SEERMAP

South-East Europe Electricity Roadmap

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Energy Economics Group

Energy policy - support instruments for renewable energy sources: key principles & lessons learnt

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3. Lessons learnt

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Market Failures and External Cost

- The term **external cost** or **externality** is used to define the costs that arise from any human activity when the agent responsible for the activity does not take full account of the impacts on others of his or her actions.

- **External costs** typically **arise when markets fail to provide a link** between the person who creates the "externality" and the person who is affected by it, or more generally when property rights for the relevant resources are not well defined.

- One principle way to correct the failure **in the case of climate change** would be to **impose a tax on CO_2 emissions** or to **define a cap** on the overall emissions budget and trade the allowances
(→ EU Emission Trading Scheme (ETS))

- So **why is additional intervention in the form of renewables support policies justified**?

Introduction

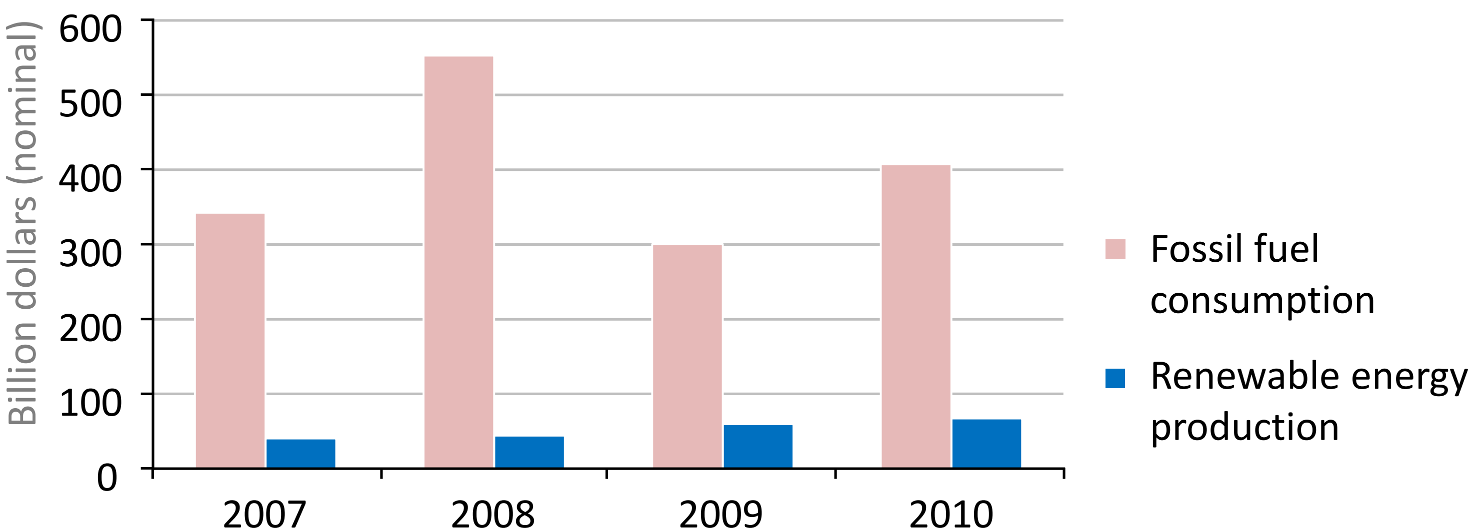
From „first best“ to „second best“ policies

- **Several other market failures exist** that cannot be addressed by putting a price on carbon alone.
- One argument is that **investors will fail to invest into RES at the socially optimal level if knowledge spill-overs exist** so that they cannot privatize the full benefit of their investment.
- **Risk-averse investors will also fail** to deliver the right investments **under long term uncertainty** in order to prevent „carbon lock-in“.
- **Security of supply is a public good** thus investors are not able to appropriate this benefit
- One more practical argument is that **through RES policies extreme distributional effects of climate policy can be prevented** by not using a „one fits all“ approach.

The majority of energy subsidies still go to fossil fuels

◄ **World subsidies to fossil fuels consumption & renewable energy:**

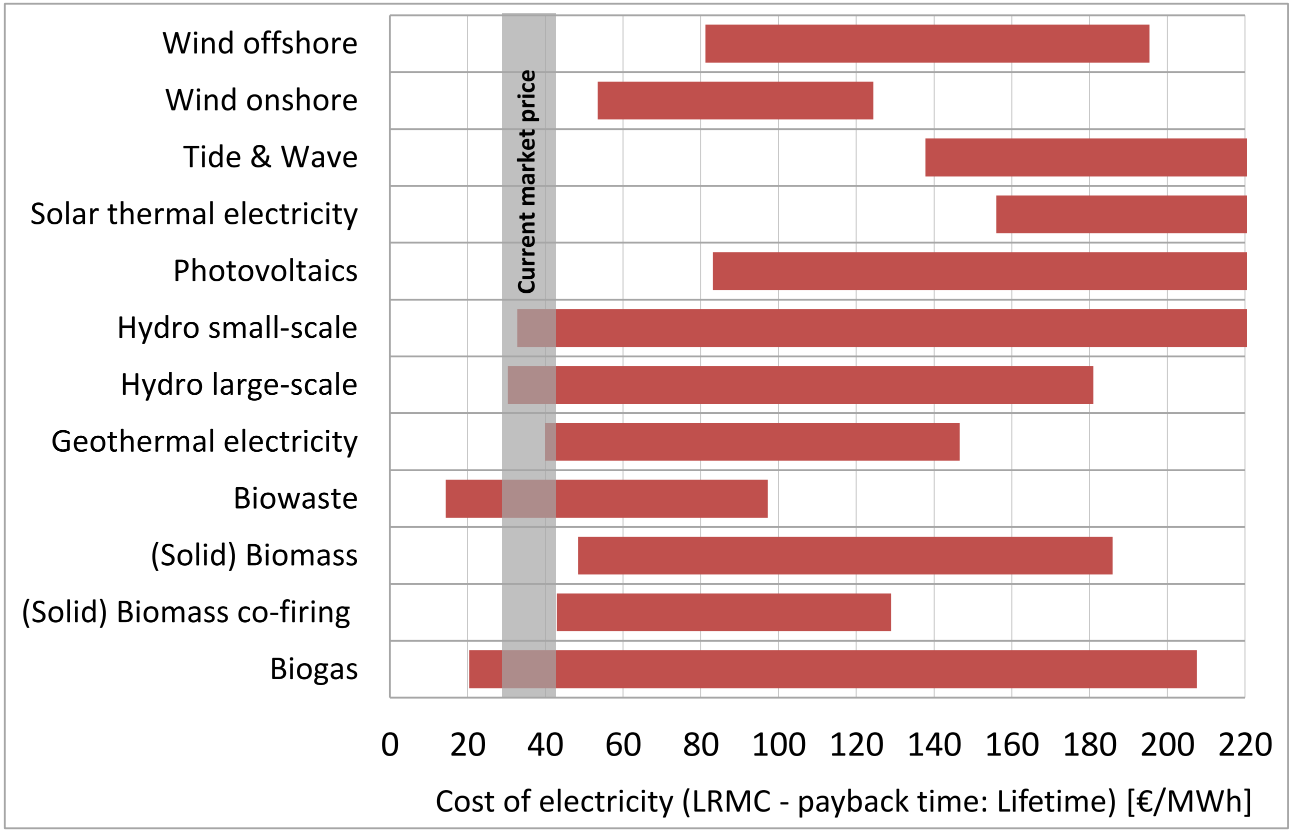
"Fossil-fuels subsidies amounted to $409 billion in 2010 – down from the peak of $550 billion in 2008 but still much larger than subsidies to renewables, which reached $66 billion in 2010 "



Source: IEA, World Energy Outlook 2011

Challenges and expected effects of Support Policies for Renewables:

◀ Renewable energies typically show **higher generation costs (presently) and higher learning rates** compared to conventional alternatives



Challenges and expected effects of Support Policies for Renewables:

◀ Renewable energies typically show **higher generation costs (presently) and higher learning rates** compared to conventional alternatives

◀ Renewable energies are **capital intensive**.

◀ Future **reference final energy prices are subject to substantial uncertainty**.

… Policy needs to **compensate additional generation costs**, provide **low risk financing**, **accelerate technological and institutional learning** and **reduce non-economic barriers**

… **Costs** of the **policy** should be **minimized**.

→ *Policies for Renewable Energies (RE) need to be* **effective** in terms of resulting RE deployment & **efficient (static & dynamic)** on the resulting public cost

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Support schemes

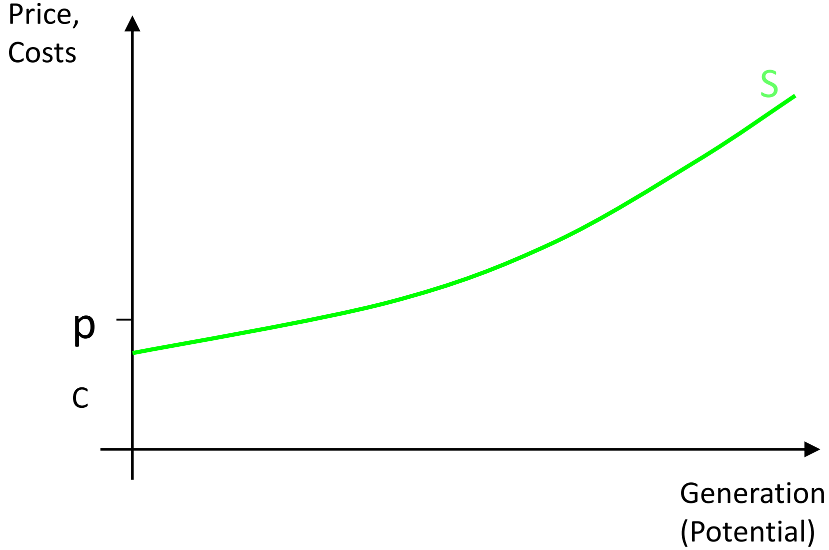
… basic principles

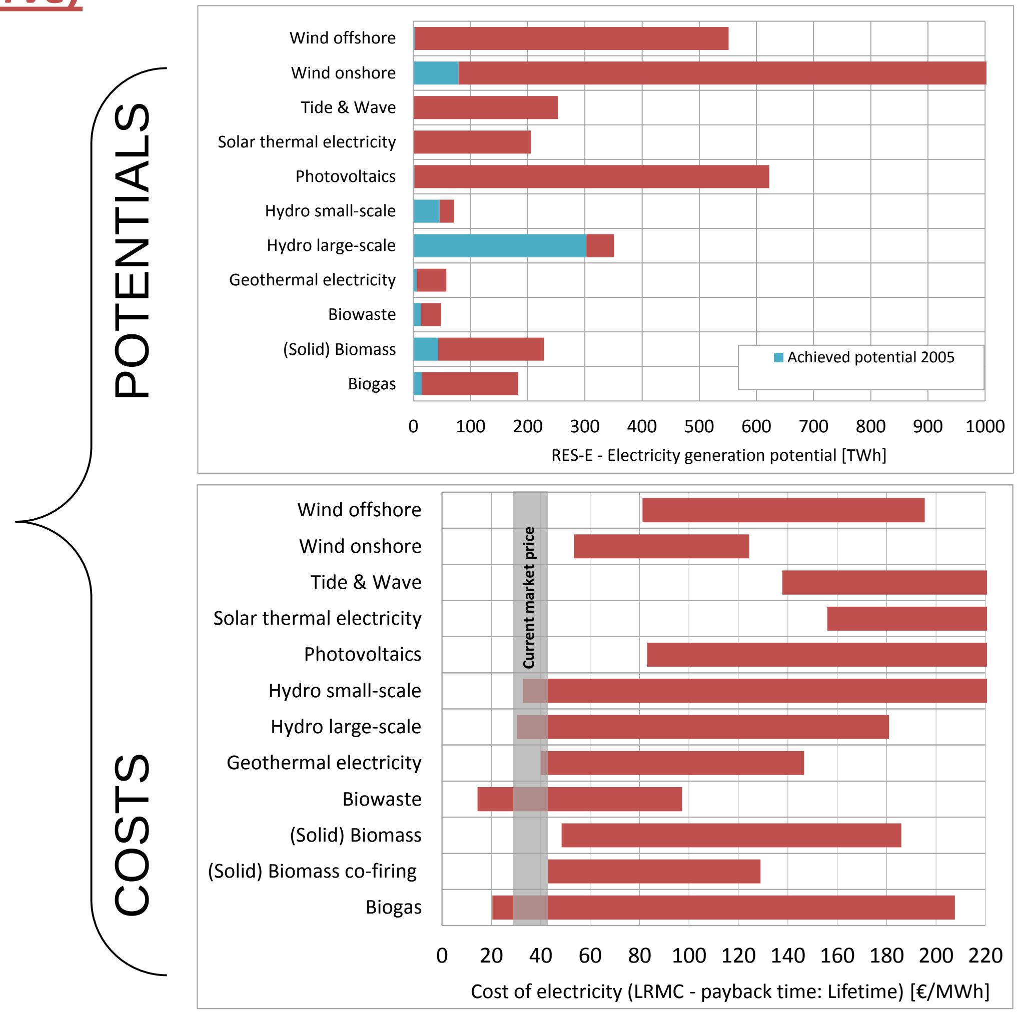
Combining information on costs & potentials

(RES-E): <u>Static cost-resource curve (supply curve)</u>

Combines information on the **potential** and the according **costs of electricity**

- ► All costs/potentials-bands are sorted in a least cost way
- ► For limited resources (as RES-E) costs rise with increased utilization.





Support schemes

... basic principles

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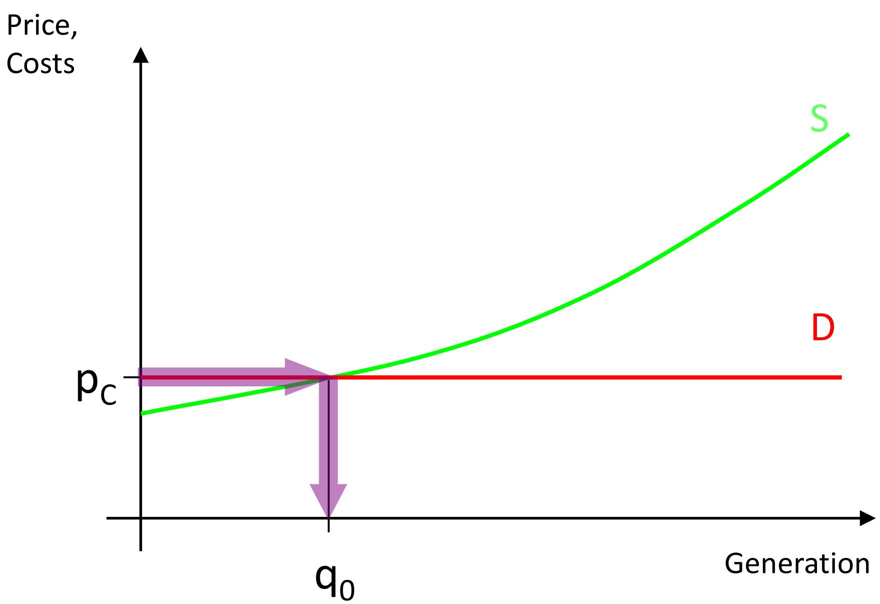
The industrial economic point-of-view

- **The price** for (conventional) electricity **is set by supply and demand** for electricity in general. Due to specific market conditions across Europe, **this price differs by country and by region**. These differences will continue to change due to the ongoing liberalization process.
- Under the assumption that no other promotional instrument exists, the **price of conventional electricity (p_C)** would **determine the market penetration of RES-E** (**demand D**). In this case only the quantity of green electricity would be produced that could be generated at lower or equal costs than the according conventional price level (**quantity q_0**).



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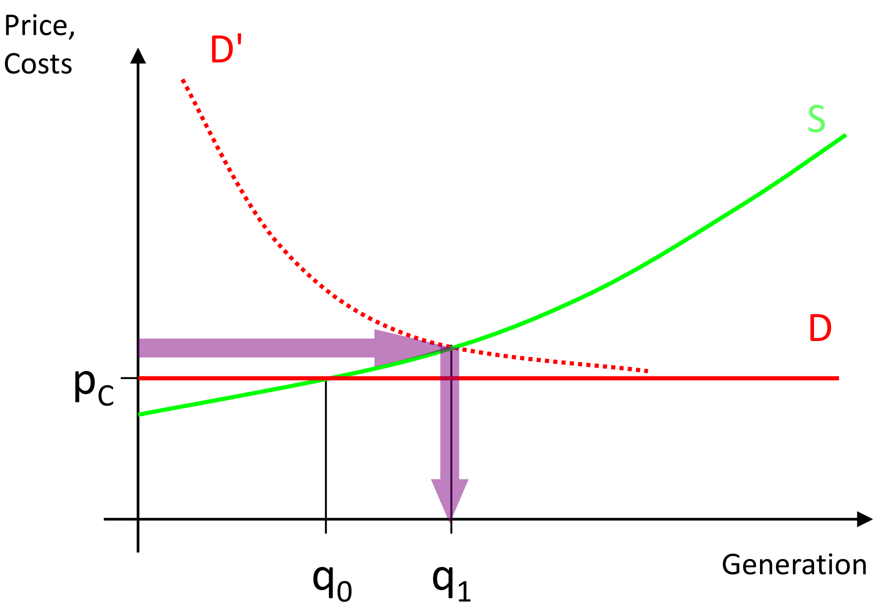
Voluntary willingness to pay (more) for electricity from RES

► Voluntary approaches to promote RES-E (e.g. 'Green tariffs') are based on consumers' willingness to pay voluntarily more for 'green' electricity compared its 'grey' counterpart.

► In the case of a voluntary demand characterized by the **willingness to pay (D')**, **electricity output will increase** up to q_1.



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Support schemes

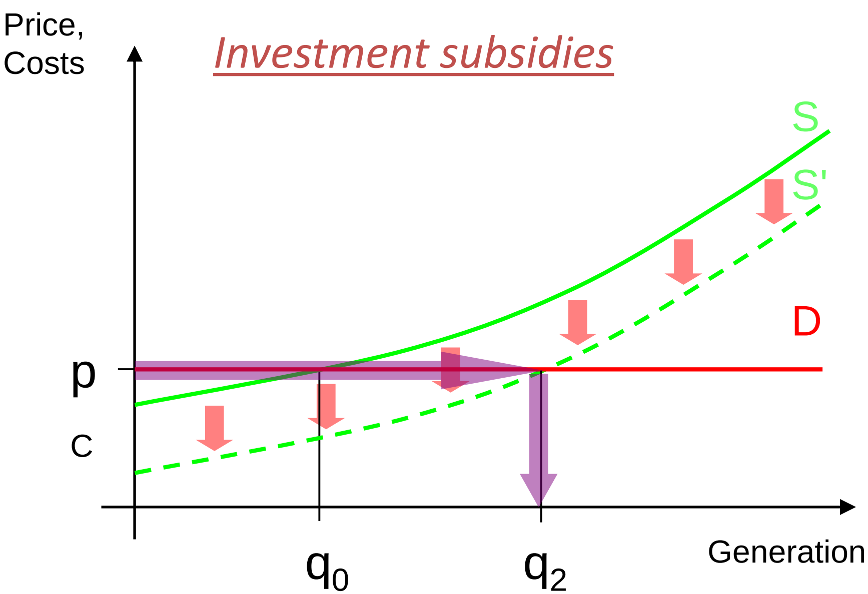
… basic principles

Price-driven strategies

(Promotion instruments for RES-E on the supply-side)

► **Price-driven policies**, e.g. investment subsidies or feed-in tariffs, **shift the supply curve downwards (S') *or simply offer higher prices for RES.***

► As a consequence, the total amount of **electricity generation from RES increases from q_0 to q_2.**



Fiscal incentives / investment grants

- Tax incentive: Reduction or exemption of tax payment → *price-based*
- Investment grants: Reduction of capital costs → *price-based*

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Support schemes

... basic principles

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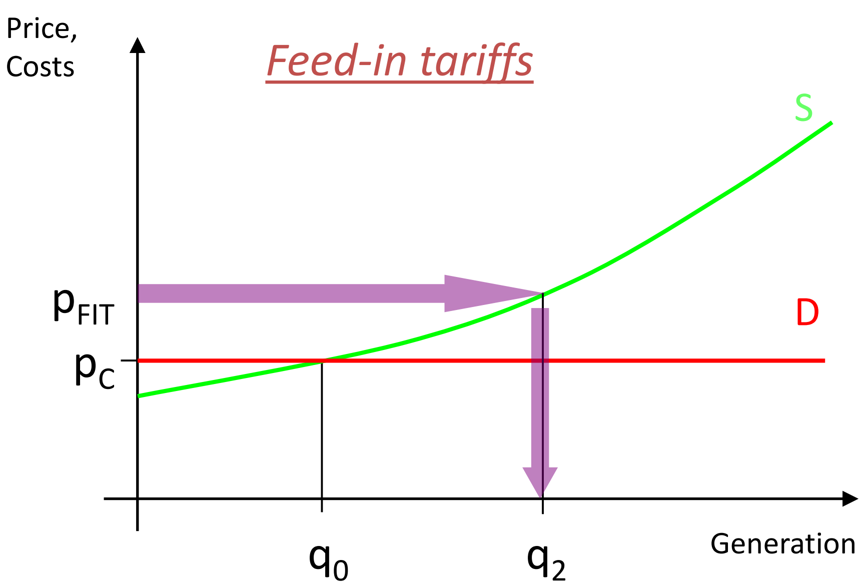

Feed-in tariffs (FiT)
Feed-in premiums (FiP)

◄ Renewable electricity can be fed into the grid at a guaranteed tariff for a determined period of time

◄ The electricity output depends on the support level → *price-based*
... and the guaranteed duration (of support)

◄ FITs may also consist of premium tariffs paid in addition to the market price **(... which is now "common practice")**
→ stronger market orientation

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Support schemes

… basic principles

(Details by policy instrument)

Feed-in premium (FiP) schemes

- Instead of giving a 'full price' support, subsidy could be given only above the market price
- No take-over obligation is attached to the RES product
- Means higher risks for investors, but gives the system higher market orientation
- Might be more costly, as investors need to be compensated over risk, but in long term can save costs

Support schemes

… basic principles

(Details by policy instrument)

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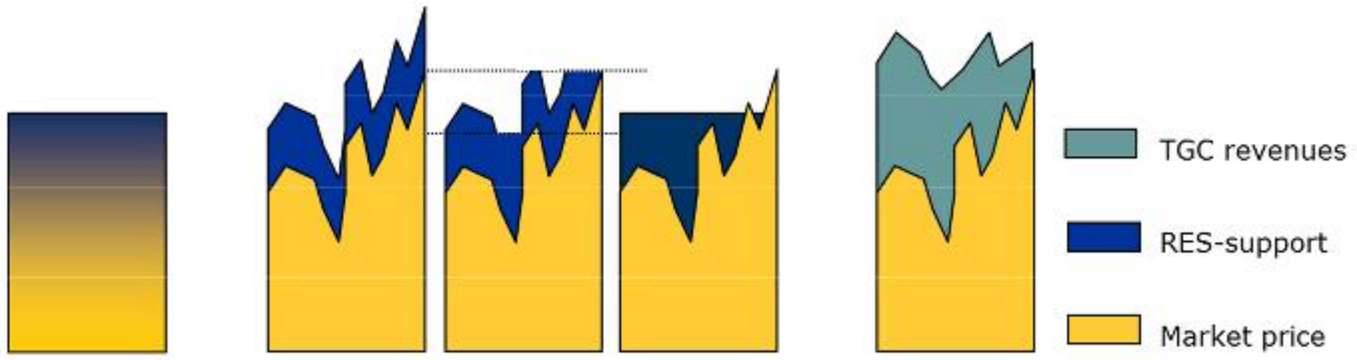
Feed-in premium (FiP)

Risk levels are different:

- floating premium gives high cost uncertainty (i.e. support expenditures) to regulators (and low risk to investors), while …
- fixed premium gives higher risks to investors compared to FIT.

Fixed /cap&floor/ floating



FIT Premium Green Certificate

Source: Ecofys 2014

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Support schemes
... basic principles

(Details by policy instrument)

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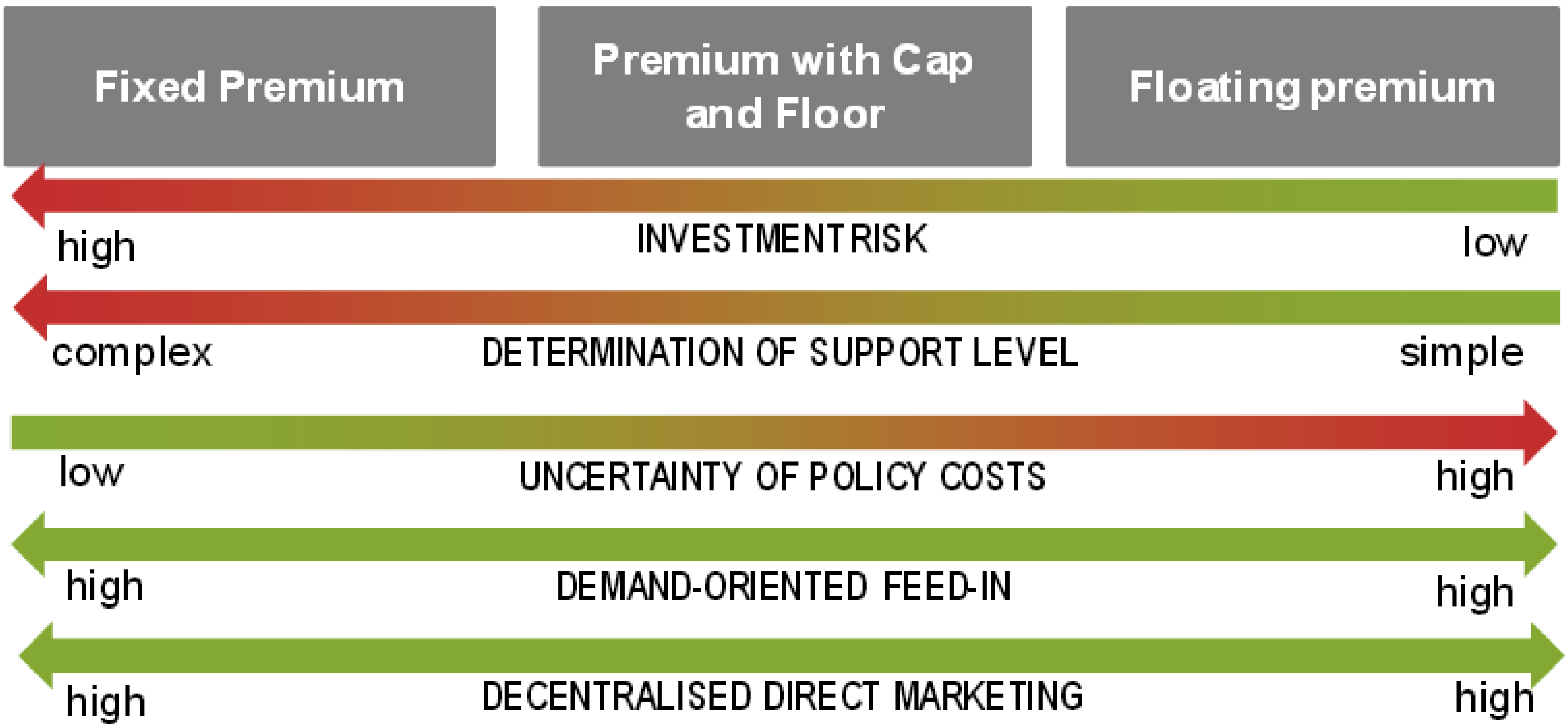
Feed-in premium (FiP)

◄ **Characteristics of FiP systems**



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Source: Ecofys 2014

Stepped Feed-in tariffs

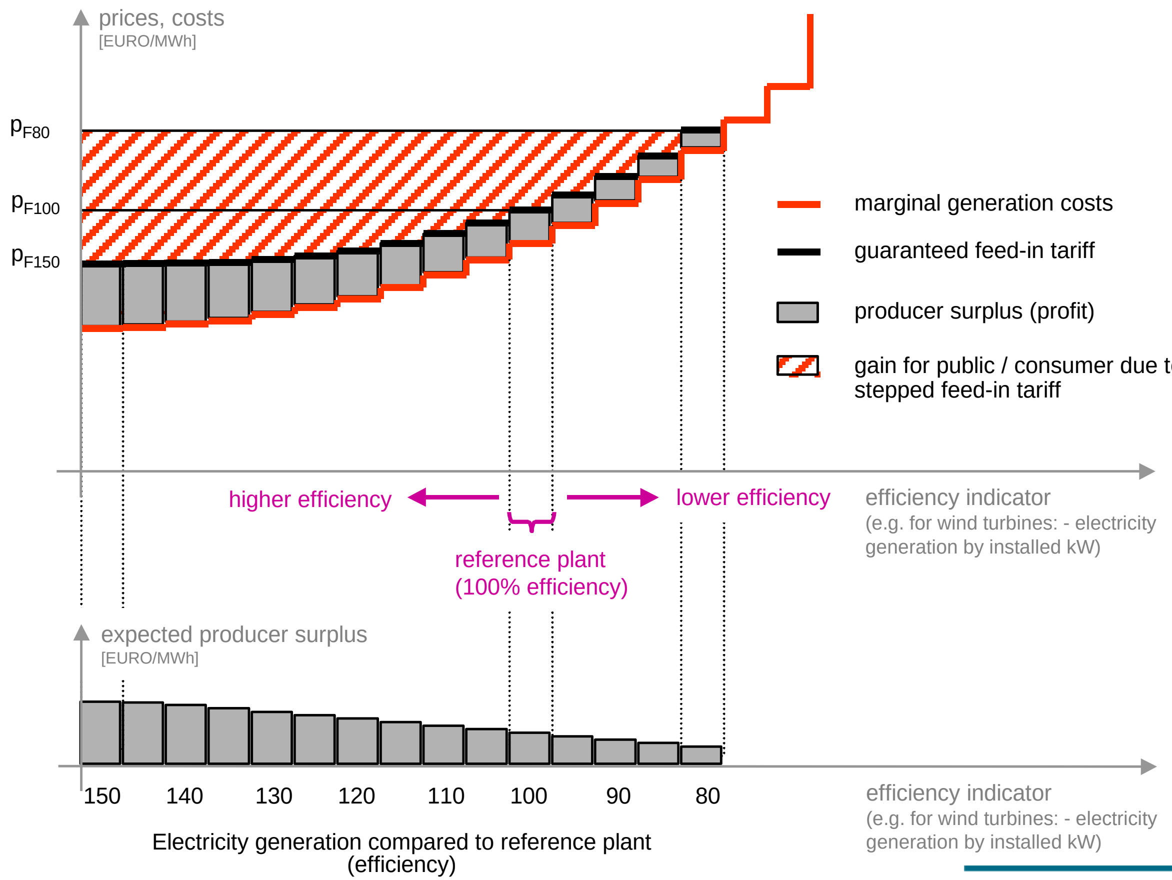
In the last years a special design of a feed-in tariff has been developed, the so called 'stepped' feed-in tariff. In practice **this kind of tariff scheme is used for wind energy in Germany, France and Portugal.**

► **A stepped feed-in tariff is characterized by lower subsides as the 'generation efficiency' increases.**

►The **decline** in the guaranteed **price**, however, must be **less than the total revenue that can be gained if an efficient plant and location is chosen** - otherwise investors have no incentive to implement the most efficient technologies and locations.

This means that **profits must be higher at cost efficient locations compared to less efficient ones**.

E.g. wind energy: 20% expected profit for locations with 2400 full-load hours and 14% for locations with 1800 expected full-load hours.



Support schemes

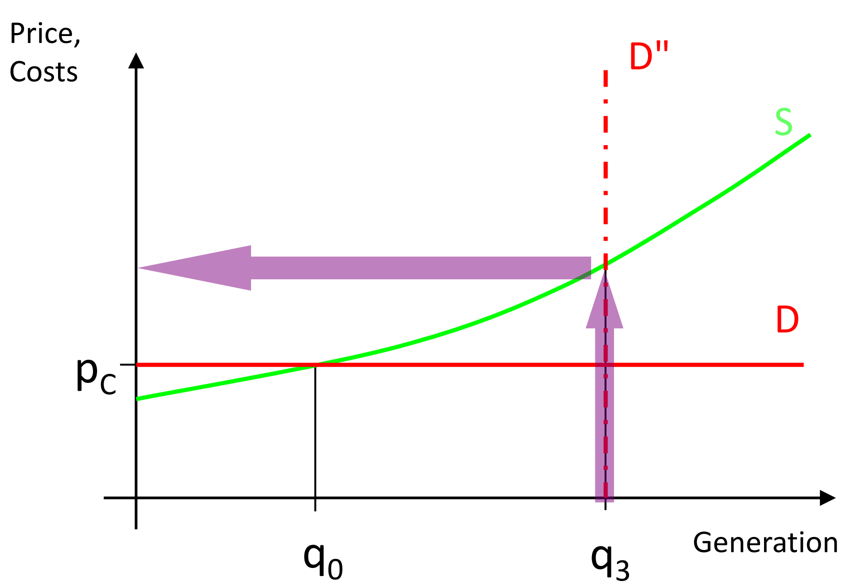
… basic principles

Quantity/Demand-driven strategies

(Promotion instruments for RES-E on the demand-side)

► To promote RES-E, a **mandatory demand** could be **set by the government**. Assuming, a quota for RES-E is introduced, a mandatory (inelastic) demand for electricity from RES results (**demand D"**).

►This inelastic demand, characterized by the vertical line, occurs because **obliged actors are required to pay a high price for electricity from RES in order to fulfill the quota q_3**.



Quota obligation with tradable green certificates (TGC)

- Determination of quota target
- Renewable electricity is sold at the market electricity price
- Additional revenue from selling TGCs
- Certificate price depends on predefined quota target and is determined on the market → *quantity-based* (but penalty of key relevance)

Tendering systems

- A predefined target of additional capacity or generation is set
- In a bidding round projects with the lowest generation costs can obtain financial support i.e. in form of long-term feed-in tariffs
  → *quantity-based*

Quota obligation based on TGC's

A mandatory demand may be set by government via quota obligations (i.e. legally enforceable orders to producers for specified amounts of RES-E to be sold) to promote electricity generation from RES. Quota systems usually operate in a liberalized electricity market The main objective of a legally enforceable quota system is to secure the penetration of a pre-defined amount of renewable energy.

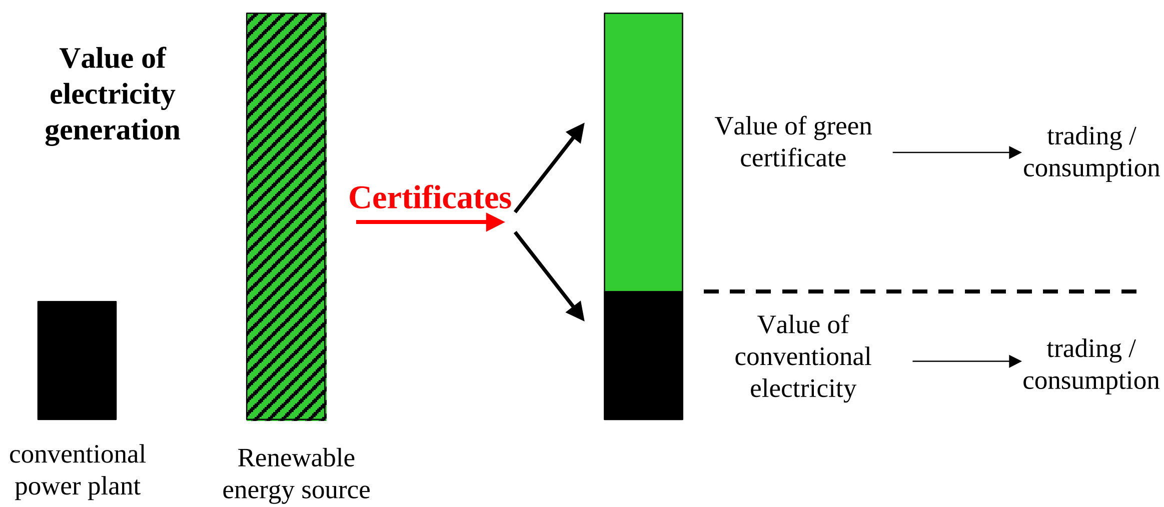
In general two different approaches exist:

- Non-tradable quotas: Renewable Portfolio Standards and Obligations
- Tradable quotas: Electricity or emissions (e.g. CO_2) based certificates

► The advantage of tradable green certificates (TGCs) is to facilitate the fulfillment of the quota obligation, and to increase the economic efficiency of the promotion strategy.

► A **TGC** is used to **represent the 'added value' or 'greenness' of one pre-defined unit of electricity produced from RES.** If only a TGC system operates, each producer of RES-E is producing **two goods**:

- **physical electricity**, which is fed into the grid (exported) and sold at market prices for conventional electricity
- **TGC**, which **represents the added value of the 'greenness'**



Support schemes

... basic principles

Classification of energy policy instruments

Classification of policy instruments for supporting energy technologies		Direct		Indirect
		Price-driven	*Quantity/Demand-driven*	
Regulatory	*Investment focussed*	•**Investment subsidies** •**Tax incentives**	•**Tendering system**	•Environmental taxes
	Generation based	•**Feed-in tariffs / Feed-in premiums** •**Tax incentives**	•**Tendering system**	
		•Rate-based incentives	•**Quota obligation (RPS) based on TGCs**	
Voluntary	*Investment focussed*	•Shareholder Programs •Contribution Programs		•Voluntary agreements
	Generation based	•Green tariffs		

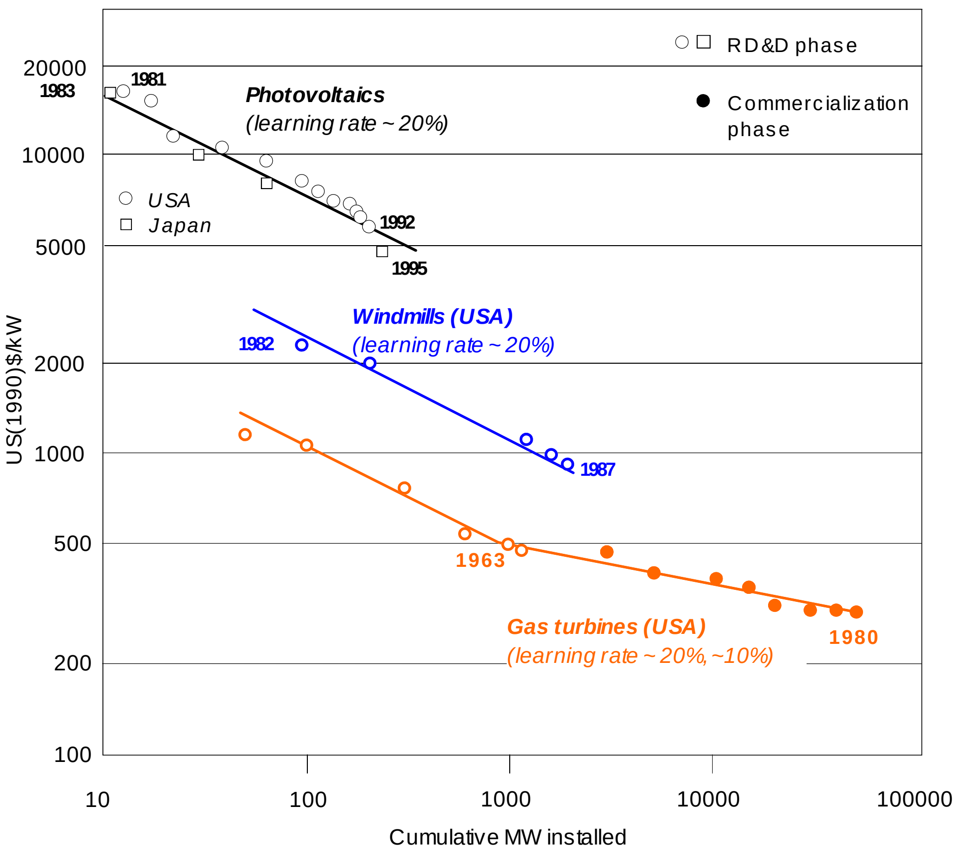
Support schemes
… dynamic adaptation

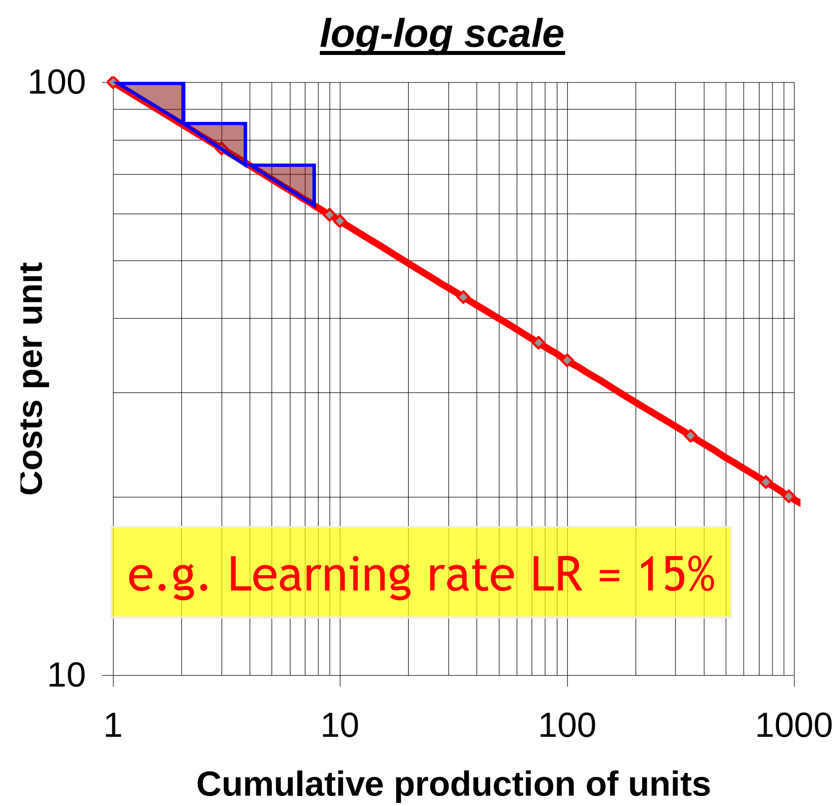
Basic principles: Experience curves

$$C_{CUM} = C_0 * CUM^b$$

C_{CUM}	Costs per unit
C_0	Costs of the first unit
CUM	Cumulative production
b	Experience index
LR	Learning rate ($LR=1-2^b$)

- ►describe ***how costs decline with cumulative production***.
- ►Empirical observations … costs decline by a ***constant percentage with each doubling*** of the units produced or applied.





Support schemes

… dynamic adaptation

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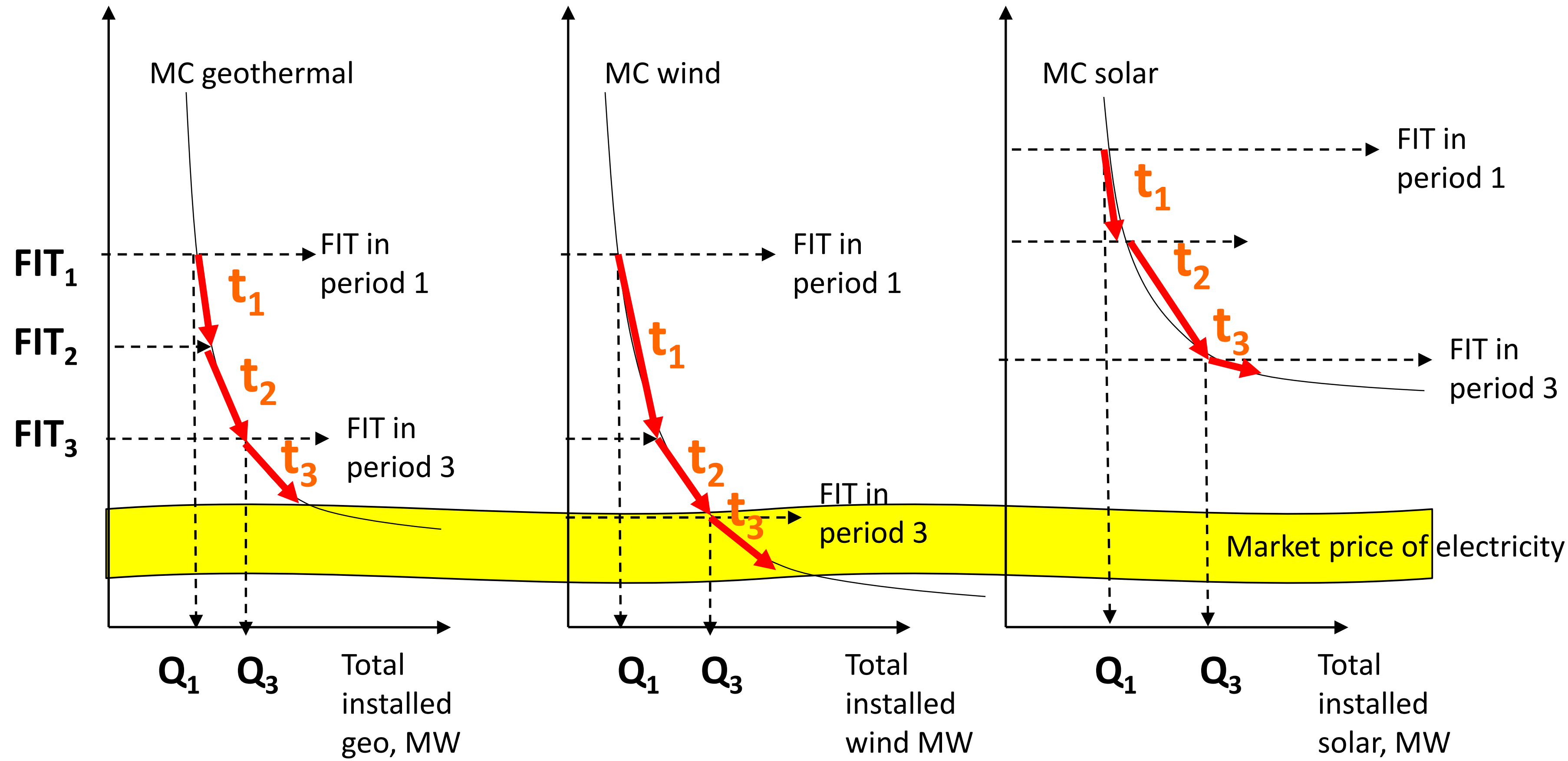
Experience curves and **adjustment of support levels** (in the case of price based support)



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Concluding remark ...

Support schemes for Renewable Energies create an artificial market!

... either by setting a price *(Feed-in tariff/premium)* with the **uncertainty on the resulting demand**

... or by setting a demand *(Quota based on TGCs, Tendering)* with the **uncertainty on the resulting price**

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Effectiveness & (economic) efficiency

of promotion instruments for RES-E from the **historical** perspective

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(Introduction)

EU Targets

The key driver at the European level

- **RES-e DIRECTIVE 2001** : to establish a framework to **increase the share of green electricity from 14% to 21%** of gross electricity demand **by 2010**
- **White paper 1997** (Green paper 2001): increase share of RES **from 6% to 12%** of gross consumption **by 2010**
- **Liquid biofuels** targets: 2% by 2005; 5.75% by 2010
- **Energy efficiency** target to reduce energy intensity by a further 1 percentage point per year until 2010
- Comply with EU commitments under the 1997 Kyoto Protocol on **reducing greenhouse gas emissions**
- Johannesburg "**coalition of the willing**" to work to increase the use of RES using targets and timetables

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Lessons learnt… in EU countries

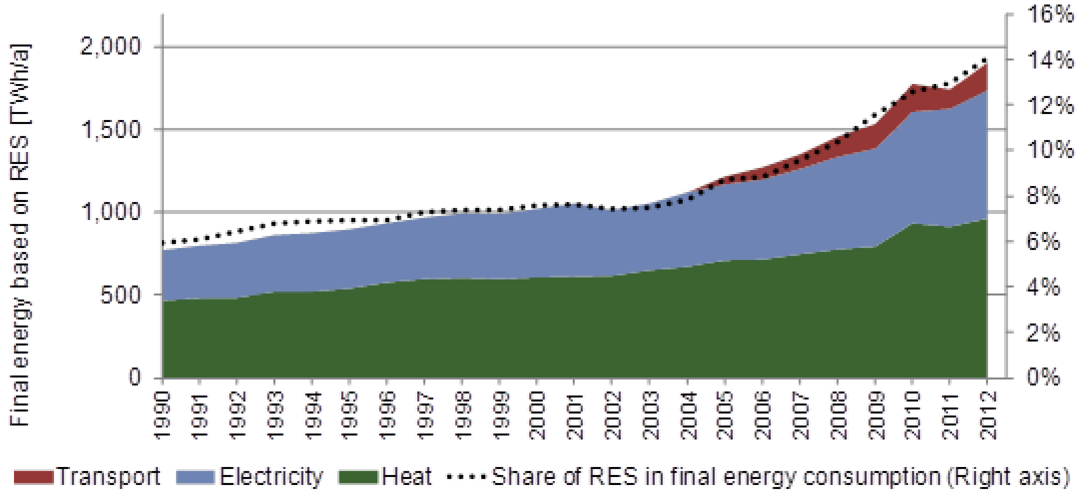
(Introduction)

▶ Historic RES evolution:

Final energy based on RES

Share on gross final consumption:
1990: 5.9%
2012: 14% (actual)
2020: ?

Final energy based on RES (in total) from 1990 to 2012 (EU28)



RES in the heat sector are of dominance, followed by electricity …

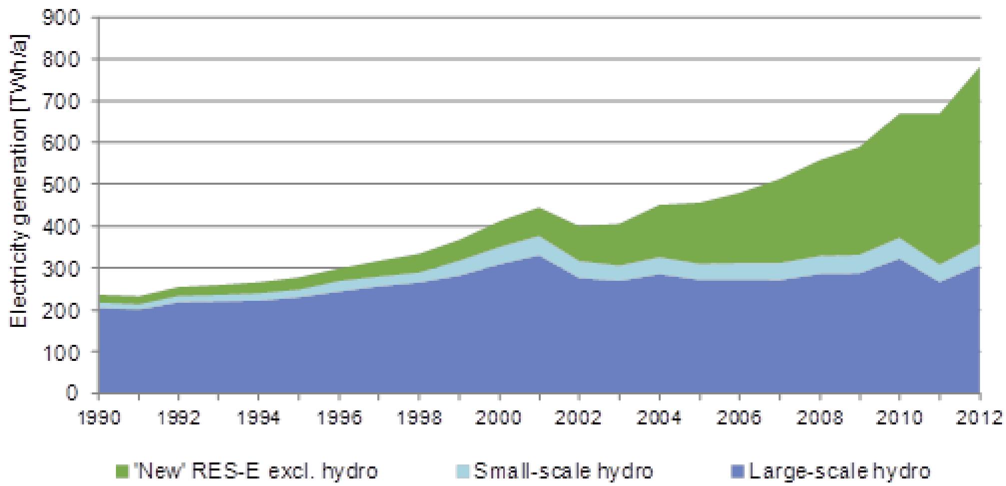
Lessons learnt... in EU countries

(Introduction)

▶ Historic RES evolution:

Electricity from renewable energy sources (RES-E)

Electricity generation from RES-E (in total) from 1990 to 2012 (EU28)



***Hydropower** – characterised by high volatility - still of dominance, but **new RES-E** substantially increased in the last decade …*

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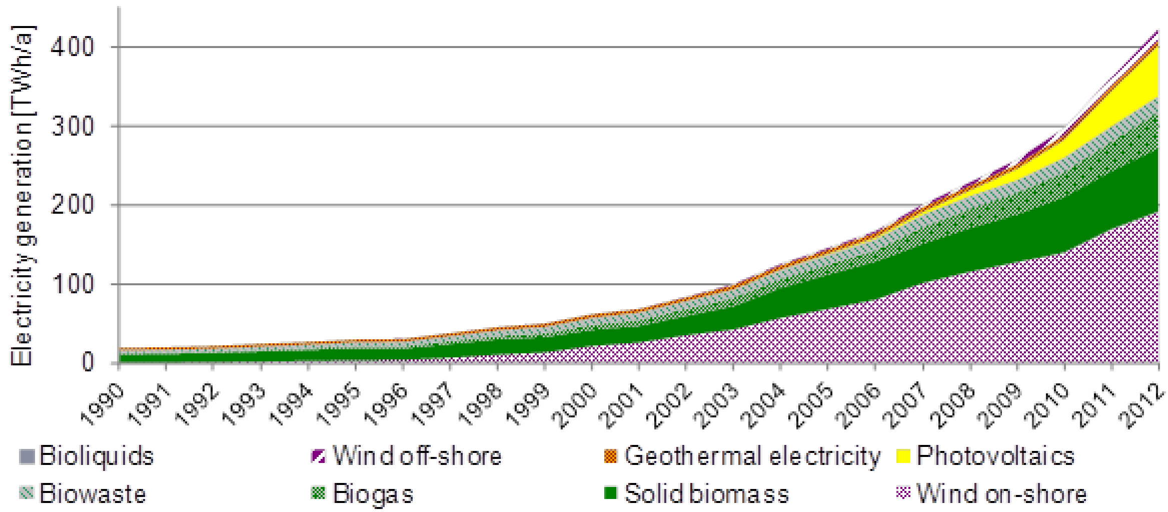
(Introduction)

▶ Historic RES evolution: Breakdown of electricity from "new" RES-E

Electricity generation from "new" RES-E (excl. hydro) from 1990 to 2012 (EU28)



The "winners": Wind energy (onshore), biomass – biogas

PV: moving up, but no substantial contribution yet

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(Introduction)

Core Objective - Method of approach

Support instruments have to be

- ***effective*** for increasing **the penetration of RES-E** and
- ***efficient*** with respect to minimising **the resulting** *public costs* over time.

Public costs or ***transfer cost for consumer / society***
(due to the promotion of RES-E) ...
... consumer → producer
... do not consider any indirect costs / benefits or externalities

***Example:* Feed-in tariff for a wind power plant**

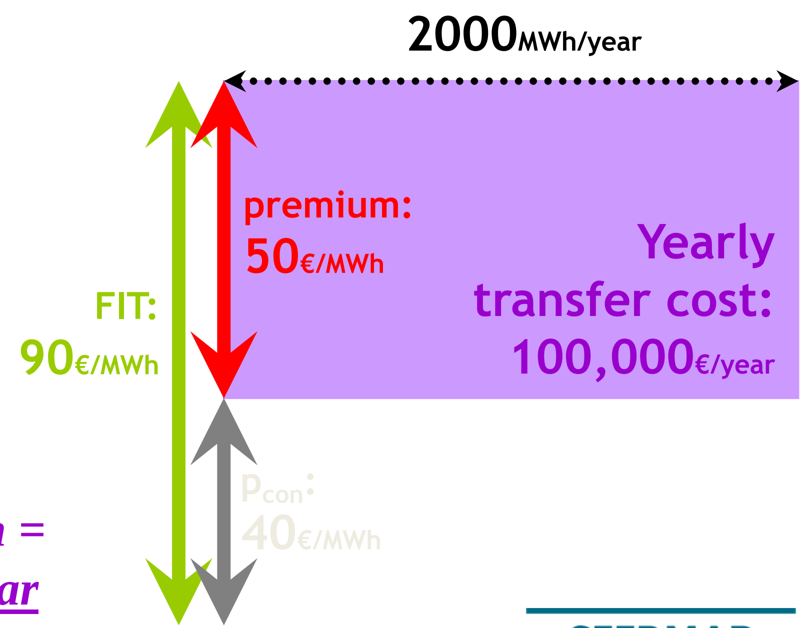
(1 MW, 2000 MWh/year)

Feed-in tariff = 90 €/MWh

Market price conventional electricity = 40 €/MWh

→Financial premium = 90 – 40 = 50 €/MWh

→Yearly transfer cost = Premium * Generation = = 50*2000 = 100 k€/year



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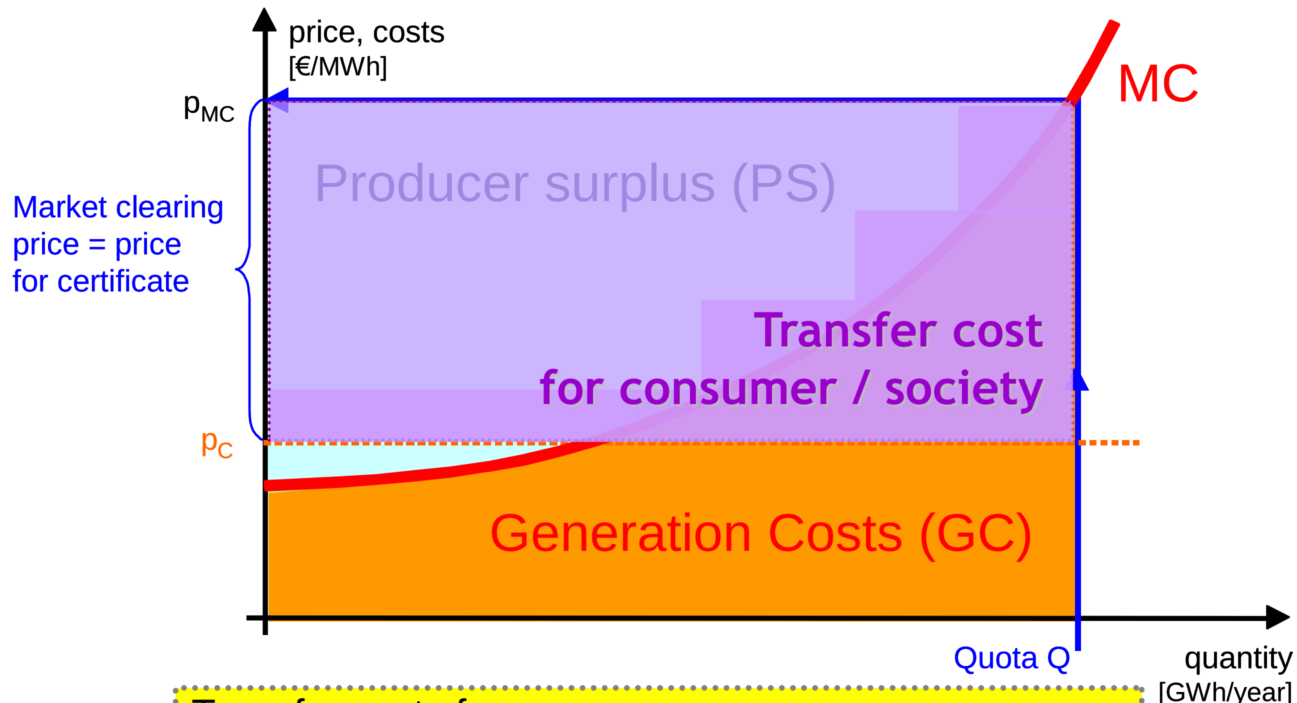
(Introduction)

Core Objective - Method of approach

Increasing the <u>efficiency</u> of RES support:

- ***Minimise generation costs***
- ***Lower producer profits***



Transfer costs for consumer (additional costs for society) $= PS + GC - p_C * Q$

p_C ... market price for (conventional) electricity

p_{MC} ... marginal price for RES-E (due to quota obligation)

MC ... marginal generation costs

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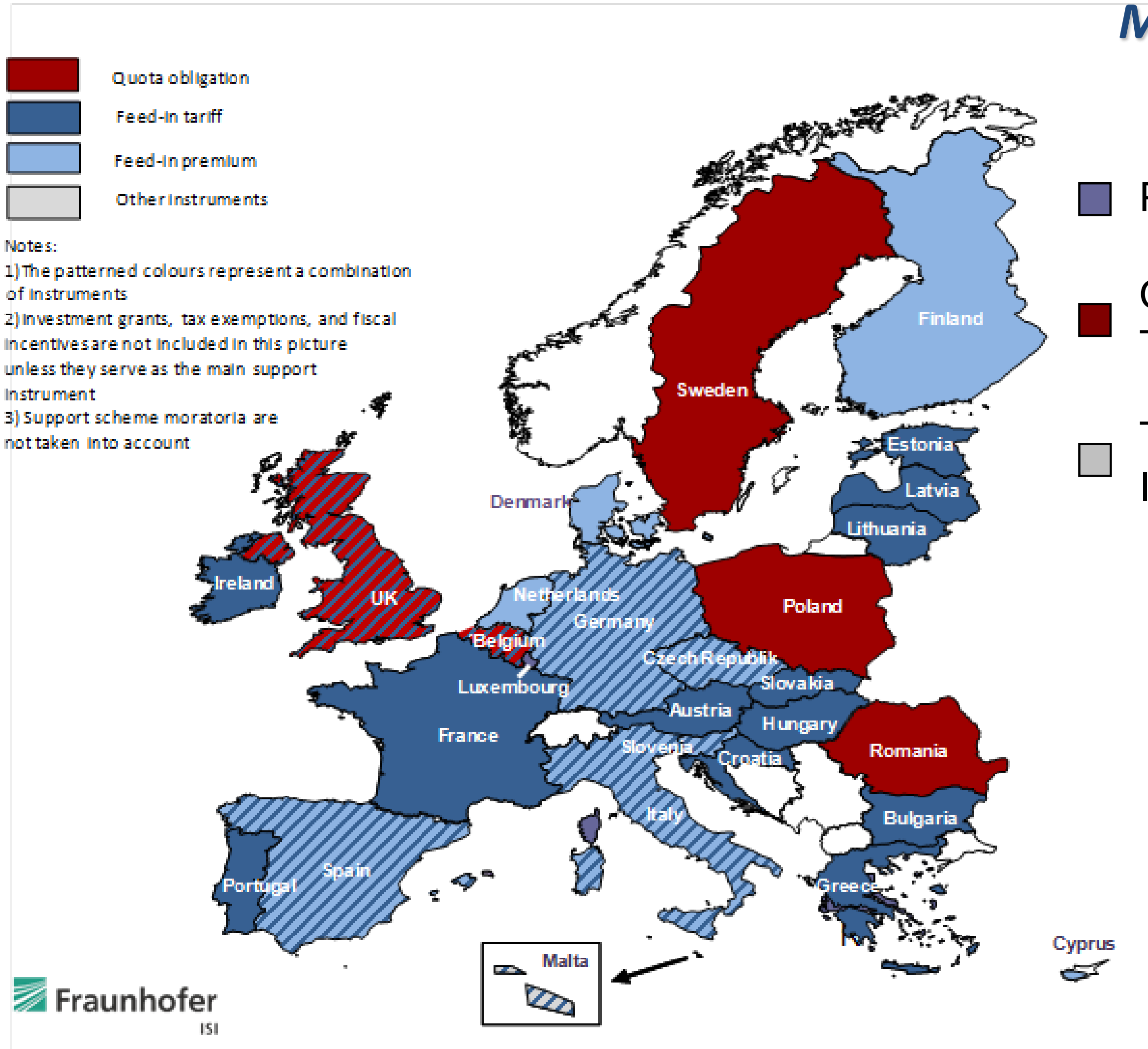
Lessons learnt... in EU countries



>> Source: DIA-CORE <<

Main support instruments for RES-E in EU-28 countries

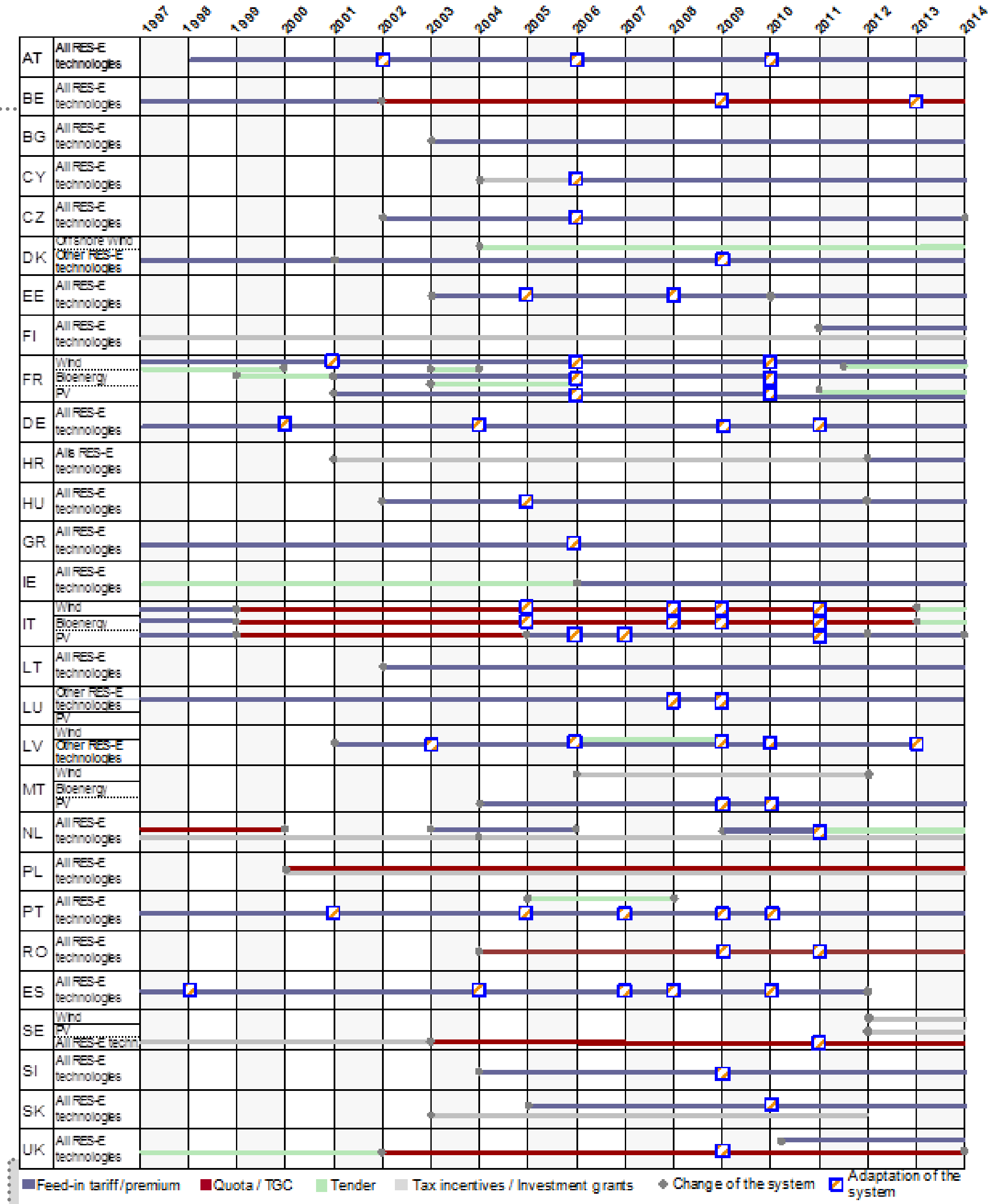
- Feed-in tariff system
- Quota obligation with Tradable Green Certificates (TGC)
- Tax incentives / Investment grants

The majority of EU Member States applies a **Feed-in Tariff/Premium system**

5 countries use a **Quota obligation based on tradable green certificates** (TGC) as main instrument

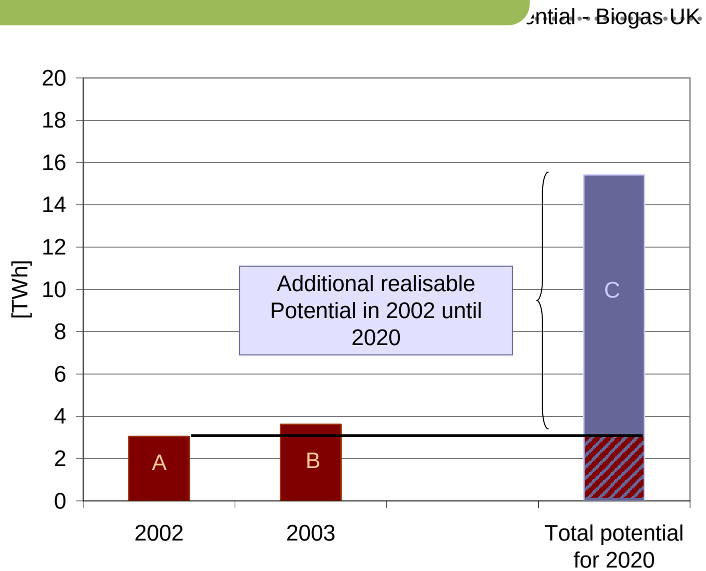
Evolution of the main instruments

in EU member states



>> Source: DIA-CORE <<

(Effectiveness & efficiency of instruments from a historical perspective)



Success in terms of resulting RES-E deployment

Effectiveness Indicator represents the RES-E produced compared to the remaining potential

E = (B-A)/C

The effectiveness of a Member State policy is interpreted in the following as the ratio of the change in the normalised final energy generation during a given period of time and the additional realisable mid-term potential until 2020 for a specific technology

$$E_n^i = \frac{Q_{n(norm)}^i - Q_{n-1(norm)}^i}{POT_{n-1}}$$

where:

E_n^i := *Effectiveness indicator for RET i in year n;*

$Q_{n(norm)}^i$:= *Normalised renewable final energy of RET i in year n (corrected by weather-related influences);*

POT_n := *Additional realisable mid-term potential in year n until 2020*

Lessons learnt... in EU countries

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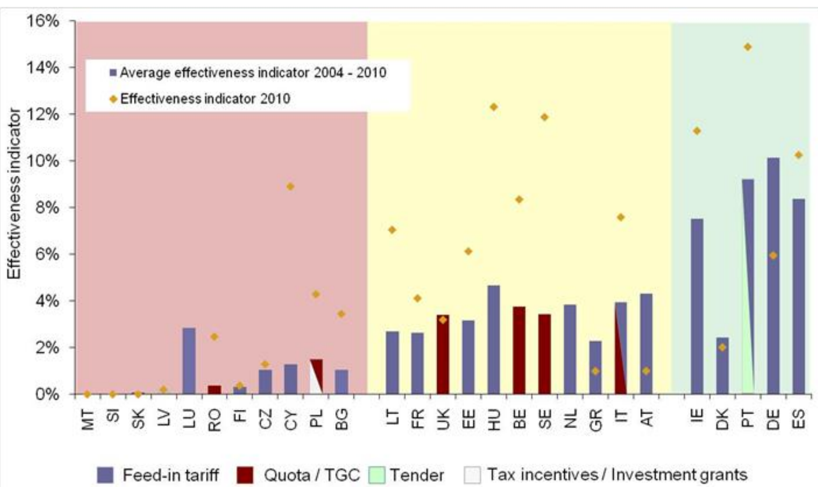
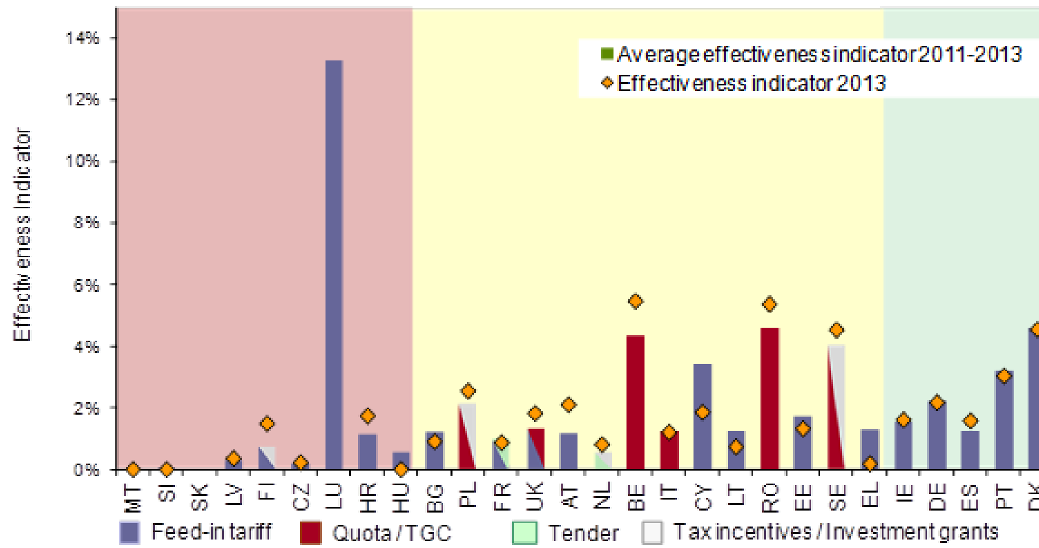
(Effectiveness & efficiency of instruments from a historical perspective)

Success in terms of resulting RES-E deployment

Effectiveness indicator for **wind onshore** electricity in the *period 2004-2010 (left)* and *2011-2013 (right)* in the EU showing the relevant policy schemes during this period





► ***Feed-in tariffs** have been **more successful** in terms of resulting **wind onshore** deployment compared to quota systems in the past decade – but the performance of quotas has improved significantly in recent years*

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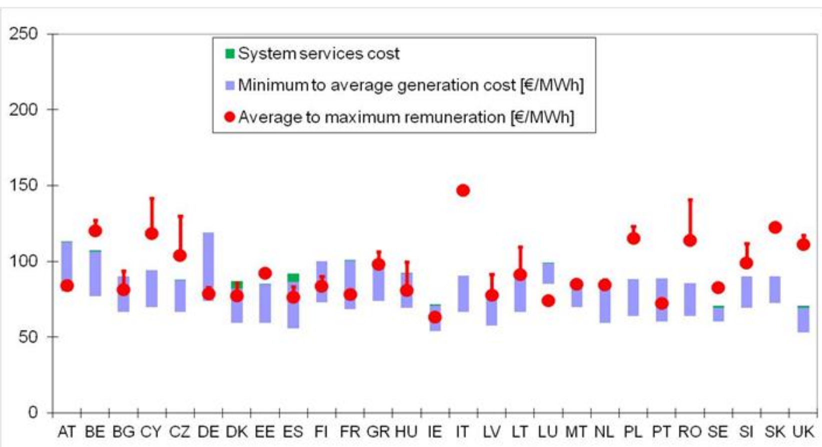
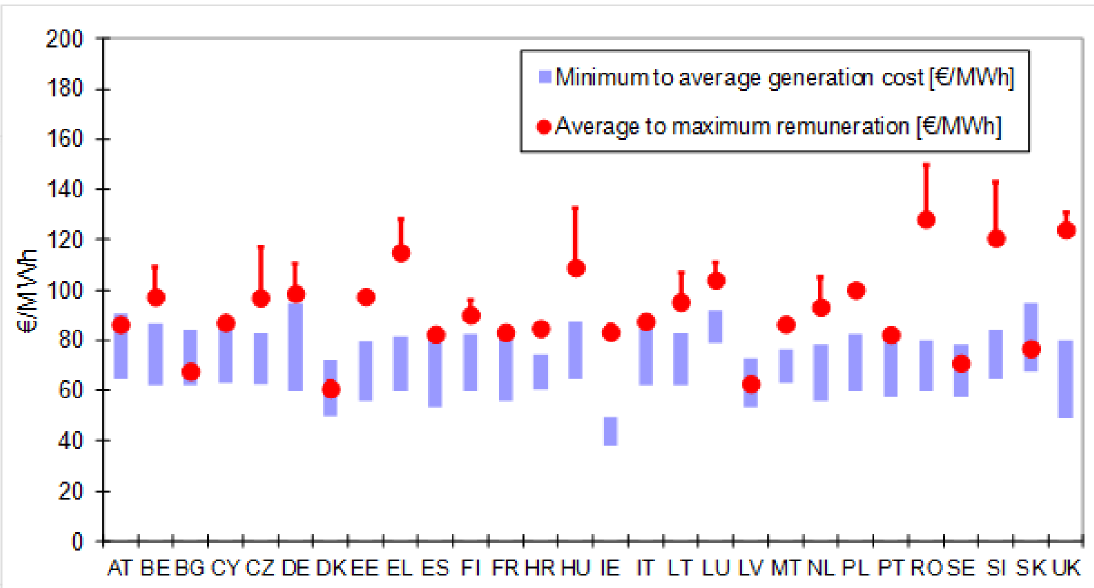
Lessons learnt... in EU countries

(Effectiveness & efficiency of instruments from a historical perspective)

Level of financial support for wind on-shore in the EU

Support level ranges (average to maximum support) for direct support of **wind onshore** in EU Member States (average tariffs are indicative) in *2011 (left) and 2013 (right)* ... compared to the long-term marginal generation costs (minimum to average costs)





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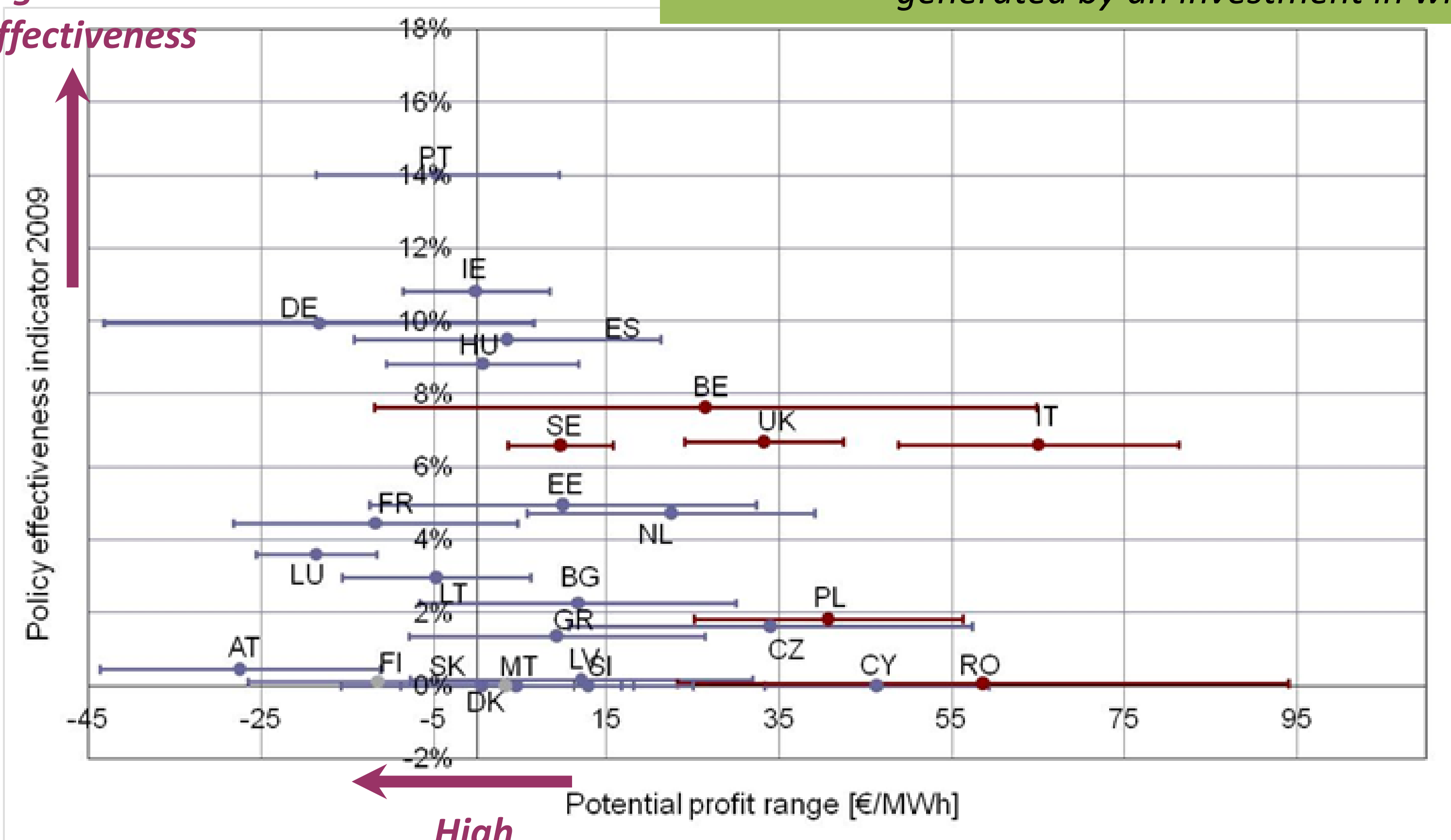
Lessons learnt... in EU countries

(Effectiveness & efficiency of instruments from a historical perspective)

Effectiveness vs. annuity (profit)
for wind onshore

Effectiveness indicator versus levelised profit.
*The figure shows a possible levelised profit per unit of electricity generated by an investment in wind onshore in **2009***

High Effectiveness



High Efficiency

► ***Effectiveness & Efficiency show a proper correlation*** *in several countries*
→ ***technology-specific Feed-in Tariffs appear clearly preferable*** *with respect to wind energy*

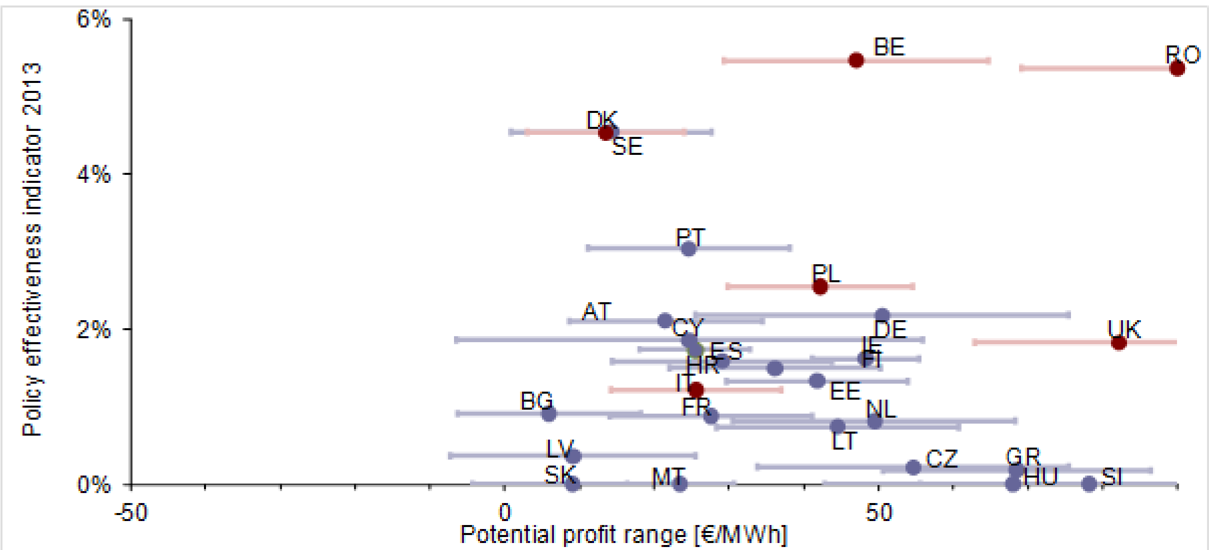
Lessons learnt… in EU countries

(Effectiveness & efficiency of instruments from a historical perspective)

Effectiveness vs. annuity (profit)
for wind onshore

Effectiveness indicator versus levelised profit.
*The figure shows a possible levelised profit per unit of electricity generated by an investment in wind onshore in **2013***

High Effectiveness



High Efficiency

► ***Most effective have been countries with high (over)support** in the case of wind energy – but several countries show a proper performance (high efficiency & moderate effectiveness)*

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Conclusions (1) ...

(Effectiveness & efficiency of instruments from a historical perspective)

- *Comparison of support scheme performance*

Compared to previous analyses the policy effectiveness in quota-using countries in the last two years shows improving values for low-cost technologies (wind onshore and biomass), but in general feed-in systems still appear to be more effective than quota obligations.

- *Policy costs*

When evaluating policy effectiveness of a support scheme, stimulated capacity growth also may develop faster than envisaged and therewith cause high policy costs.

→ technology-specific support (feed-in systems) (without budget constraints) carries the risk of involving considerable policy costs for consumers if the market for a cost-intensive technology is booming unexpectedly, as happened with the development of solar PV power plants in Spain, the Czech Republic in 2008/2009 or in Germany in 2009/2010.

→ This risk exists to a lesser extent also in quota systems with technology-specific banding or minimum prices.

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Conclusions (2) ...

(Effectiveness & efficiency of instruments from a historical perspective)

➢ *Identification of best practice countries*

- The leading countries in terms of effectively supporting **wind onshore** energy over the last seven years are Germany, Spain, Portugal and Ireland. At the same time all these countries show an advanced market deployment status.
- Looking at the effectiveness of policy support for **wind offshore**, it becomes clear that market development is just starting in a few countries (United Kingdom, the Netherlands and Denmark).
- Examples for an effective promotion of **solar PV** are Germany, the Czech Republic, Belgium, and Italy.
- In terms of supporting **biomass-based electricity** some Member States already have a very advanced deployment status. Of the others, Belgium has achieved the most effective policy support in recent years due to their low domestic potential.
- In case of **biogas power plants**, Austria, Germany and the United Kingdom still apply very effective support schemes.