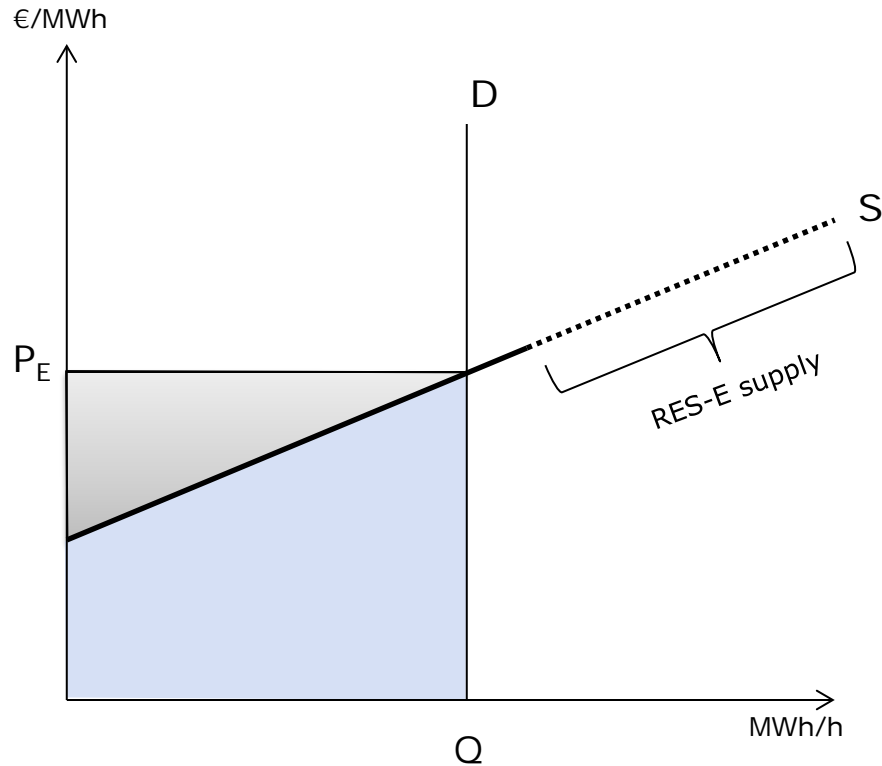
Tradable Green Certificates



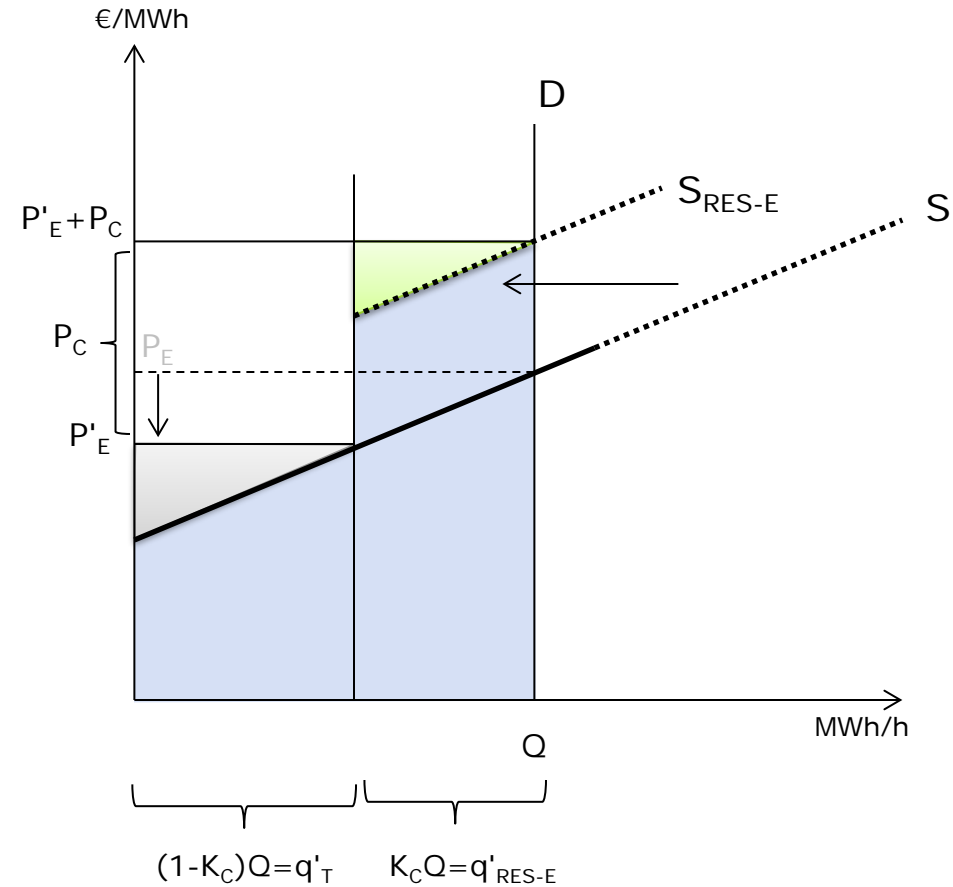
Market based system
 Regulator set green quota K_C
 RES-E receives $P_E + P_C$
 Demand according to the
 quota K_C : $K_C Q = q_{RES-E}$
 Consumers pay: $P_E + K_C P_C$

Prices without and with green certificates

Market without regulation

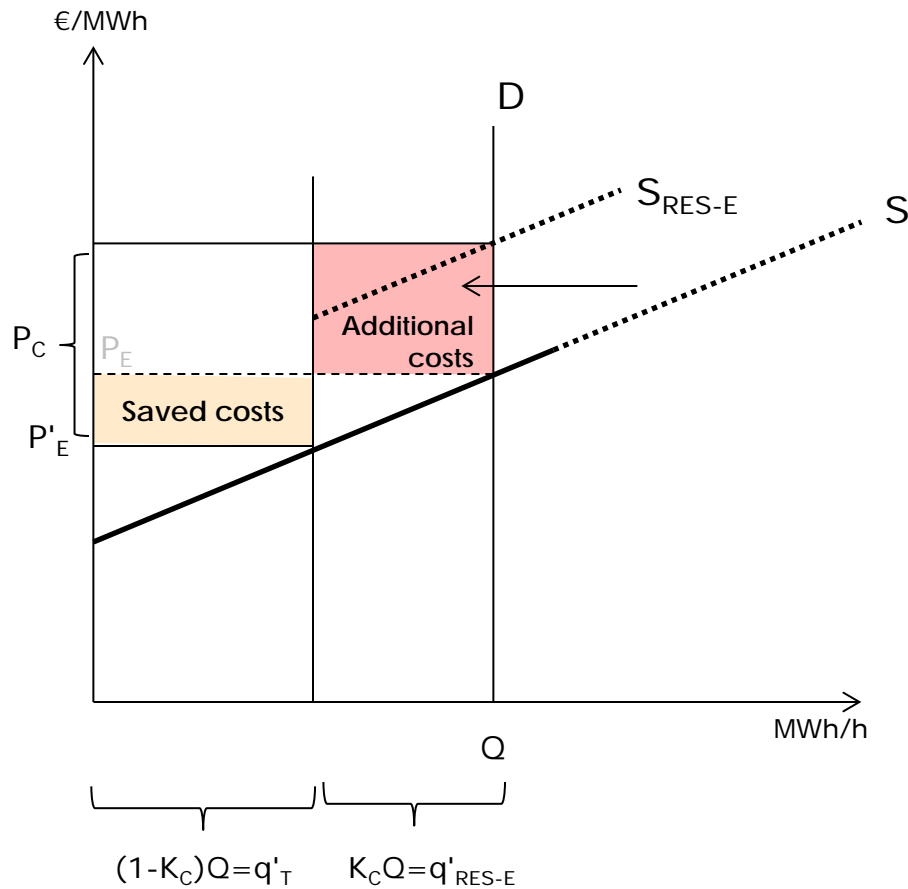


Regulation using green quota K_C

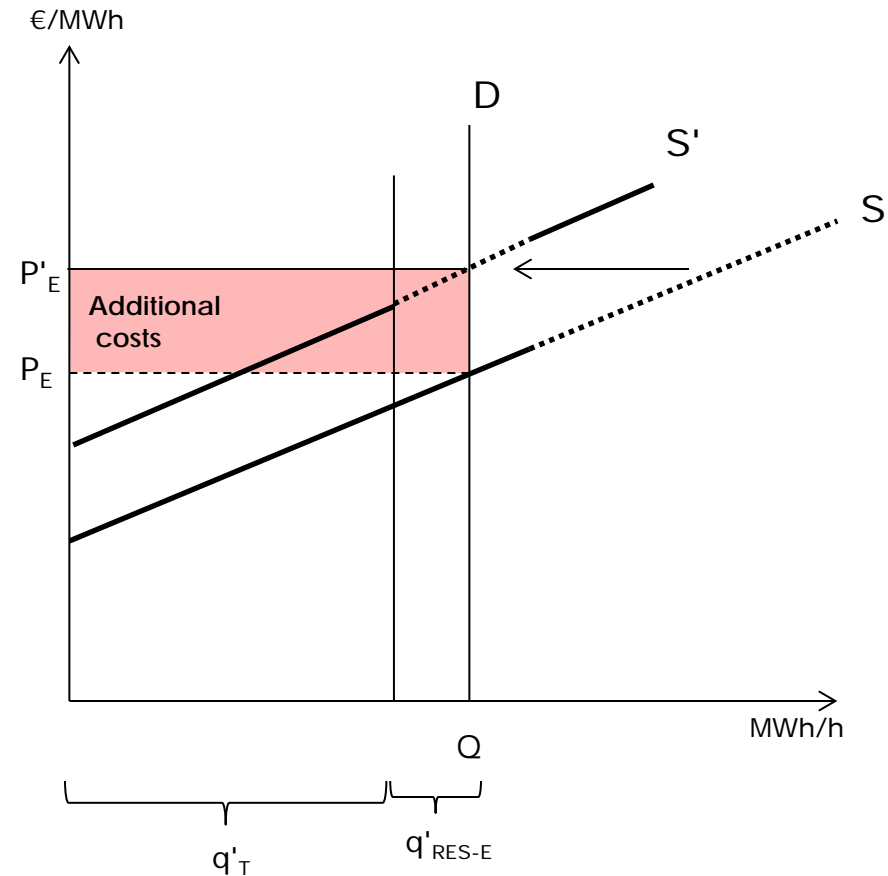


Change in consumer cost

Regulation using green quota K_C

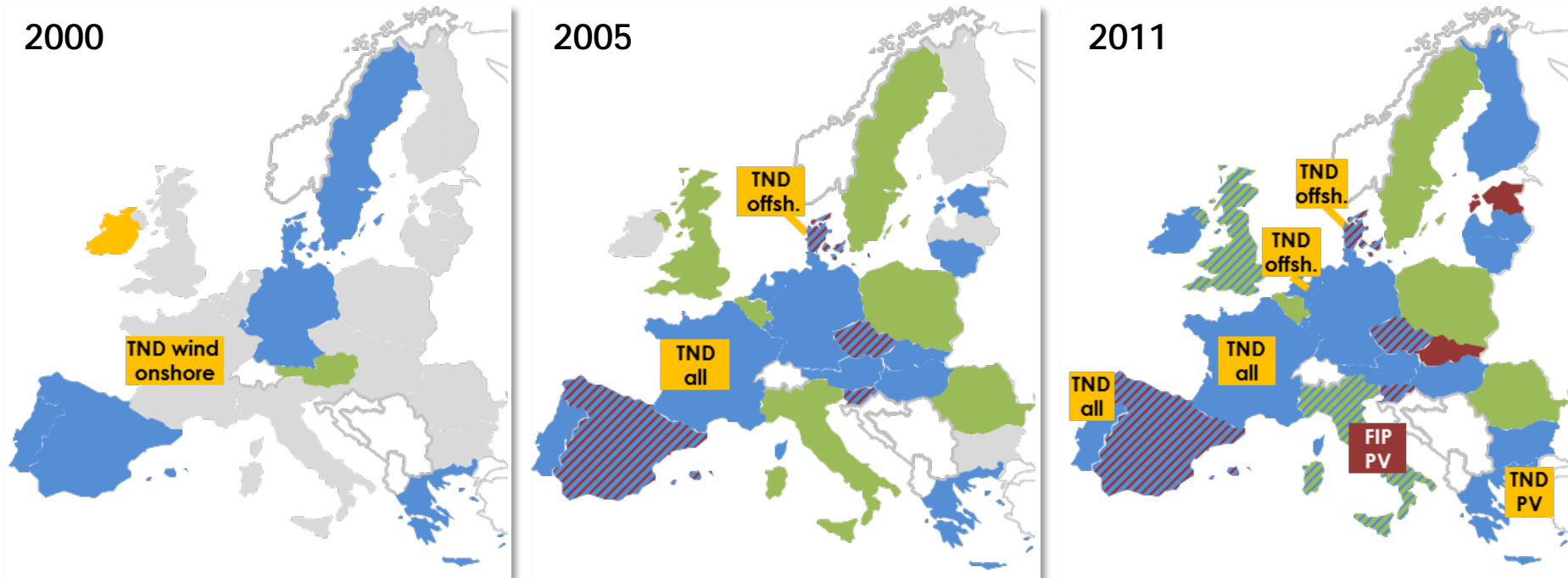


Regulation using emission quota



Development of support schemes in the EU-27

■ Feed-in Tariff (FIT) ■ Feed-in Premium (FIP) ■ Quota system (TGC) ■ Tender/Auction (TND)



- > Feed-in Tariffs by far dominant (21 countries)
- > Feed-in Premiums have recently surpassed quota systems
- > Investment grants, tax breaks, financing support are used as supplementary support instruments in all countries
- > Application of different instruments in parallel: From on average 1.0 instruments in 2000 to 3.0 instruments in 2011 (Denmark uses 6 instruments – highest in EU)

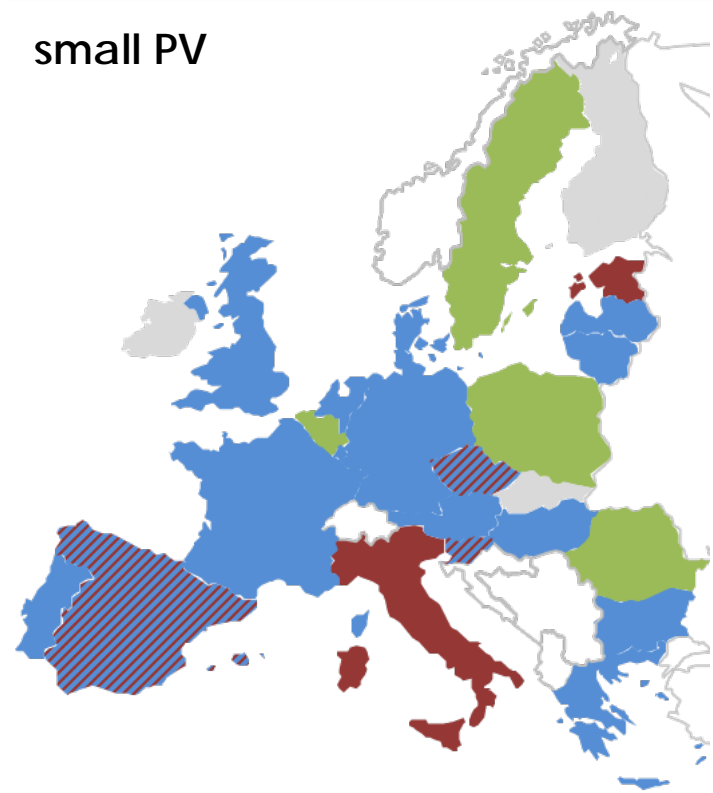
Development of support schemes in the EU-27

Status mid 2011

offshore wind



small PV



- Feed-in Tariff (FIT)
- Feed-in Premium (FIP)
- Quota system (TGC)
- Tender/Auction (TND)

- > Strong differentiation according to technology type and installation size
- > Larger installations and more mature technologies face more market integration and higher market risks

In the future:
switch to Tenders?

Summing up

- *How to ensure investment in capacity?*
- *Adequate policy/support to RES?*
- Trend to more **market and systems integration** and need of more **flexibility**
- **Regulatory RE-thinking:**
Make RE market ready vs Make markets RE ready
- Start with a well functioning power market/market design.
Then systems integration/coupling of markets

?? What is the role of markets/consumers/finance/policies in integrated energy systems of the future?

Thank you for your interest

Questions ?



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