ON MODELING THE FUTURE OF RENEWABLE ENERGY SOURCES IN EUROPE FROM A TECHNO– INSTITUTIONAL PERSPECTIVE

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SURVEY

1. Introduction
2. Political-Institutional background
3. Current state and potentials
4. Method of approach: Cost curves
5. The issue of transfer costs
6. The model GREEN-X
7. Some results from GREEN-X
8. Success of promotion strategies
9. Competitive markets?
10. Conclusions

Associated benefits of RES beyond power production:

- reduced energy import dependence and provision of a more diversified resource base;
- increases in local employment and income;
- hedge against volatile fossil fuel prices as well as avoided risks of disruption in fossil fuel supply;
- the potential to greatly reduce, and perhaps eventually eliminate pollution and greenhouse gas emissions associated with current electricity generation.

1 INTRODUCTION

CORE MOTIVATION:

Policy targets for an INCREASE of RES-E!

(e.g. currently discussed targets of 20% for 2020)

2 THE POLITICAL– INSTITUTIONAL BACKGROUND

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What is the problem?

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SURVEY ON INSTRUMENTS TO PROMOTE ELECTRICITY FROM RENEWABLES

		REGULATORY	VOLUNTARY
Capacity-driven strategies	Generation-based	• RPS • Quota-based TGCs	• National generation targets
	Investment focused	• Bidding/Tendering	• National installation or capacity targets
Price-driven strategies	Generation-based	• feed-in tariffs, • rate-based incentives • Net metering	• Green Power Marketing • Green tariffs • Solar stock exchange
	Investment focused	• Rebates • Soft loans • Tax incentives	• Contracting • Shareholder progr. • Contribution • Bidding
Other		–	• NGO-marketing • Selling green buildings • Retailer progr. • Financing • Public building prog.

What is the problem?

Which instrument fits best?

Answer depends on POLICY OBJECTIVE

Should an **ambitious RES-E target be met** in the short and long-term?

Should it reflect the external costs?

Should RES-E technologies be promoted on broad scale?

Should it be compatible with the conventional electricity market?

Should the system be implemented on a national or international level?

Is international burden sharing for consumer an important goal?

How should the premium costs / burden for consumer be distributed over time?

Source: GREEN-X

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MAJOR PROBLEM:

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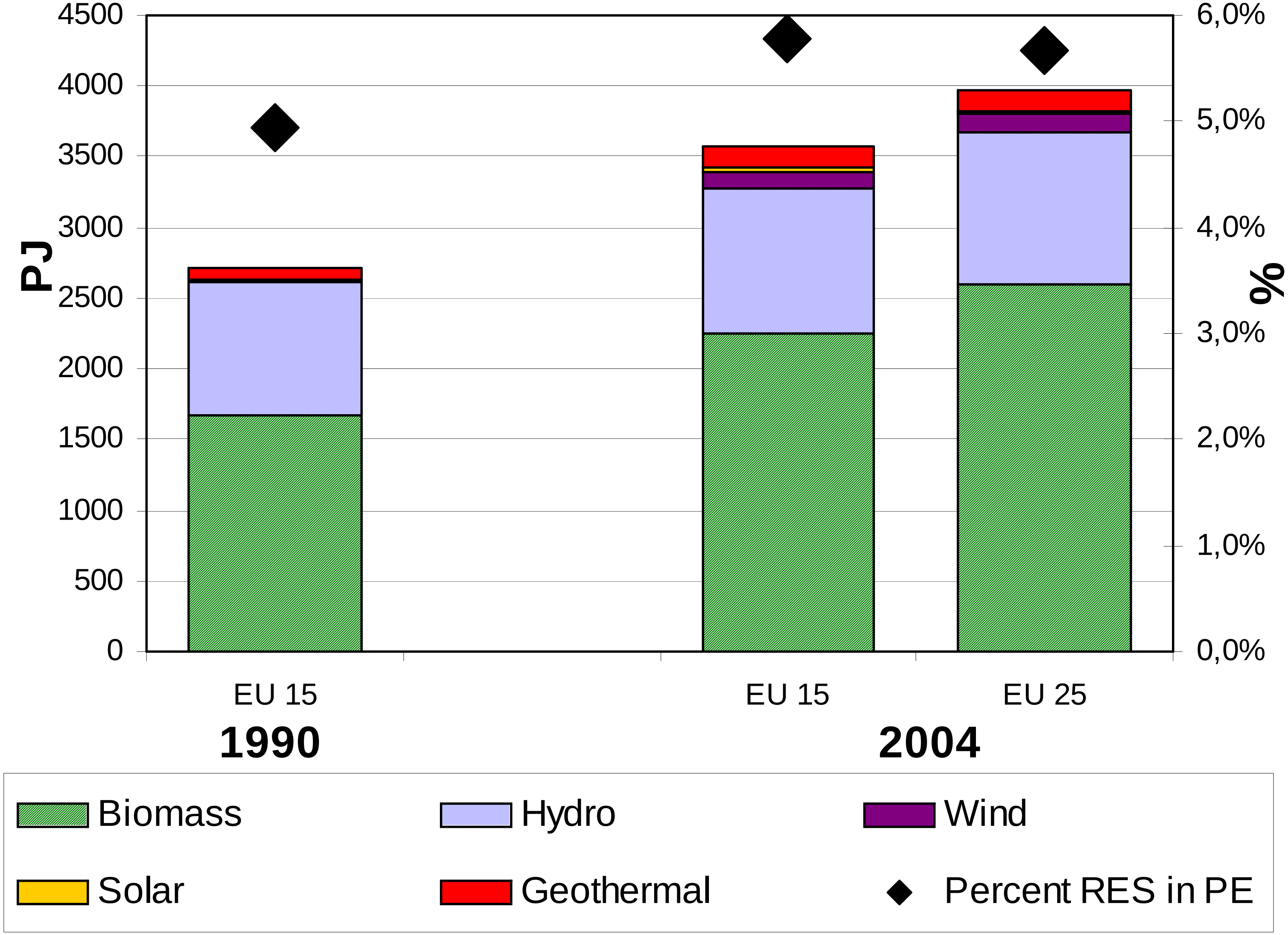
Correct design of policy

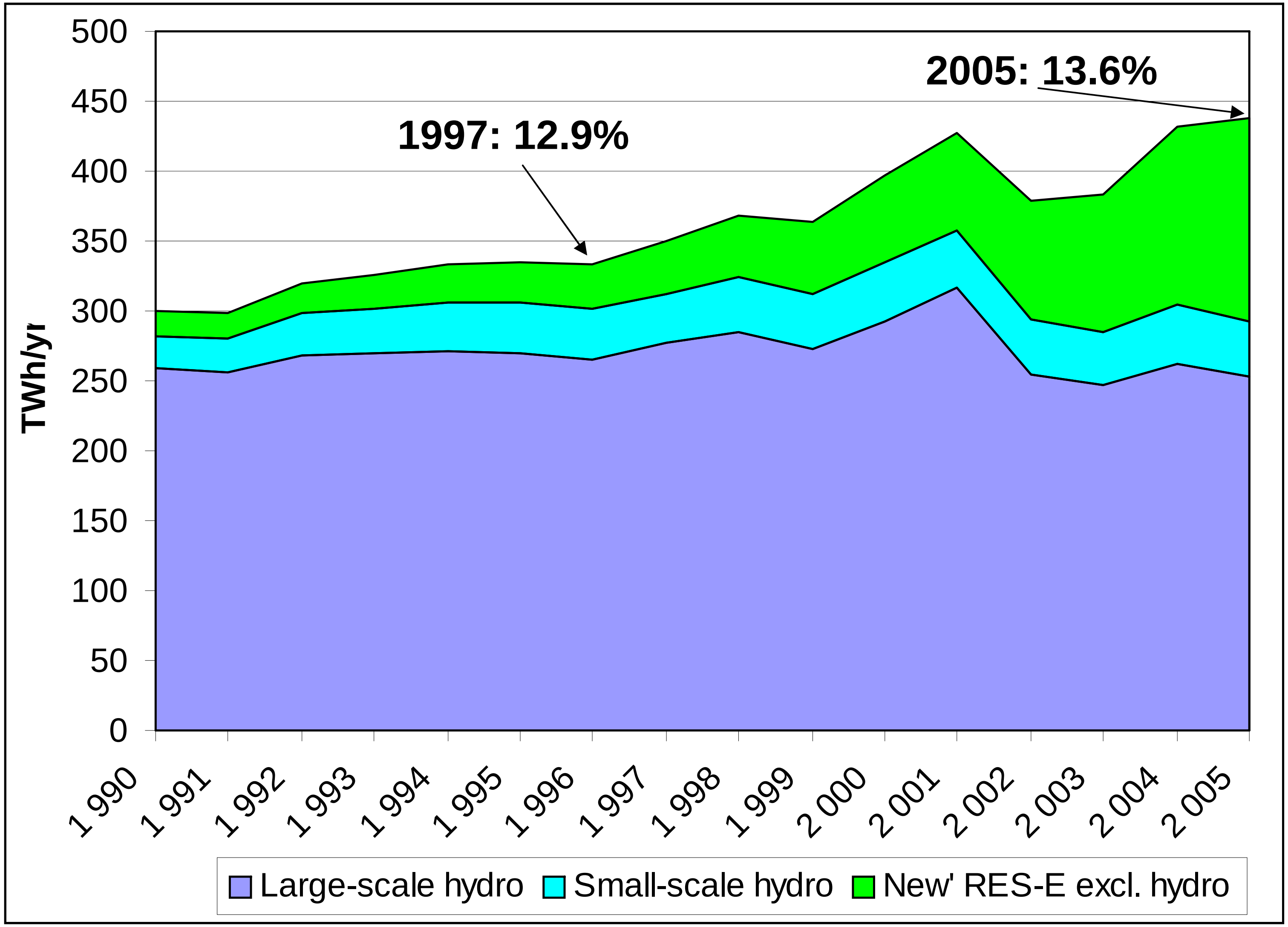
- with respect to:
  - renewable targets
  - Financial incentives
  - Credibility for investors
  - Consideration of external costs?

3. THE CURRENT SITUATION OF RENEWABLES IN EUROPE

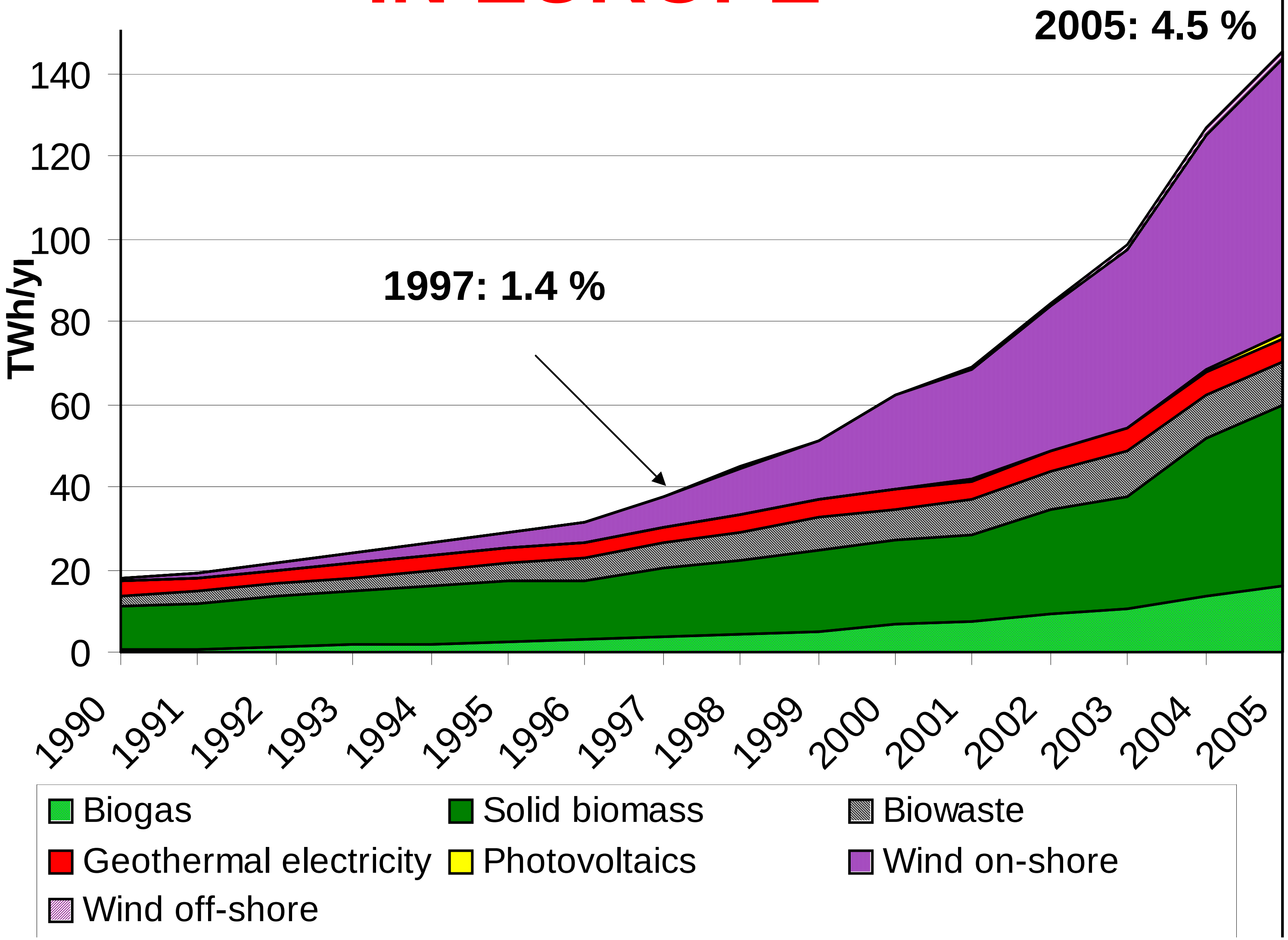
PRIMARY ENERGY FROM RES



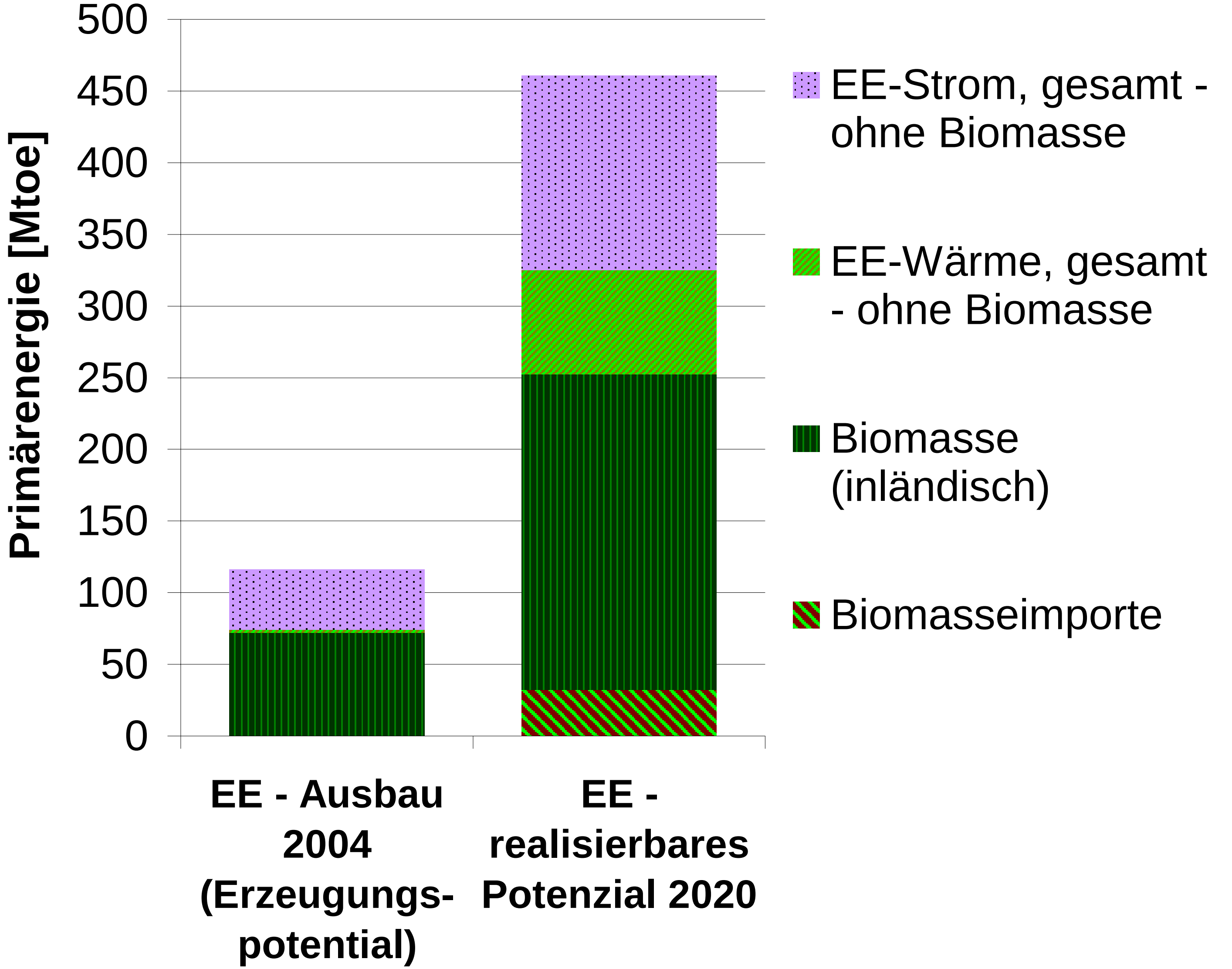
TOTAL ELECTRICITY GENERATION FROM RENEWABLES IN EUROPE



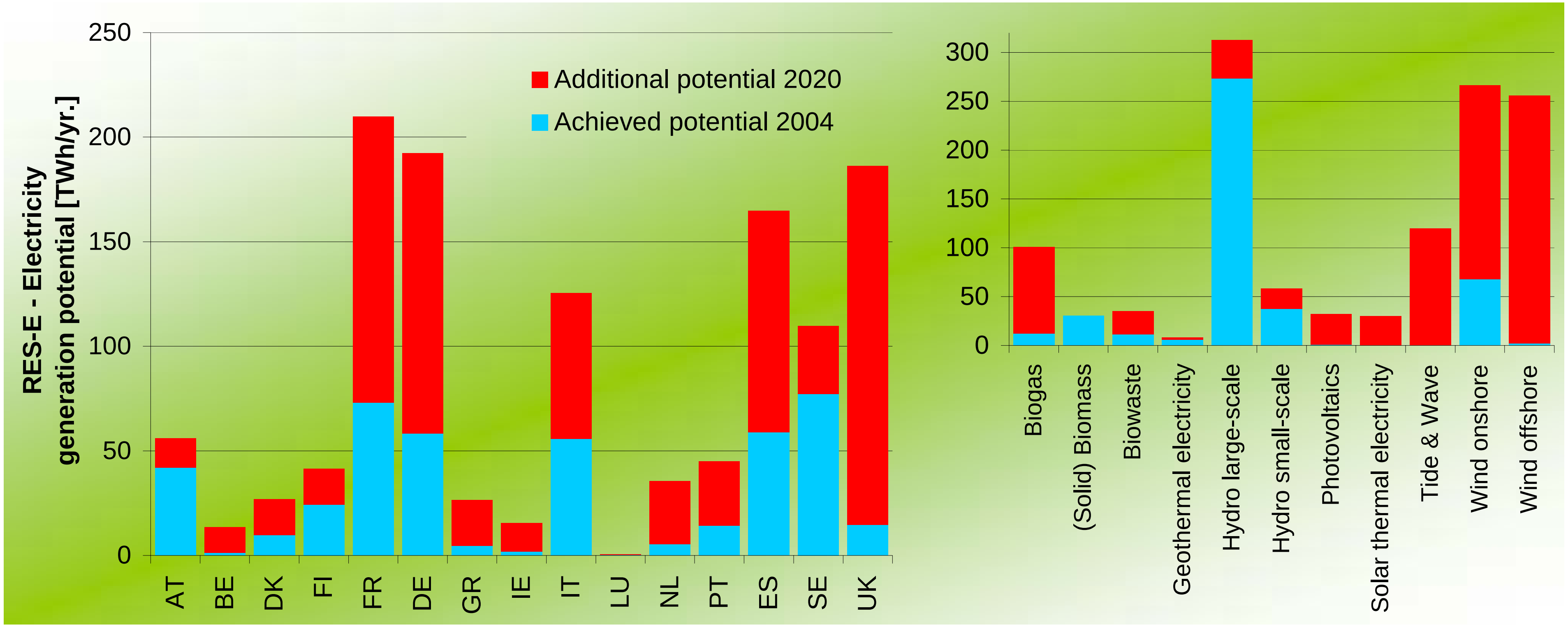
ELECTRICITY GENERATION FROM „NEW“ RENEWABLES IN EUROPE



PRIMARY ENERGY POTENTIAL 2020



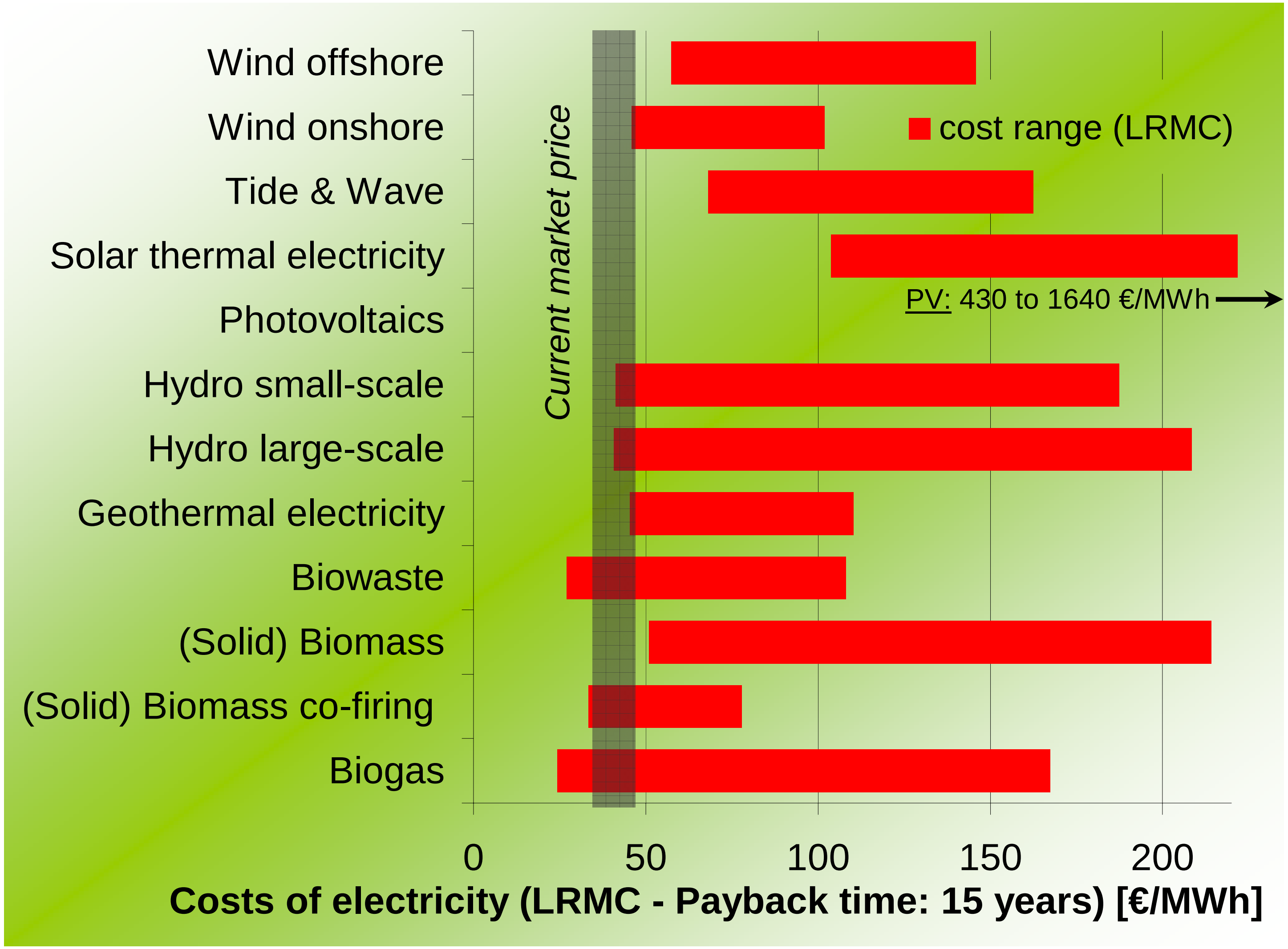
POTENTIALS CURRENT AND 2020



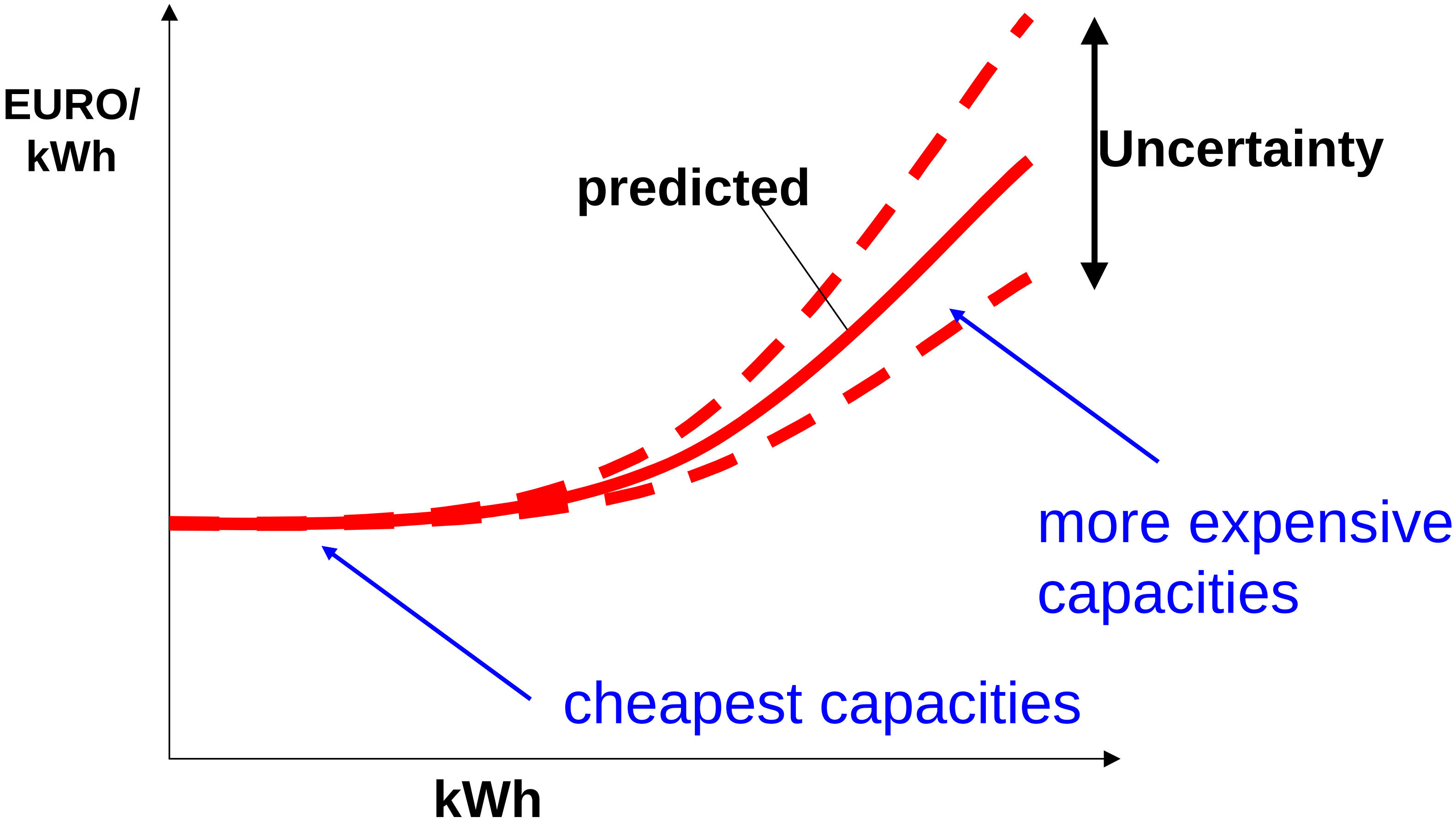
... *by country (left)*

... *by technology (right)*

GENERATION COSTS BY TECHNOLOGY



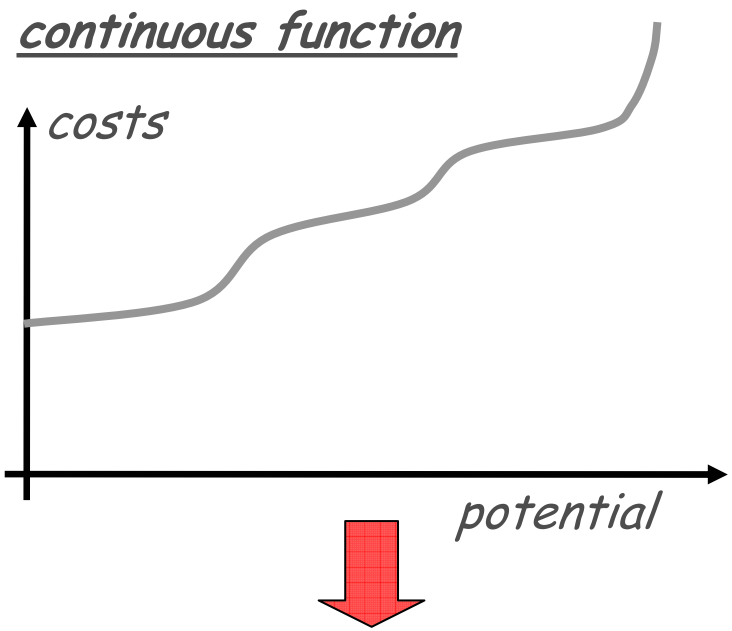
4. METHOD OF APPROACH: STATIC COST RESOURCE CURVES



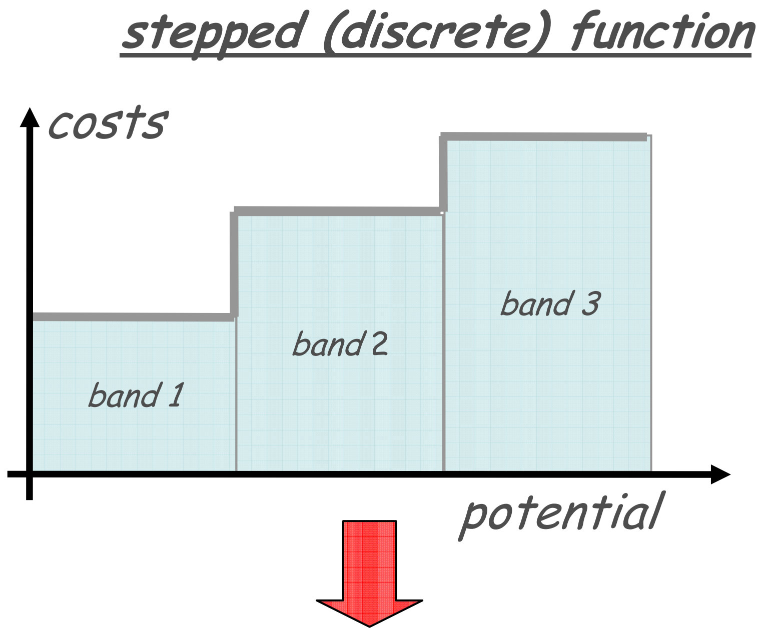
Static cost-resource curves

- Combines information on the **potential** and the according **costs** (of electricity for a specific energy source).
- For **limited resources** (as RES-E) **costs rise with increased utilization.**
- All costs/potentials-bands are **sorted in a least cost way**

costs = f (potential); t = constant



„...every location is slightly different"



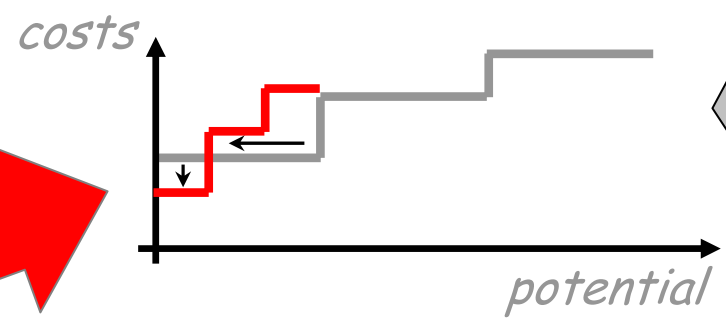
Practical approach: Sites with similar characteristics described by one band

Dynamic cost-resource curves

Potentials
- by RES-E technology *(by band)*
- by country

Costs of electricity
- by RES-E technology *(by band)*
- by country

DYNAMIC COST-RESOURCE CURVES
- by RES-E technology
- by country
- ***by year***



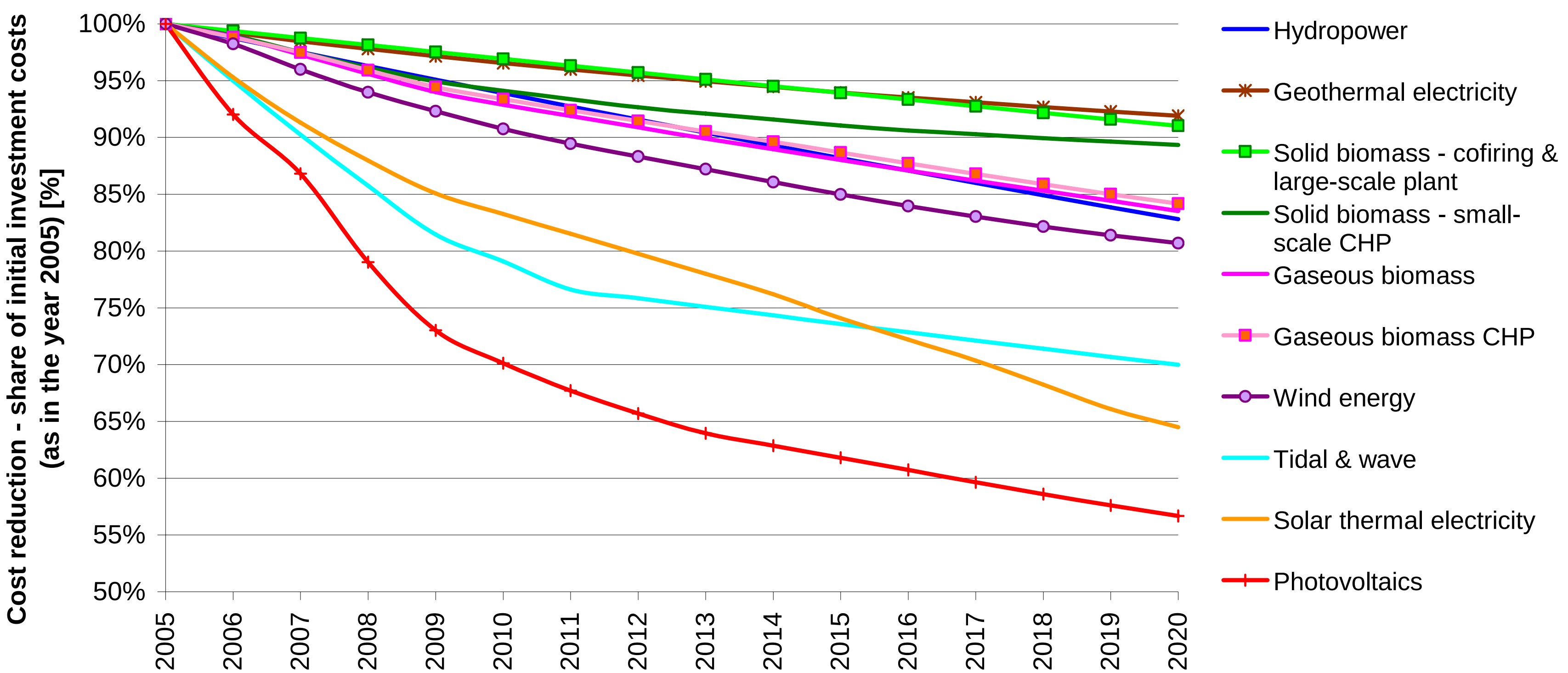
Dynamic aspects
- Costs: **Dynamic cost assessment** *(technological change)*
- Potentials: **Dynamic restrictions** *(technology diffusion)*

(7) Results

Reduction of investment cost within the BAU-scenario due to technological learning

Resulting cost reduction for RES-E technologies

BAU scenario



5. THE ISSUE OF TRANSFER COSTS AND EXTERNALITIES

All regulatory ***promotion schemes (Quota-based TGC systems, tendering systems, Feed-in tariffs) create an***

artificial market

and cause

transfer costs (additional costs)

It is important to minimize these additional transfer costs. Why?

These additional costs have finally to be paid by the electricity customers

(regardless which promotion scheme is chosen)

Method of approach (EU-project GREEN-X)

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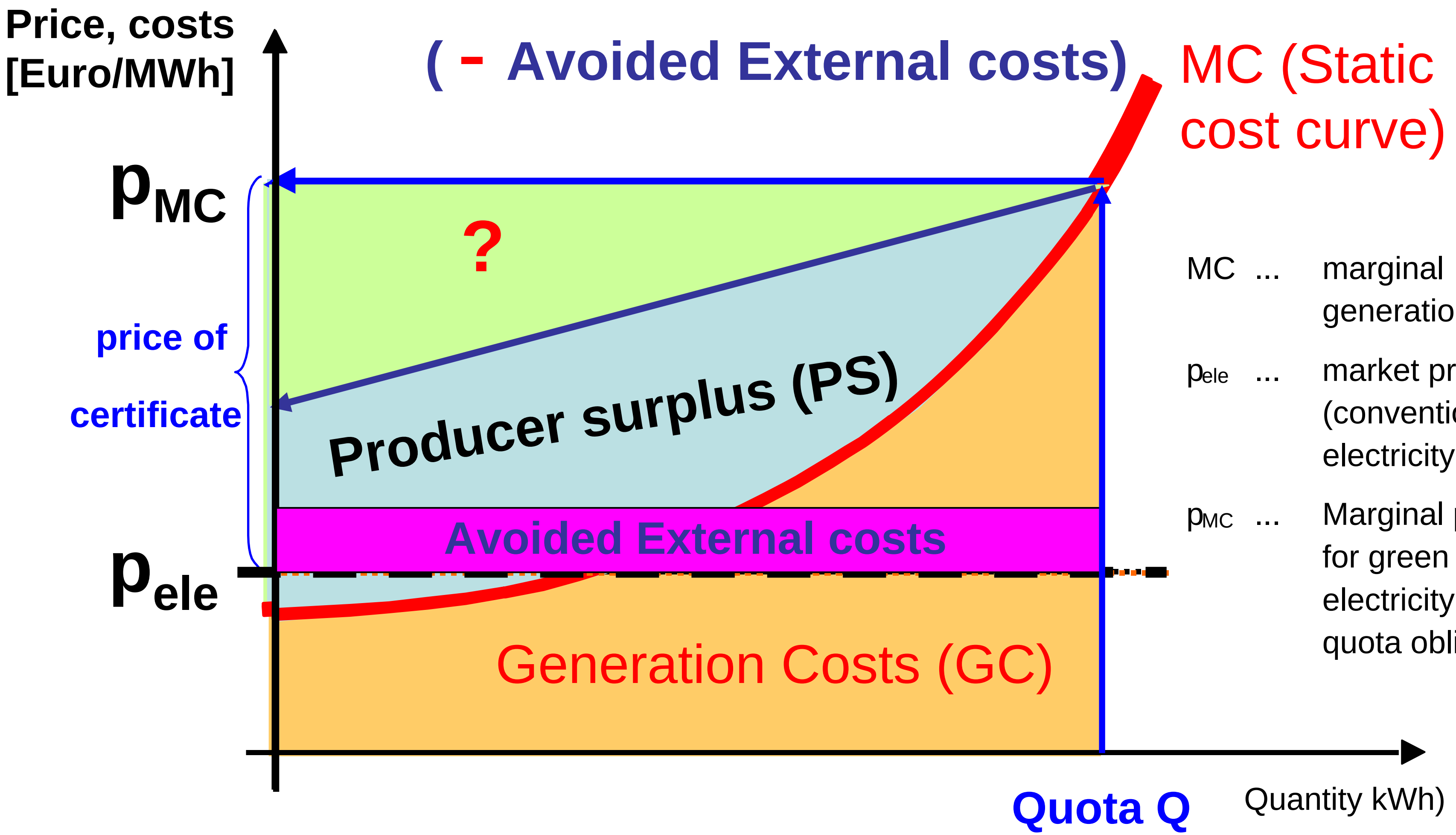
Minimise additional costs for consumers = Producer Surplus + Generation costs - Revenues electricity market (- Avoided External costs)



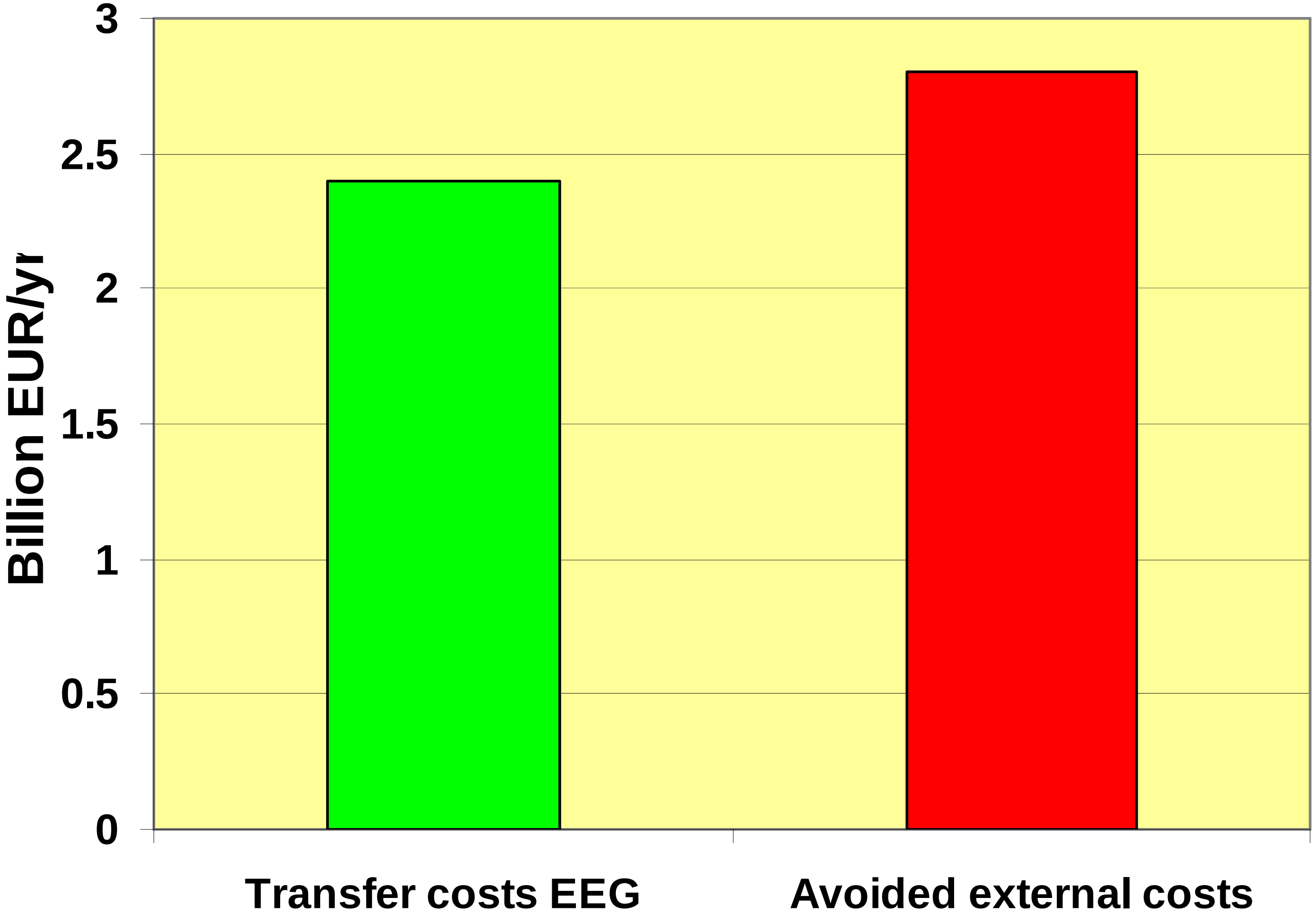
MC ... marginal generation costs

p_{ele} ... market price for (conventional) electricity

p_{MC} ... Marginal price for green electricity (due to quota obligation)

Transfer costs vs avoided costs

Example: Promotion of wind in Germany 2005



Source: Krewitt/Schlomann: Externe Kosten …(2006)

The lower the additional costs (=transfer costs) are which have finally to be paid by electricity customers

the higher will be public acceptance

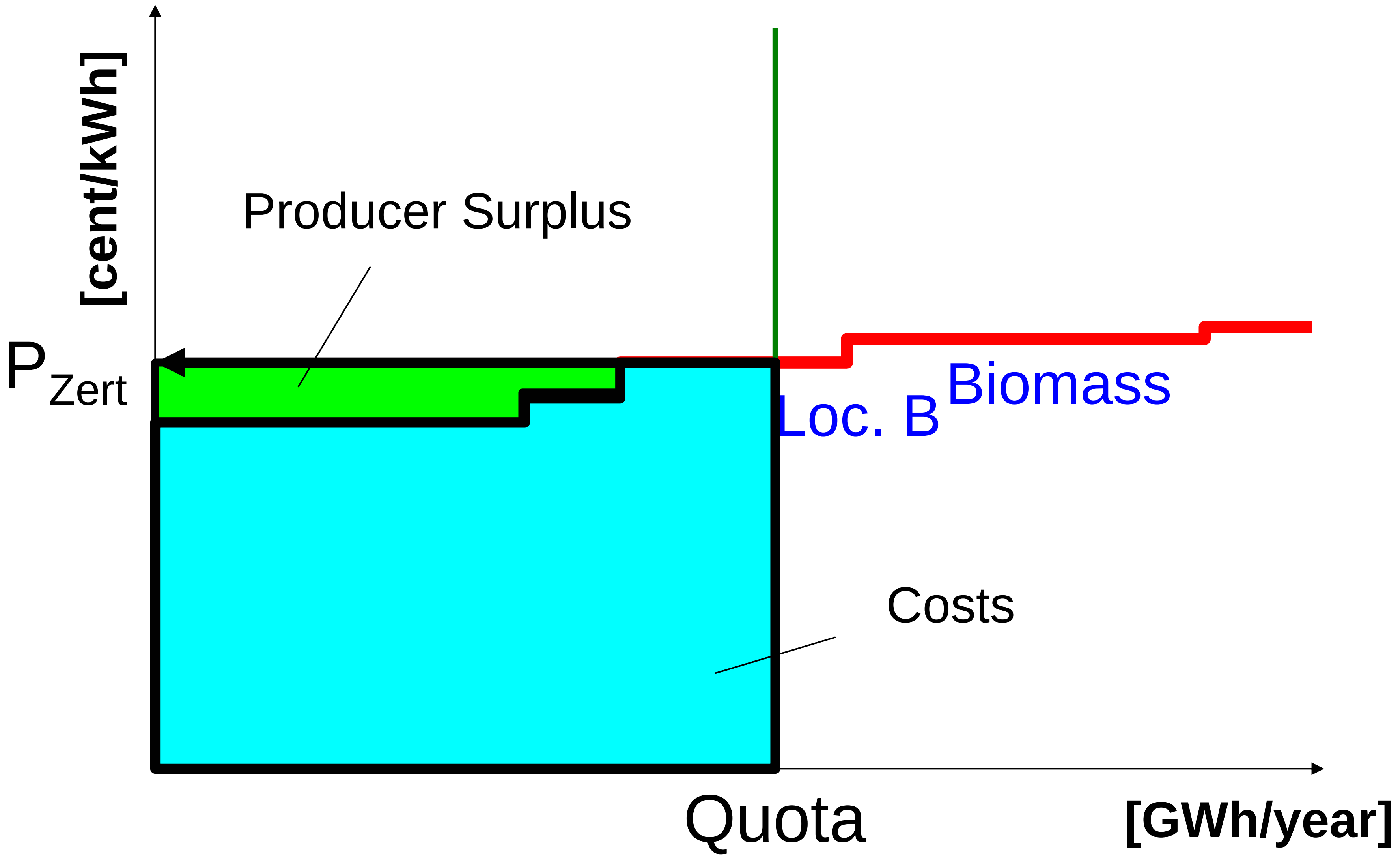
the larger will be the amount of additional electricity generated from RES.

An example from the conventional electricity market:

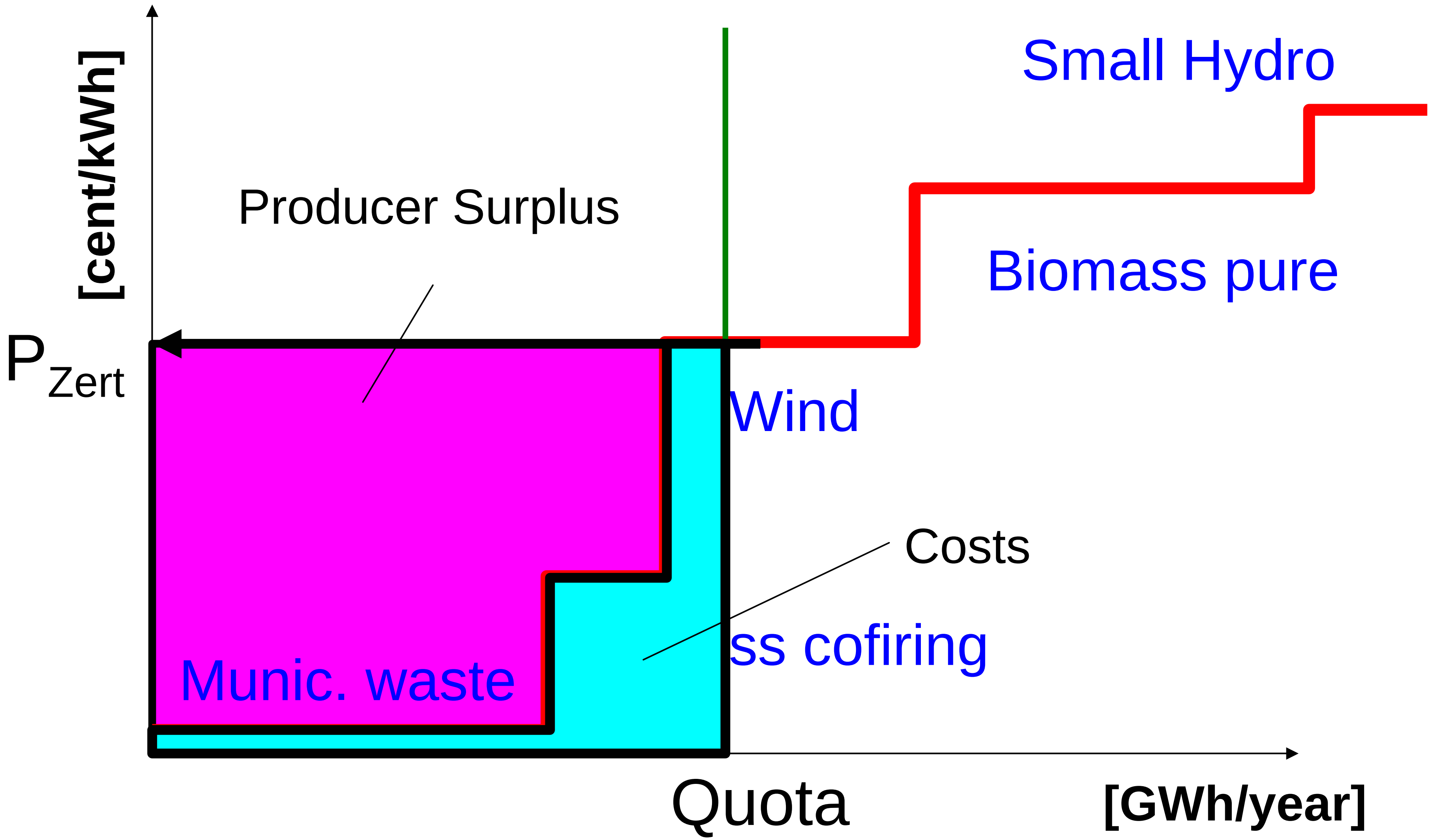
in several countries (e.g. Germany, Belgium) customers are fed up with the high profits the large incumbent utilities make in the "free" market

they request a re-regulation of electricity prices!

IMPACT OF THE SHAPE OF THE COST CURVE



IMPACT OF THE SHAPE OF THE COST CURVE



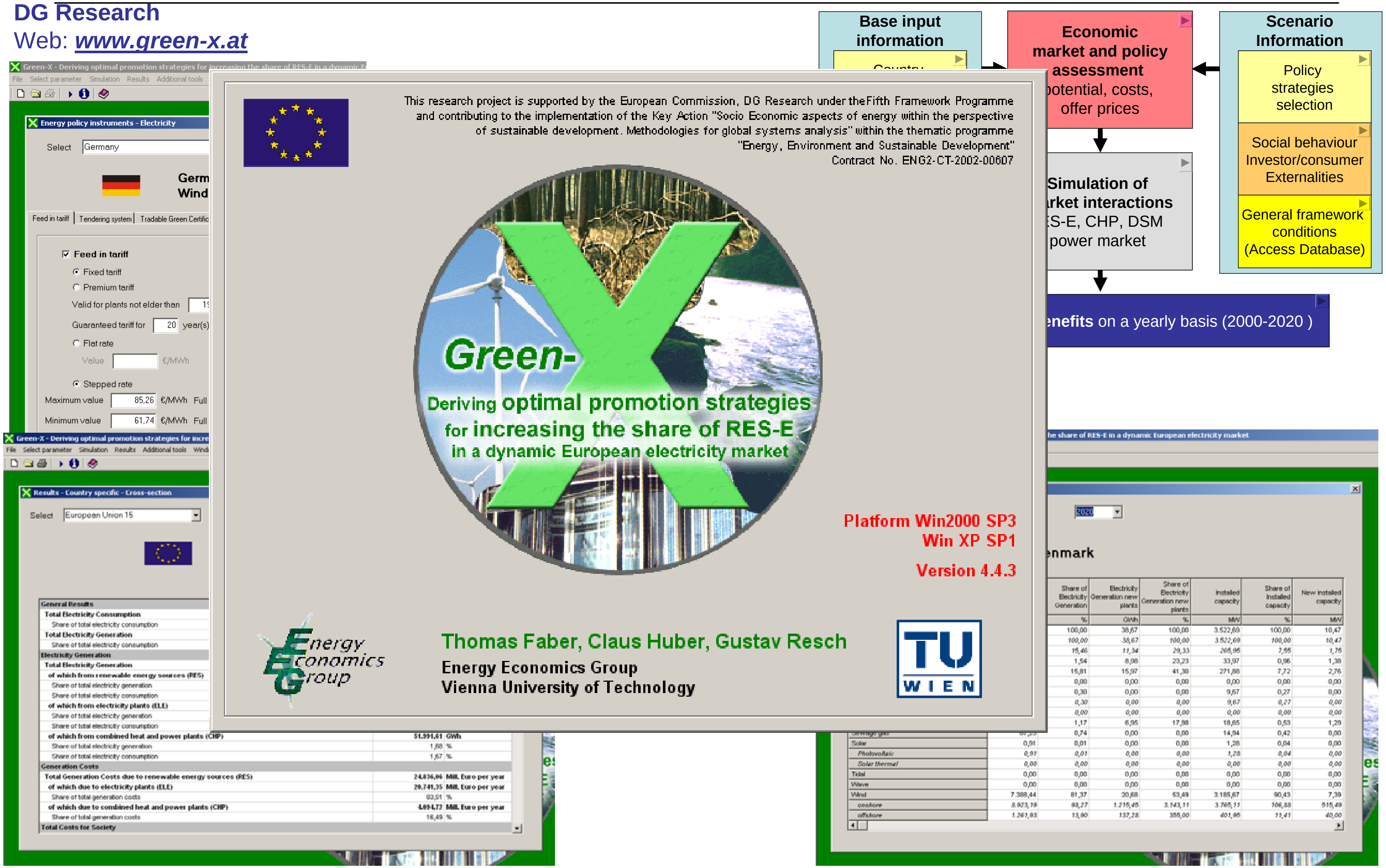
6. The simulation tool Green-X

EU-Project Green-X

DG Research

Web: *www.green-x.at*

The toolbox Green-X



GREEN-X allows…

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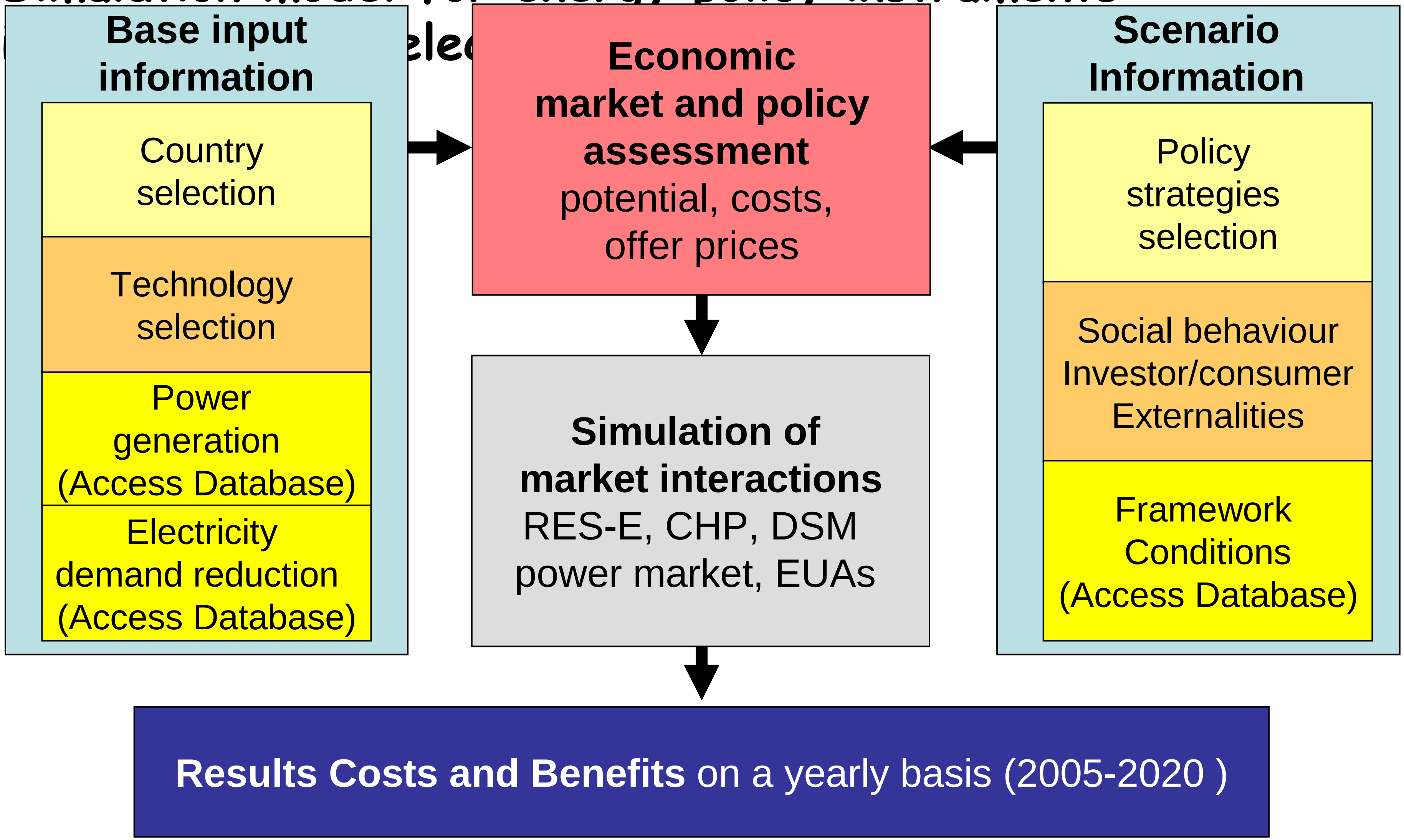
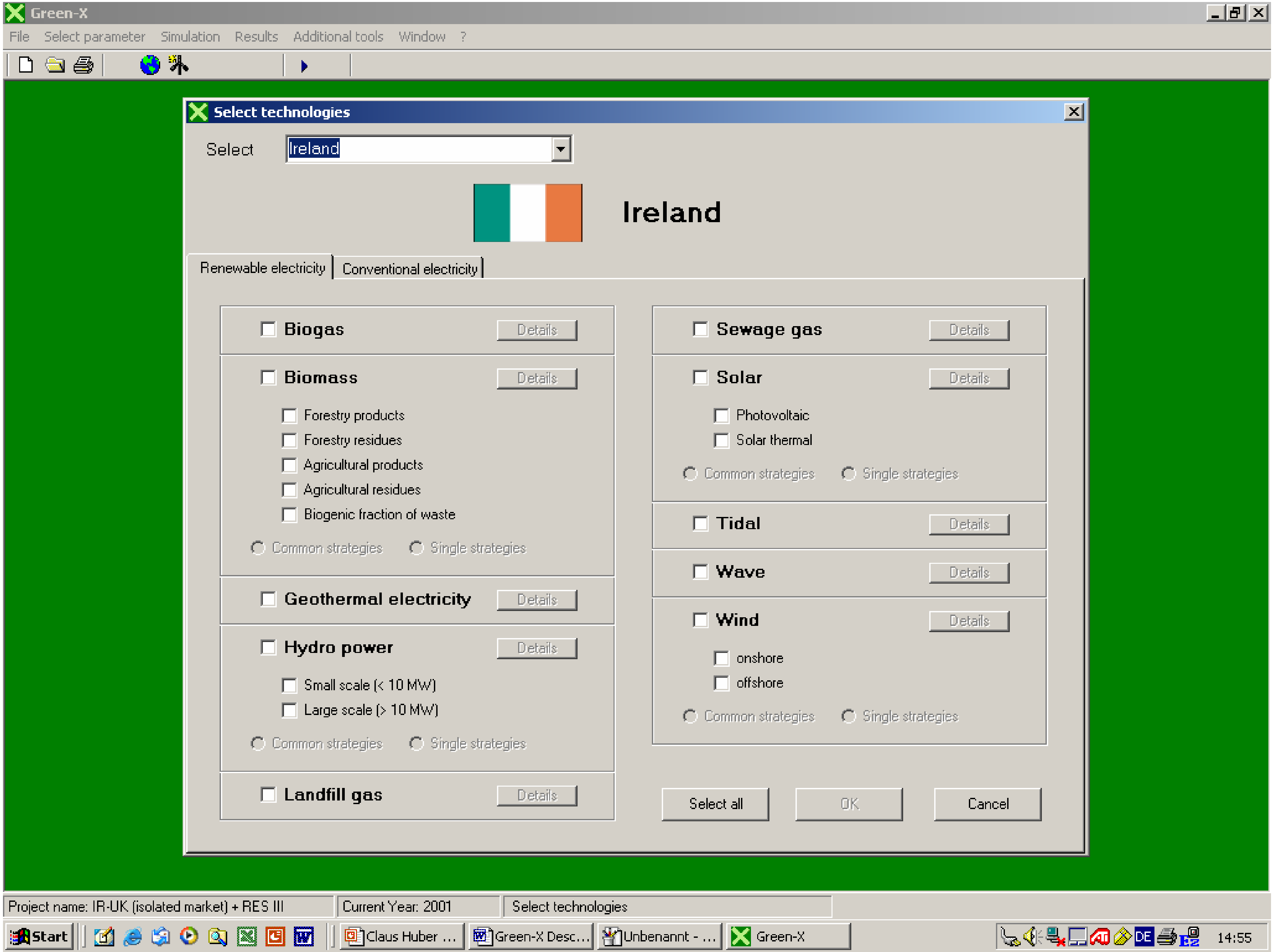
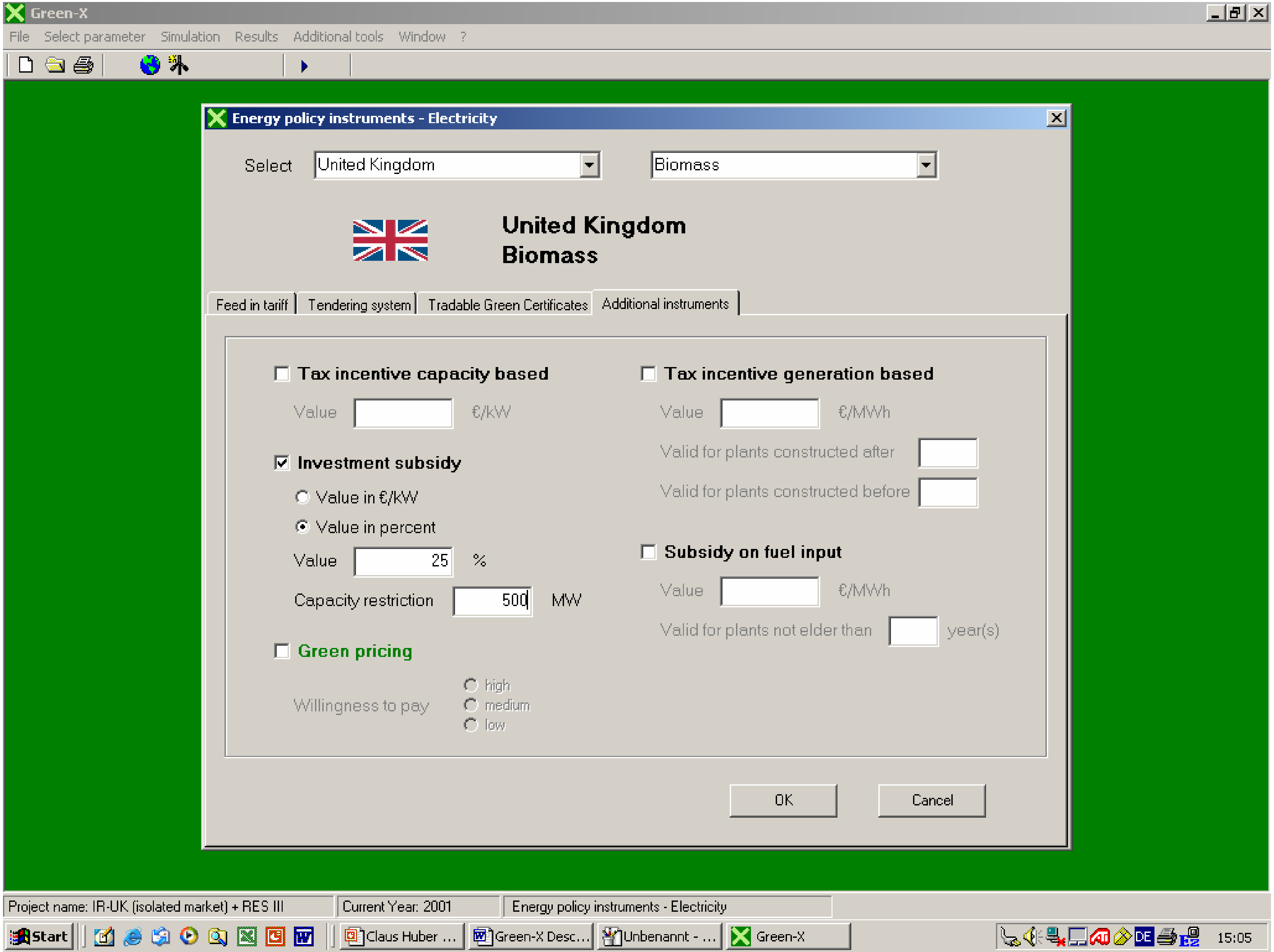
… to simulate various policy strategies for the promotion of electricity from RES in a dynamic framework on a national or international level *(considering DS-effects)*

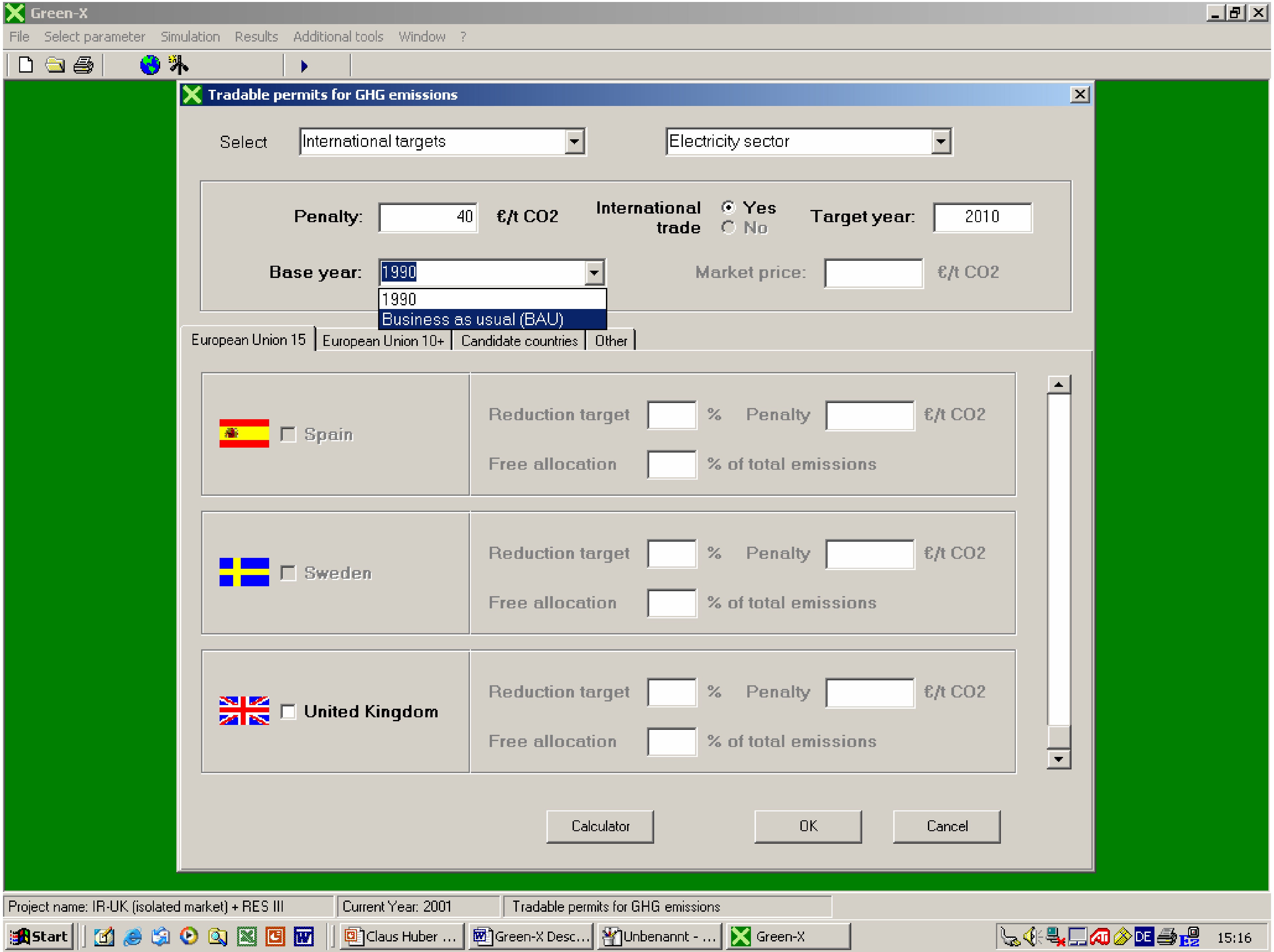
(Current: EU-25, future: EU 39???)

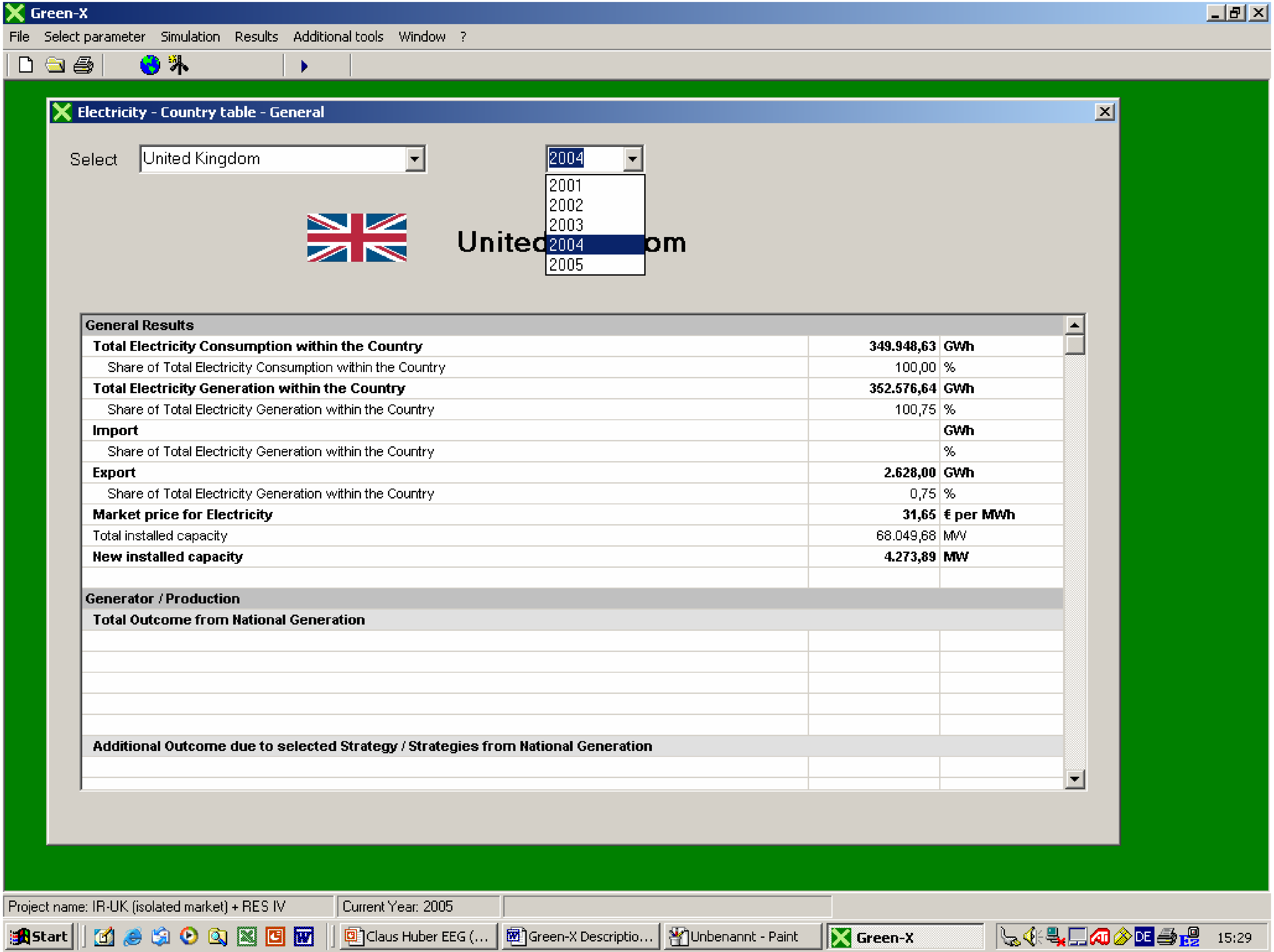
Simulation model for energy policy instruments




Green-X
File Select parameter Simulation Results Additional tools Window ?
Select technologies
Select
Ireland
Ireland
Renewable electricity
Conventional electricity
Biogas
Details
Biomass
Details
Forestry products
Forestry residues
Agricultural products
Agricultural residues
Biogenic fraction of waste
Common strategies
Single strategies
Geothermal electricity
Details
Hydro power
Details
Small scale (< 10 MW)
Large scale (> 10 MW)
Common strategies
Single strategies
Landfill gas
Details
Sewage gas
Details
Solar
Details
Photovoltaic
Solar thermal
Common strategies
Single strategies
Tidal
Details
Wave
Details
Wind
Details
onshore
offshore
Common strategies
Single strategies
Select all
OK
Cancel
Project name: IR-UK (isolated market) + RES III
Current Year: 2001
Select technologies
Start
Claus Huber ...
Green-X Desc...
Unbenannt - ...
Green-X
14:55


Green-X
File
Select parameter
Simulation
Results
Additional tools
Window
?
Energy policy instruments - Electricity
Select
United Kingdom
Biomass
United Kingdom
Biomass
Feed in tariff
Tendering system
Tradable Green Certificates
Additional instruments
Tax incentive capacity based
Value
€/kW
Tax incentive generation based
Value
€/MWh
Valid for plants constructed after
Valid for plants constructed before
Investment subsidy
Value in €/kW
Value in percent
Value
25
%
Capacity restriction
500
MW
Subsidy on fuel input
Value
€/MWh
Valid for plants not elder than
year(s)
Green pricing
Willingness to pay
high
medium
low
OK
Cancel
Project name: IR-UK (isolated market) + RES III
Current Year: 2001
Energy policy instruments - Electricity
Start
Claus Huber ...
Green-X Desc...
Unbenannt - ...
Green-X
15:05


Green-X
File
Select parameter
Simulation
Results
Additional tools
Window
?
Tradable permits for GHG emissions
Select
International targets
Electricity sector
Penalty:
40
€/t CO2
International trade
Yes
No
Target year:
2010
Base year:
1990
Market price:
€/t CO2
1990
Business as usual (BAU)
European Union 15
European Union 10+
Candidate countries
Other
Spain
Reduction target
%
Penalty
€/t CO2
Free allocation
% of total emissions
Sweden
Reduction target
%
Penalty
€/t CO2
Free allocation
% of total emissions
United Kingdom
Reduction target
%
Penalty
€/t CO2
Free allocation
% of total emissions
Calculator
OK
Cancel
Project name: IR-UK (isolated market) + RES III
Current Year: 2001
Tradable permits for GHG emissions
Start
Claus Huber ...
Green-X Desc...
Unbenannt - ...
Green-X
15:16


Green-X
File Select parameter Simulation Results Additional tools Window ?
Electricity - Country table - General
Select United Kingdom
2004
2001
2002
2003
2004
2005
United Kingdom
General Results
Total Electricity Consumption within the Country 349.948,63 GWh
Share of Total Electricity Consumption within the Country 100,00 %
Total Electricity Generation within the Country 352.576,64 GWh
Share of Total Electricity Generation within the Country 100,75 %
Import GWh
Share of Total Electricity Generation within the Country %
Export 2.628,00 GWh
Share of Total Electricity Generation within the Country 0,75 %
Market price for Electricity 31,65 € per MWh
Total installed capacity 68.049,68 MW
New installed capacity 4.273,89 MW
Generator / Production
Total Outcome from National Generation
Additional Outcome due to selected Strategy / Strategies from National Generation
Project name: IR-UK (isolated market) + RES IV
Current Year: 2005
Start
Claus Huber EEG (...
Green-X Descriptio...
Unbenannt - Paint
Green-X
15:29

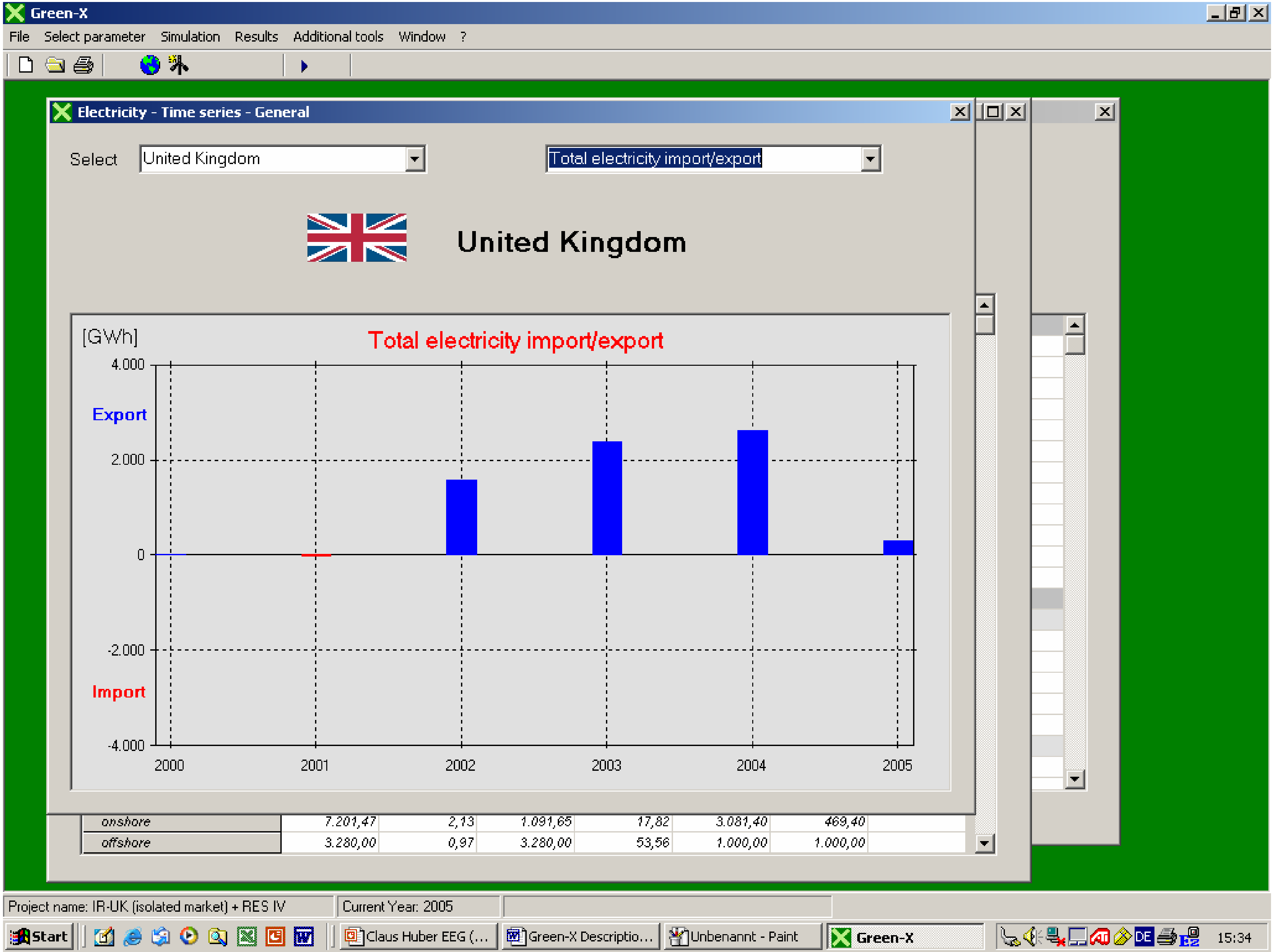
Electricity - Country table - Technologies

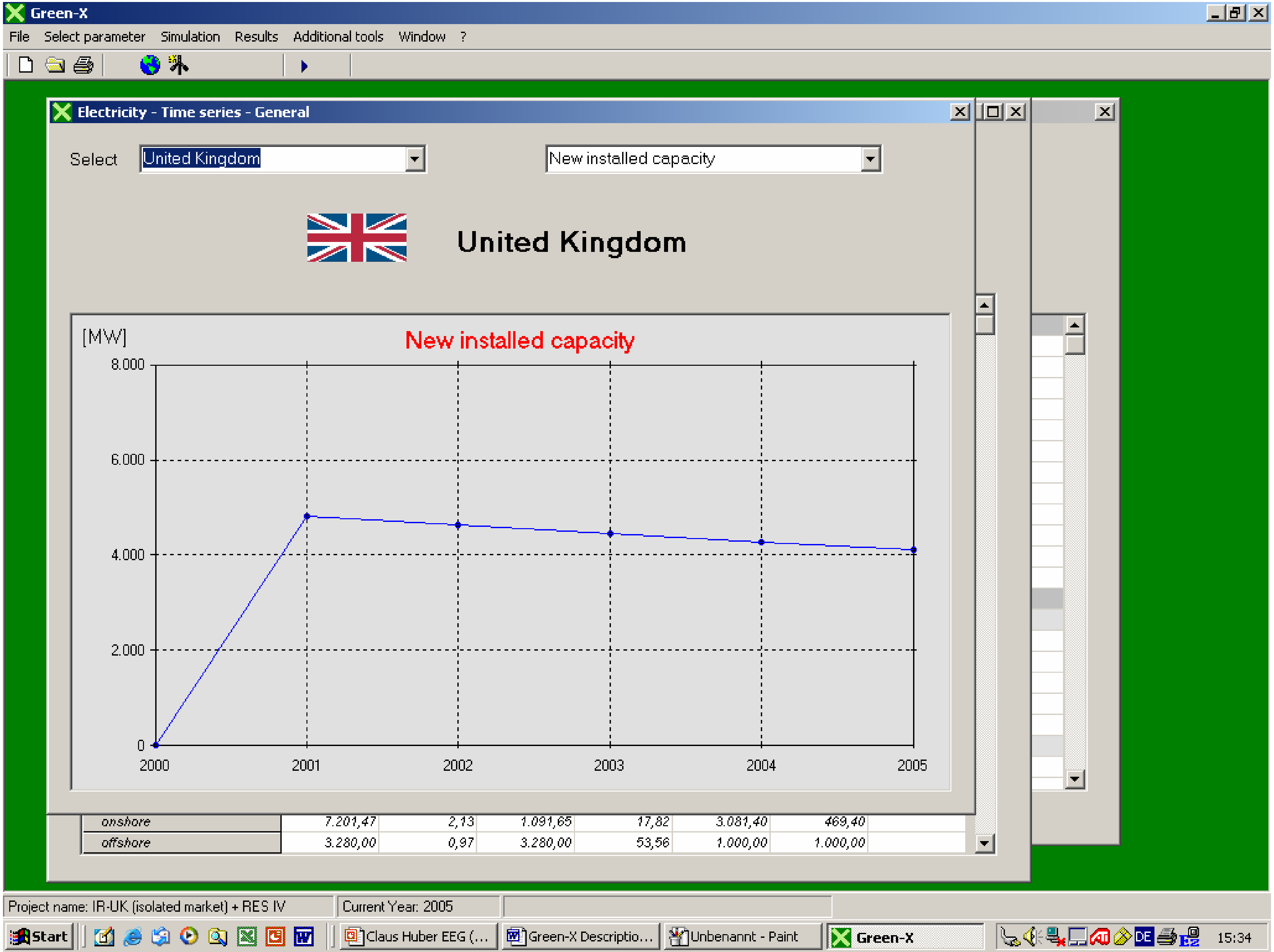
Select United Kingdom 2005

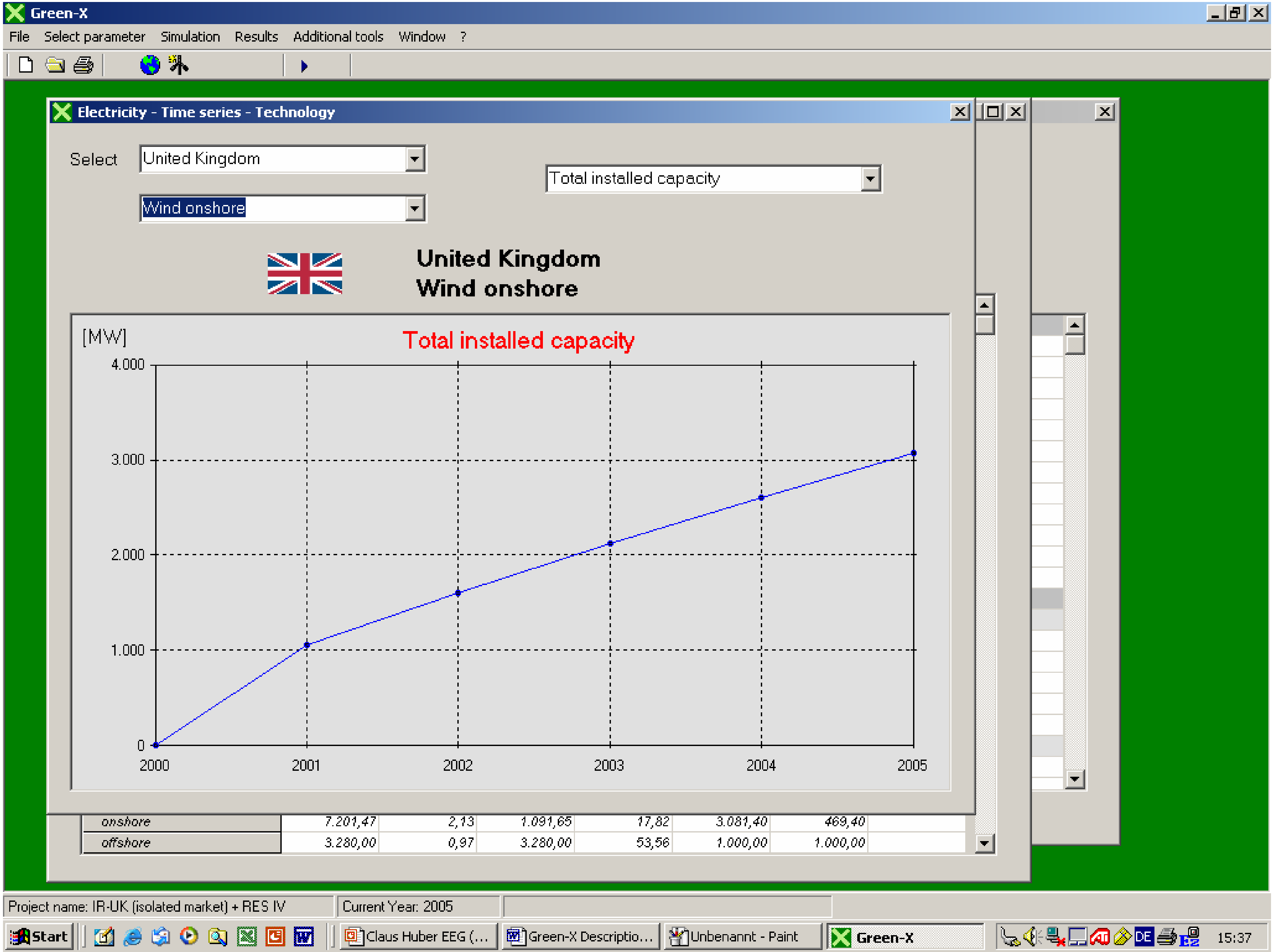
United Kingdom

Technology	Total Amount of Electricity Generation	Share of Total Electricity Generation	Total Amount of Electricity Generation new plants	Share of Total Electricity Generation new plants	Total installed capacity	New installed capacity
	GWh	%	GWh	%	MW	MW
Renewable power plants	**27.832,00**	**8,24**	**6.124,49**	**100,00**	**20.761,55**	**4.110,19**
Biogas	0,00	0,00	0,00	0,00	0,00	0,00
Biomass	0,00	0,00	0,00	0,00	0,00	0,00
Forestry products	*0,00*	*0,00*	*0,00*	*0,00*	*0,00*	*0,00*
Forestry residues	*0,00*	*0,00*	*0,00*	*0,00*	*0,00*	*0,00*
Agricultural products	*0,00*	*0,00*	*0,00*	*0,00*	*0,00*	*0,00*
Agricultural residues	*0,00*	*0,00*	*0,00*	*0,00*	*0,00*	*0,00*
Biogenic fraction of waste	*0,00*	*0,00*	*0,00*	*0,00*	*0,00*	*0,00*
Geothermal electricity	0,00	0,00	0,00	0,00	0,00	0,00
Hydro power	4.930,83	1,46	0,00	0,00	1.507,90	0,00
Small scale (< 10MW)	*594,81*	*0,18*	*0,00*	*0,00*	*181,90*	*0,00*
Large scale (> 10MW)	*4.336,02*	*1,28*	*0,00*	*0,00*	*1.326,00*	*0,00*
Landfill gas	2.300,65	0,68	0,00	0,00	418,30	0,00
Sewage gas	382,50	0,11	0,00	0,00	85,00	0,00
Solar	9.736,54	2,88	1.752,83	28,62	14.668,95	2.640,79
Photovoltaic	*9.736,54*	*2,88*	*1.752,83*	*28,62*	*14.668,95*	*2.640,79*
Solar thermal	*0,00*	*0,00*	*0,00*	*0,00*	*0,00*	*0,00*
Tidal	0,00	0,00	0,00	0,00	0,00	0,00
Wave	0,00	0,00	0,00	0,00	0,00	0,00
Wind	10.481,47	3,10	4.371,65	71,38	4.081,40	1.469,40
onshore	*7.201,47*	*2,13*	*1.091,65*	*17,82*	*3.081,40*	*469,40*
offshore	*3.280,00*	*0,97*	*3.280,00*	*53,56*	*1.000,00*	*1.000,00*

Project name: IR-UK (isolated market) + RES IV | Current Year: 2005

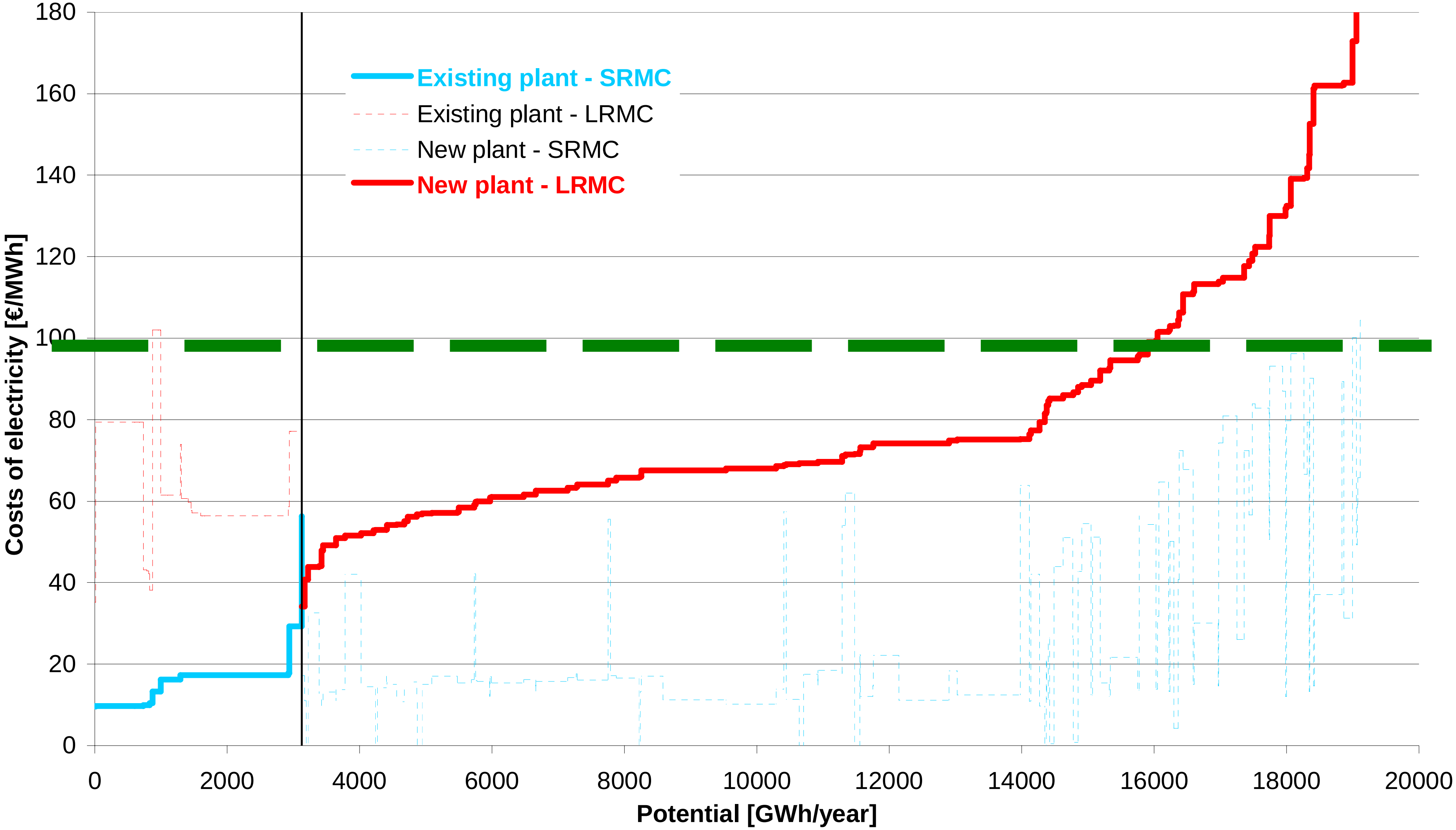

Green-X
File Select parameter Simulation Results Additional tools Window ?
Electricity - Time series - General
Select
United Kingdom
Total electricity import/export
United Kingdom
[GWh]
Total electricity import/export
4.000
2.000
0
-2.000
-4.000
Export
Import
2000
2001
2002
2003
2004
2005
onshore 7.201,47 2,13 1.091,65 17,82 3.081,40 469,40
offshore 3.280,00 0,97 3.280,00 53,56 1.000,00 1.000,00
Project name: IR-UK (isolated market) + RES IV
Current Year: 2005
Start
Claus Huber EEG (...
Green-X Descriptio...
Unbenannt - Paint
Green-X
15:34


Green-X
File
Select parameter
Simulation
Results
Additional tools
Window
?
Electricity - Time series - General
Select
United Kingdom
New installed capacity
United Kingdom
[MW]
New installed capacity
8.000
6.000
4.000
2.000
0
2000
2001
2002
2003
2004
2005
onshore
7.201,47
2,13
1.091,65
17,82
3.081,40
469,40
offshore
3.280,00
0,97
3.280,00
53,56
1.000,00
1.000,00
Project name: IR-UK (isolated market) + RES IV
Current Year: 2005
Start
Claus Huber EEG (...
Green-X Descriptio...
Unbenannt - Paint
Green-X
15:34


Green-X
File Select parameter Simulation Results Additional tools Window ?
Electricity - Time series - Technology
Select
United Kingdom
Wind onshore
Total installed capacity
United Kingdom
Wind onshore
[MW]
Total installed capacity
4.000
3.000
2.000
1.000
0
2000
2001
2002
2003
2004
2005
onshore 7.201,47 2,13 1.091,65 17,82 3.081,40 469,40
offshore 3.280,00 0,97 3.280,00 53,56 1.000,00 1.000,00
Project name: IR-UK (isolated market) + RES IV
Current Year: 2005
Start
Claus Huber EEG (...
Green-X Descriptio...
Unbenannt - Paint
Green-X
15:37

Example IRELAND

Static cost-resource curve for all RES-E (achieved potential up to 2005 and the additional mid-term potential)



Example AUSTRIA

Static cost-resource curve for all RES-E (achieved potential up to 2005 and the additional mid-term potential)

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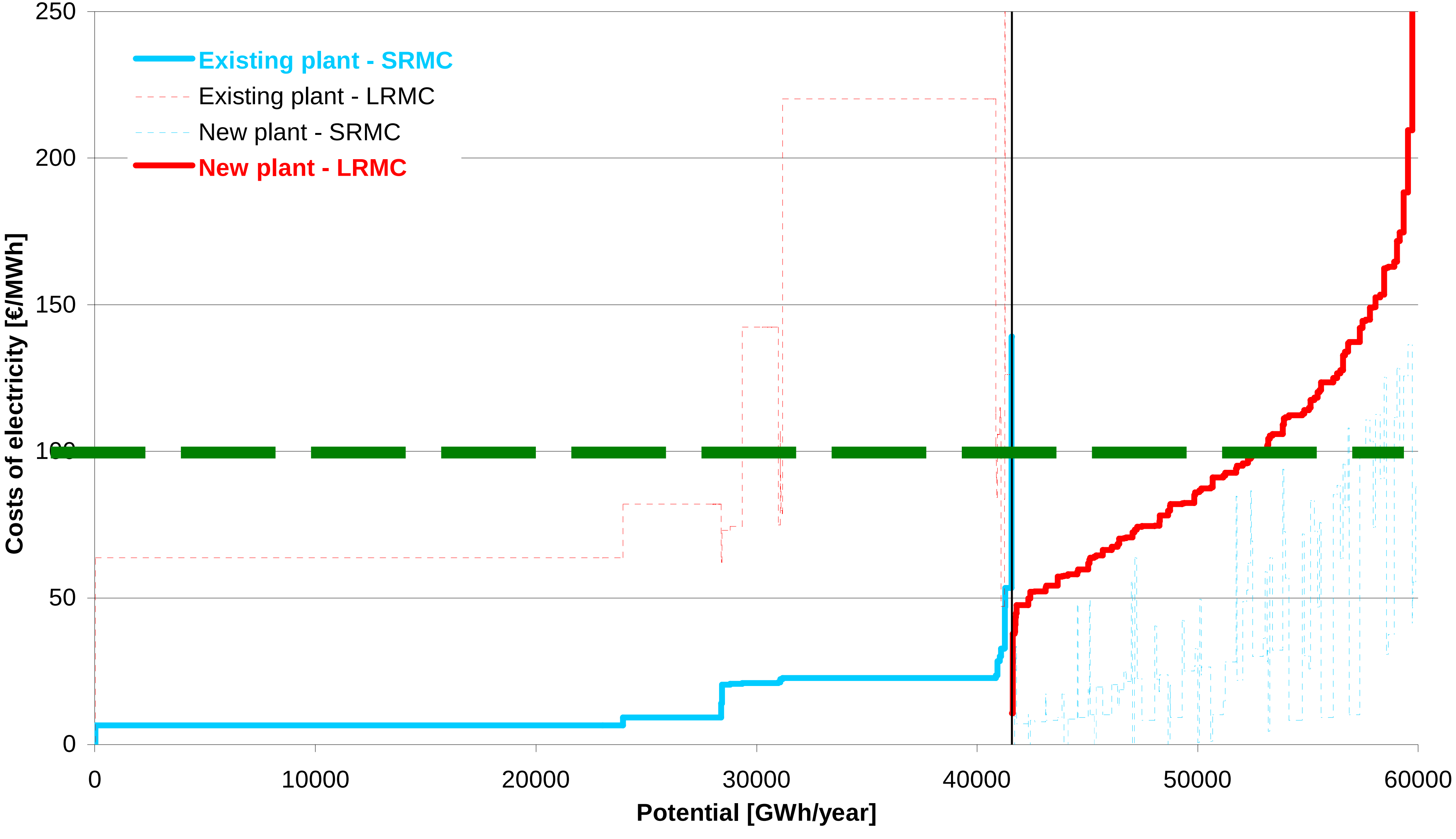
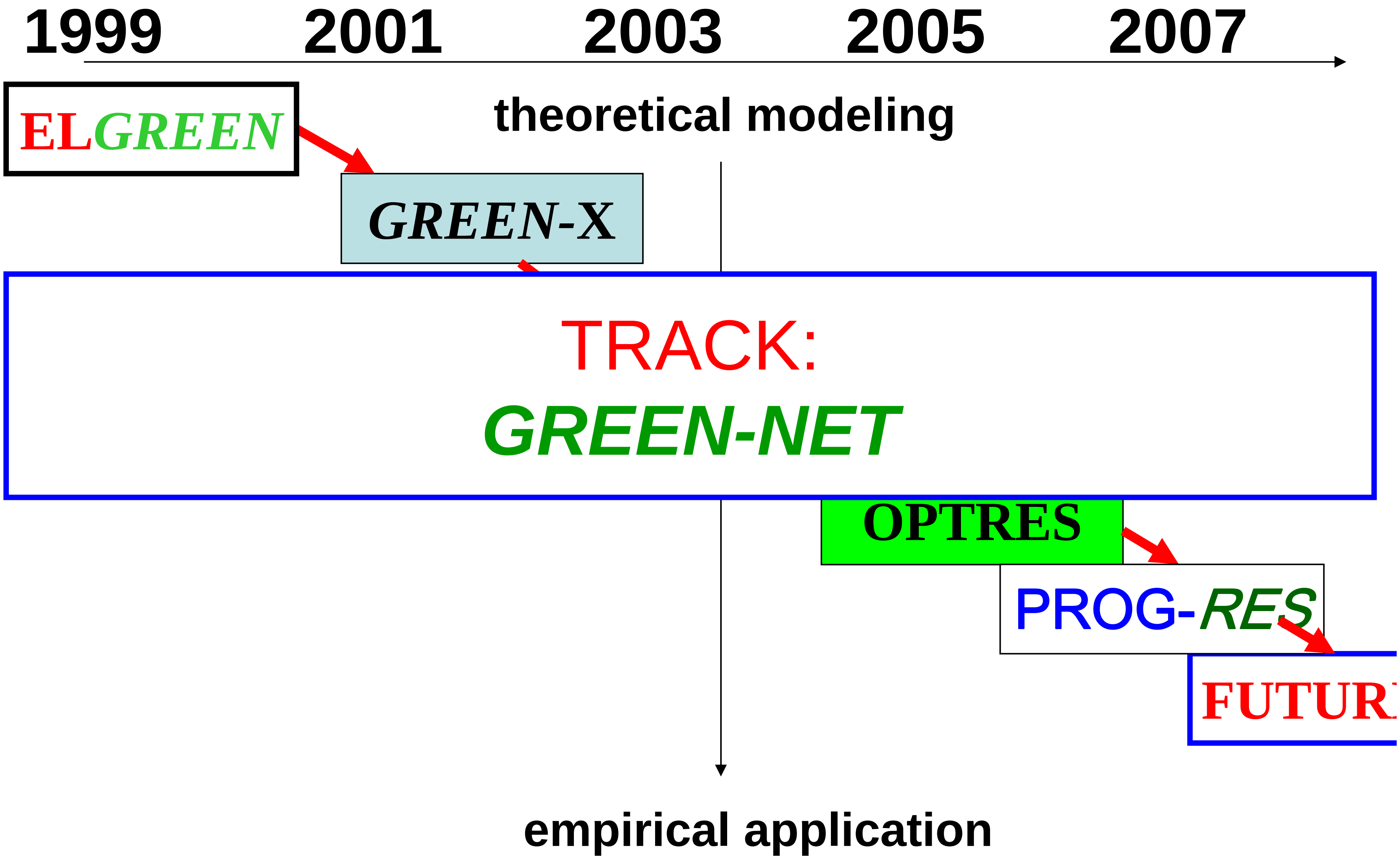
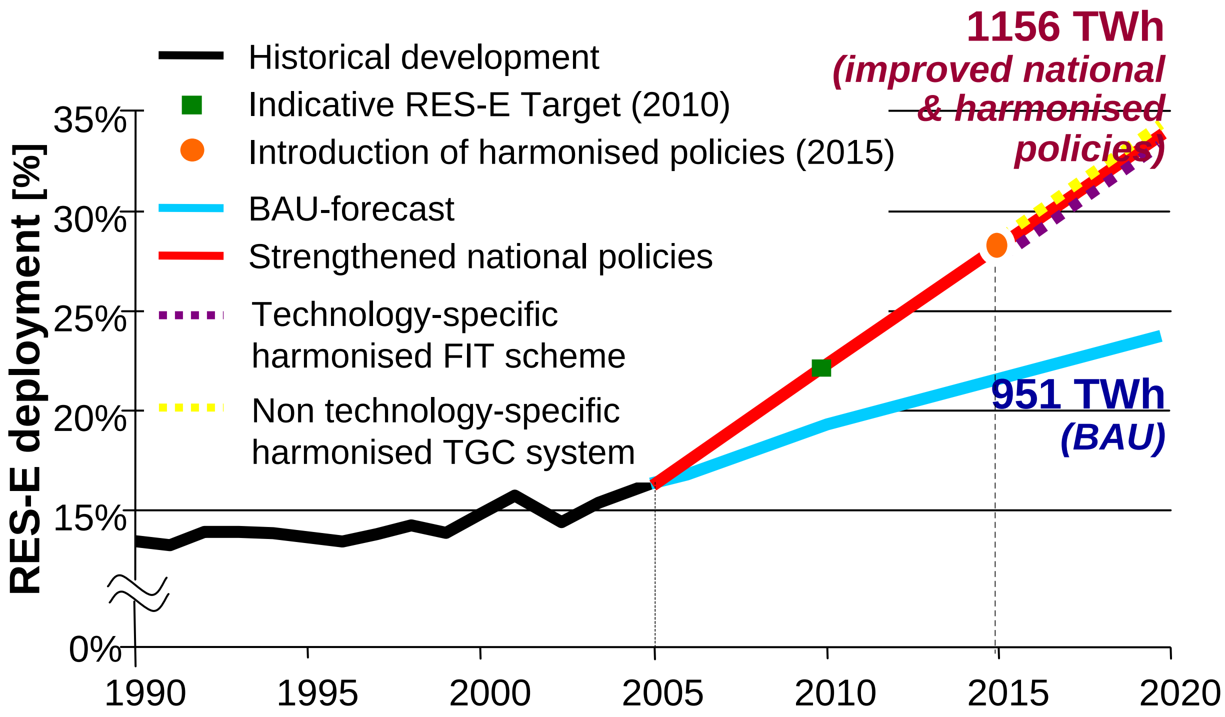


THE „POLICY“ TRACK



7. SOME RESULTS OF GREEN-X: CASE STUDY 2020

Total current electricity consumption: 3200 TWh

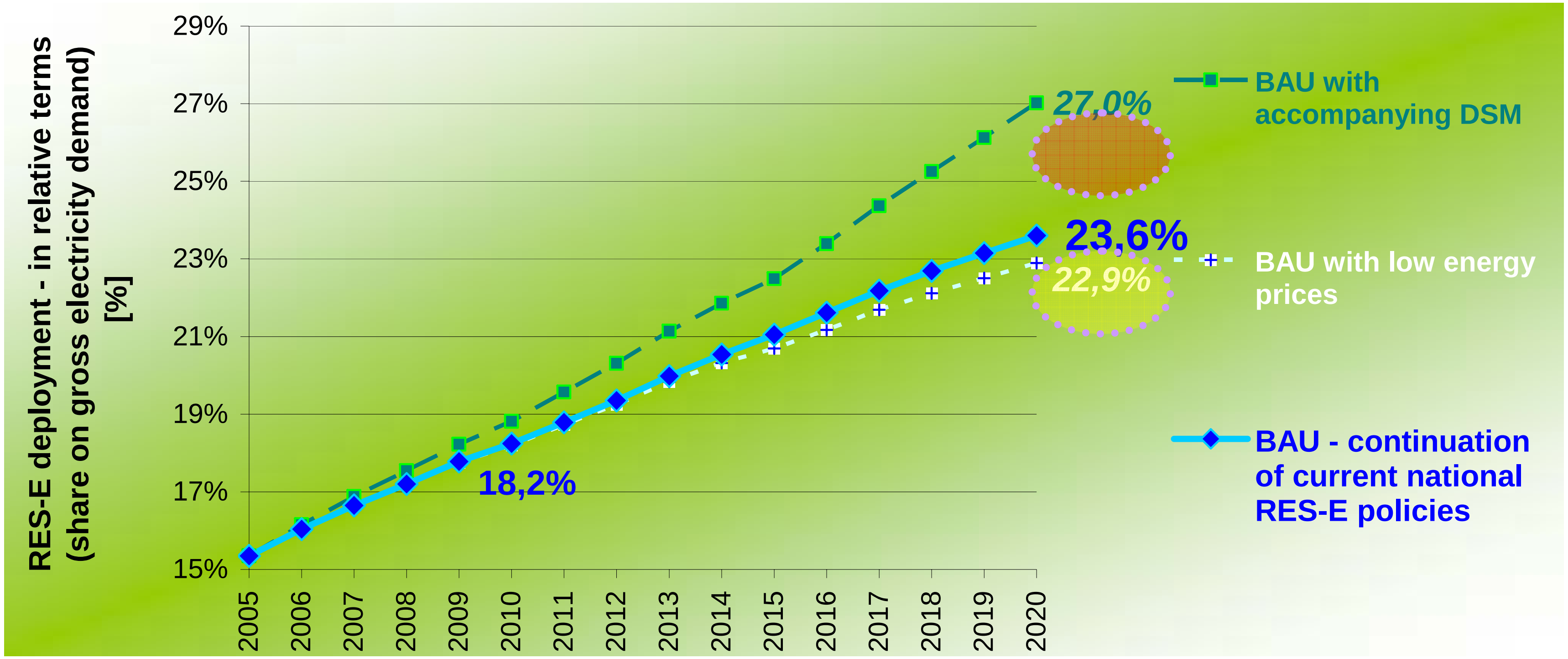


Investigated cases:

NO HARMONISATION		HARMONISATION IN 2015	
Business-as-usual (BAU) Continuation of current national policies up to 2020	**Improved national policies** Efficient & effective national policies	**Technology-specific support** Feed-in tariffs - harmonised	**Non technology-specific support** Quota obligation based on TGCs - harmonised

Total electricity generation from RES (EU25) as share of gross electricity demand

BAU scenario … how far will we come with current RES policies?

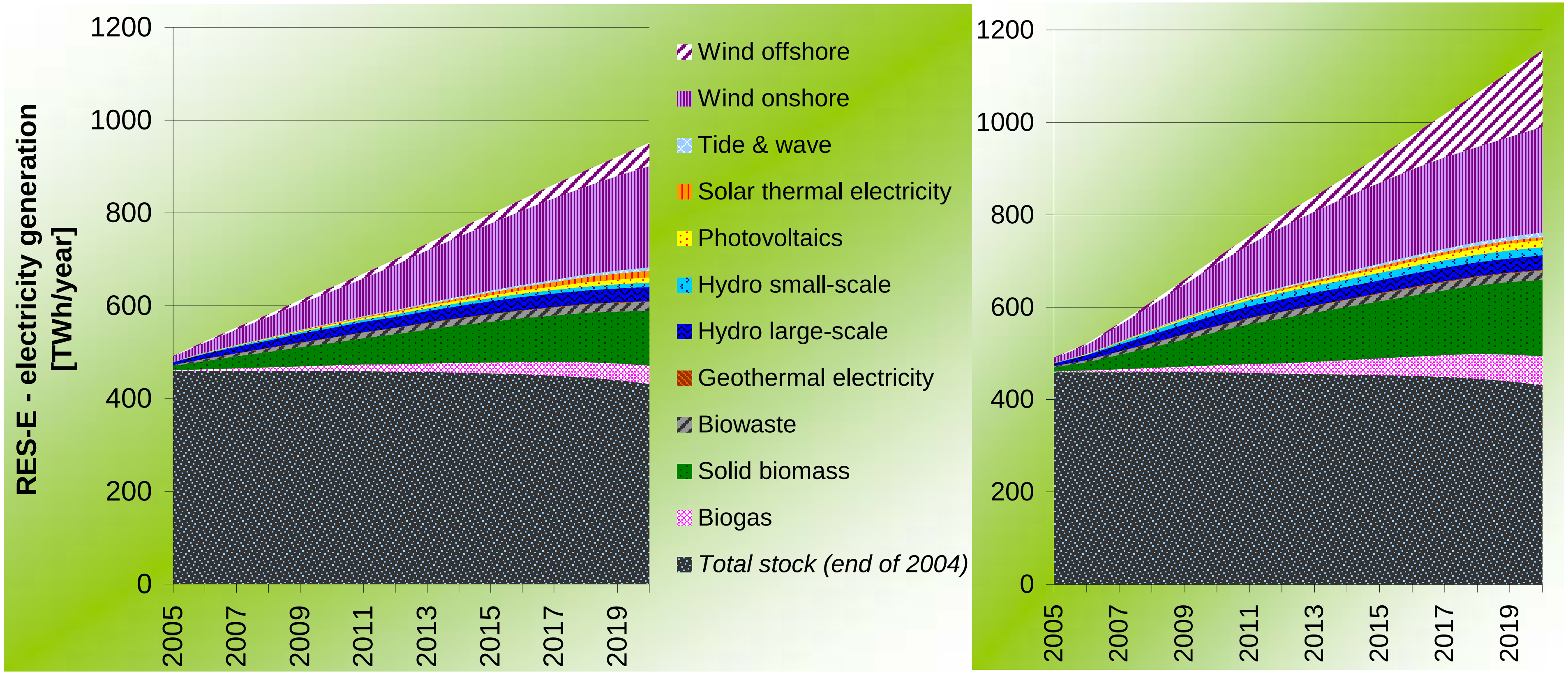


… the impact of an active DSM policy and conventional energy prices

(7) Results

Total electricity generation from RES (EU25)

BAU scenario | **Improved national policies scenario**



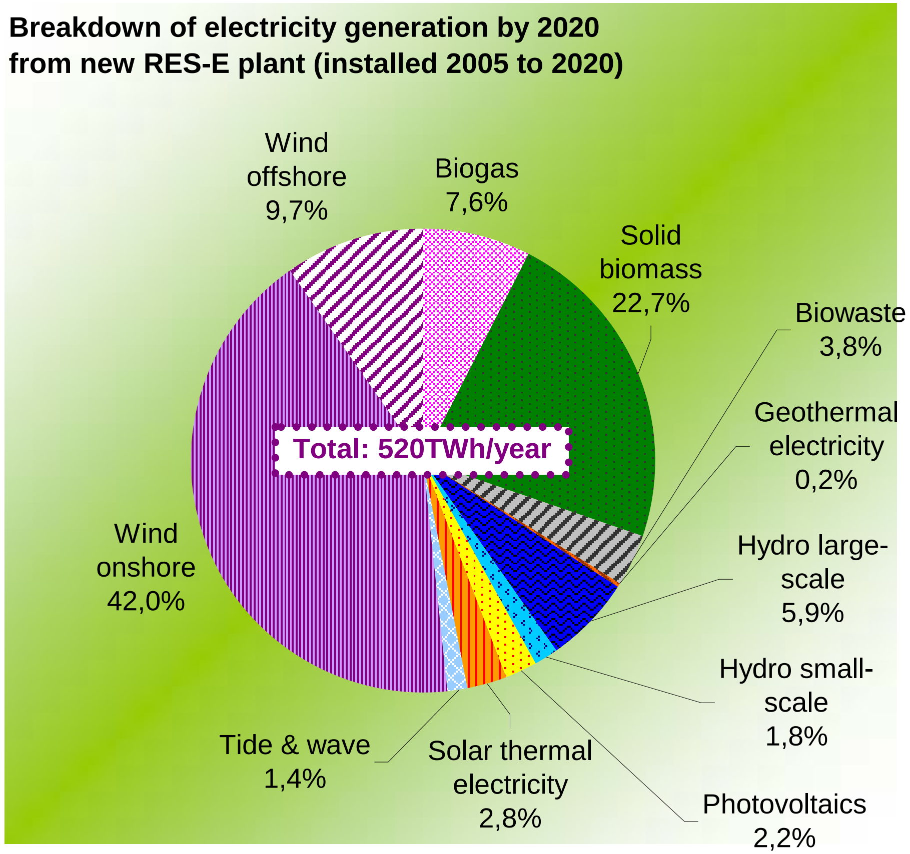
… both cases based on purely national support schemes

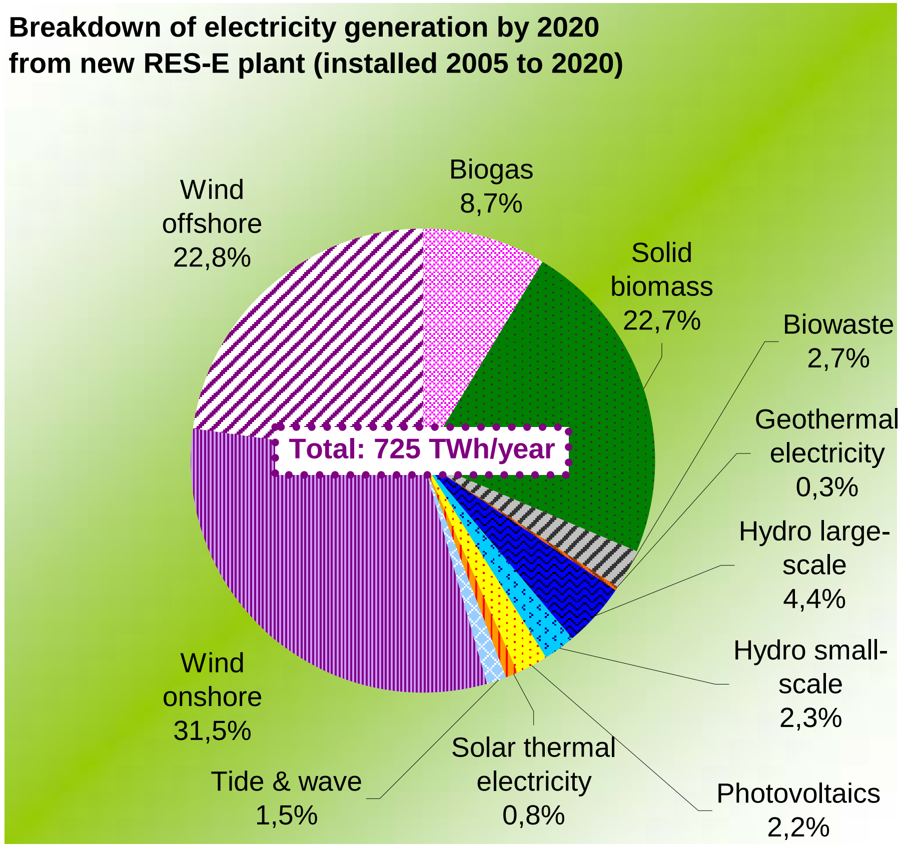
Breakdown of electricity generation from new RES-E plant

(installed in the period 2005 to 2020) on EU-25 level

BAU scenario

Improved national policies scenario





(7) Results

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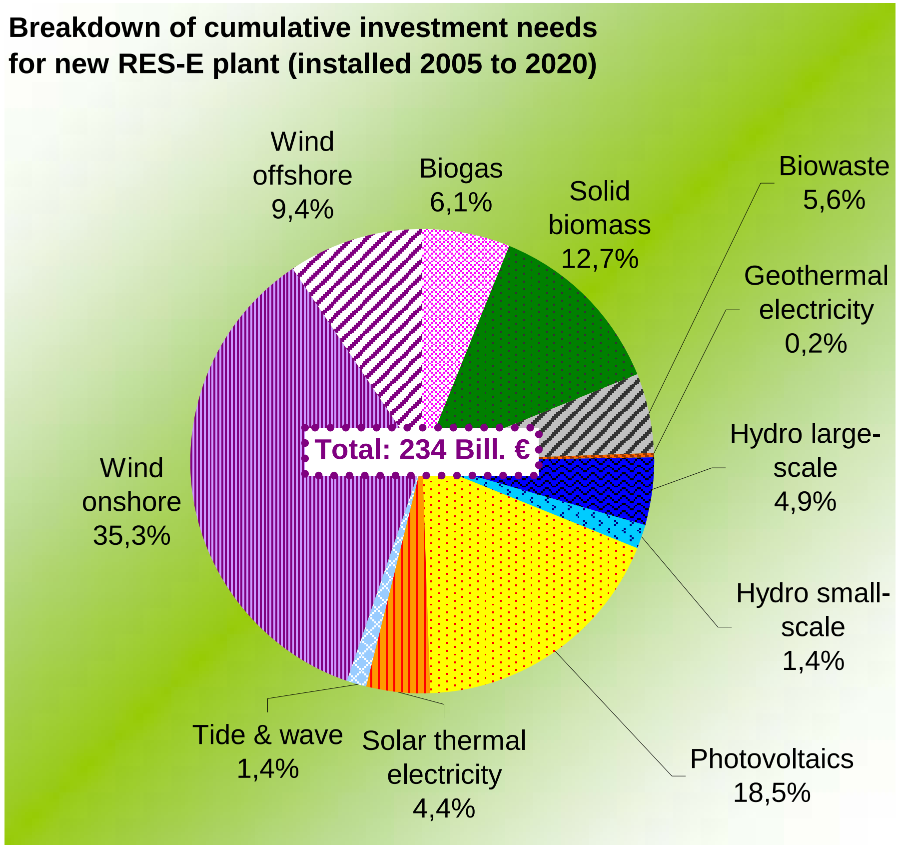
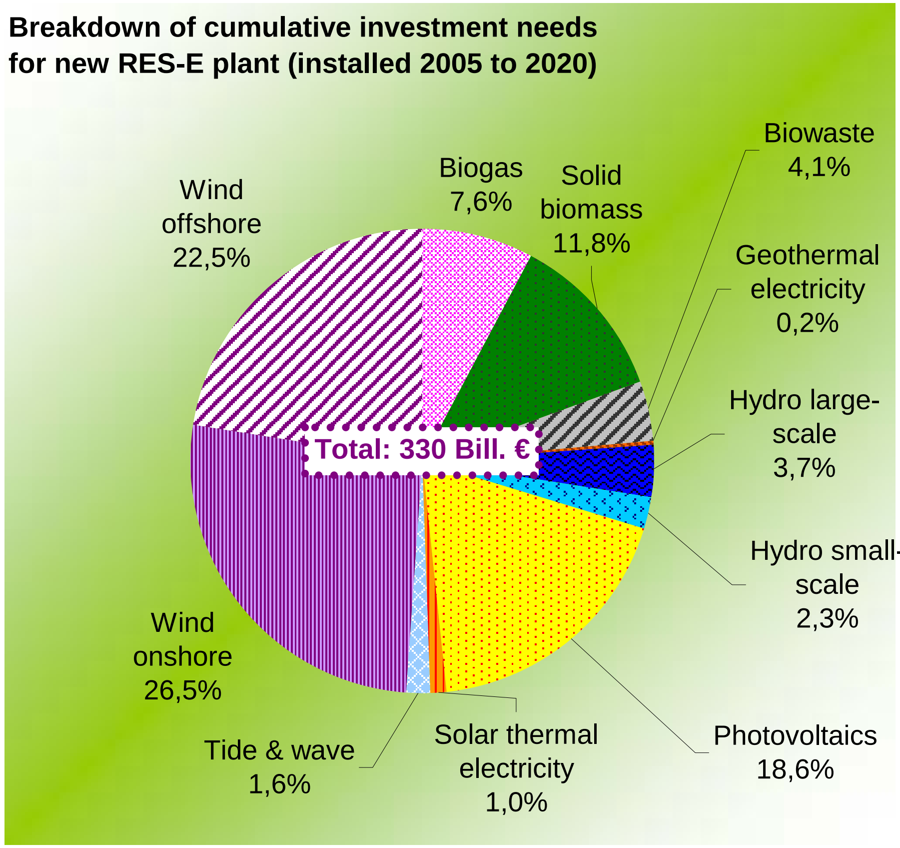
Breakdown of investment needs for new RES-E plant

(installed in the period 2005 to 2020) on EU-25 level

BAU scenario

Improved national policies scenario





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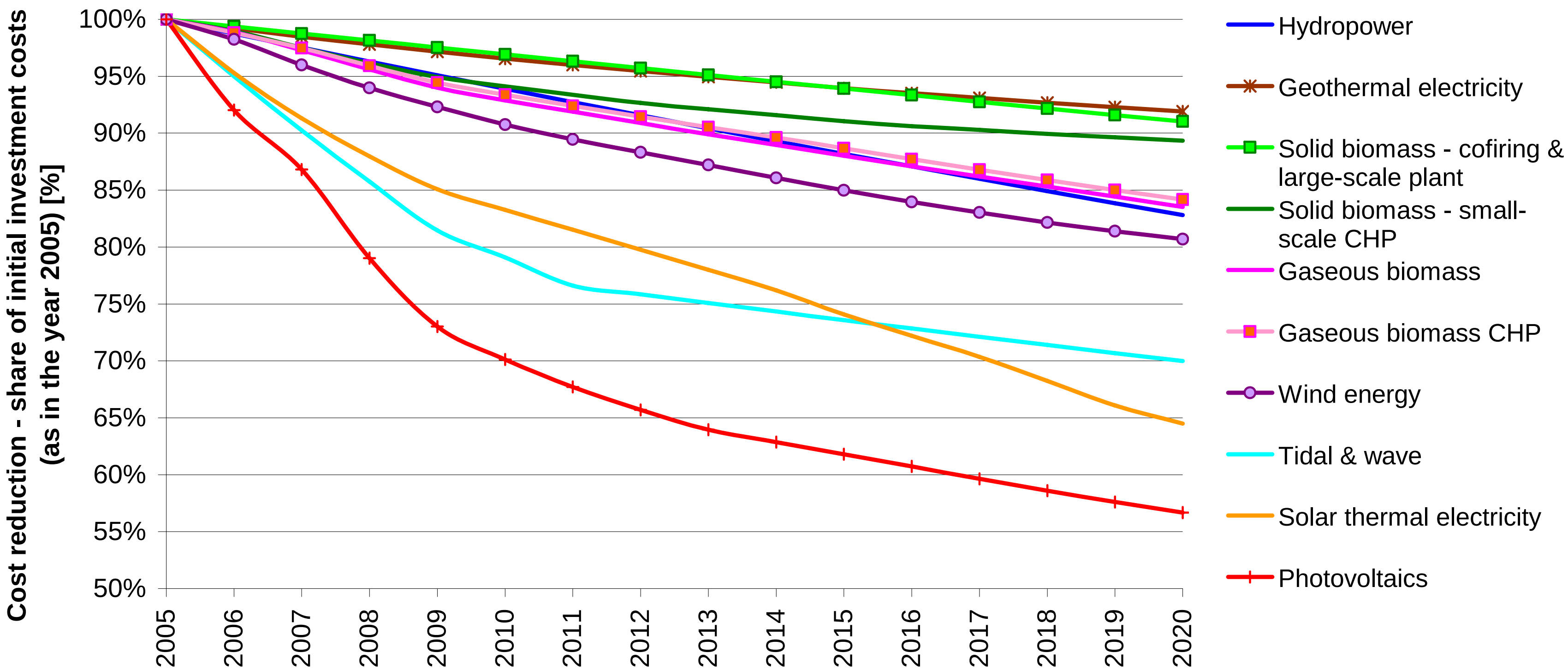
Reduction of investment cost within the BAU-scenario due to technological learning

Resulting cost reduction for RES-E technologies

BAU scenario



(7) Results

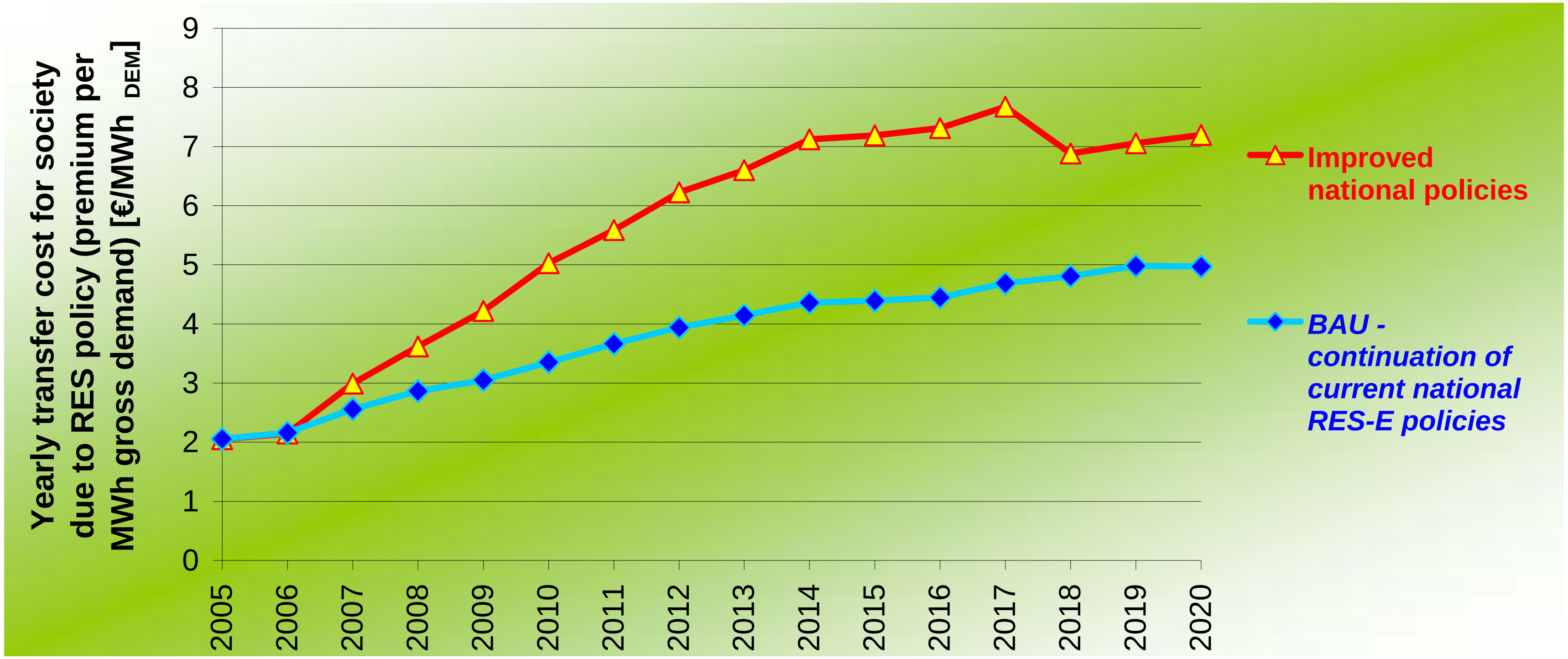
Energy Economics Group

Transfer costs for consumer (due to the promotion of RES-E)

Unit: M€/year or €/MWh$_{DEMAND}$

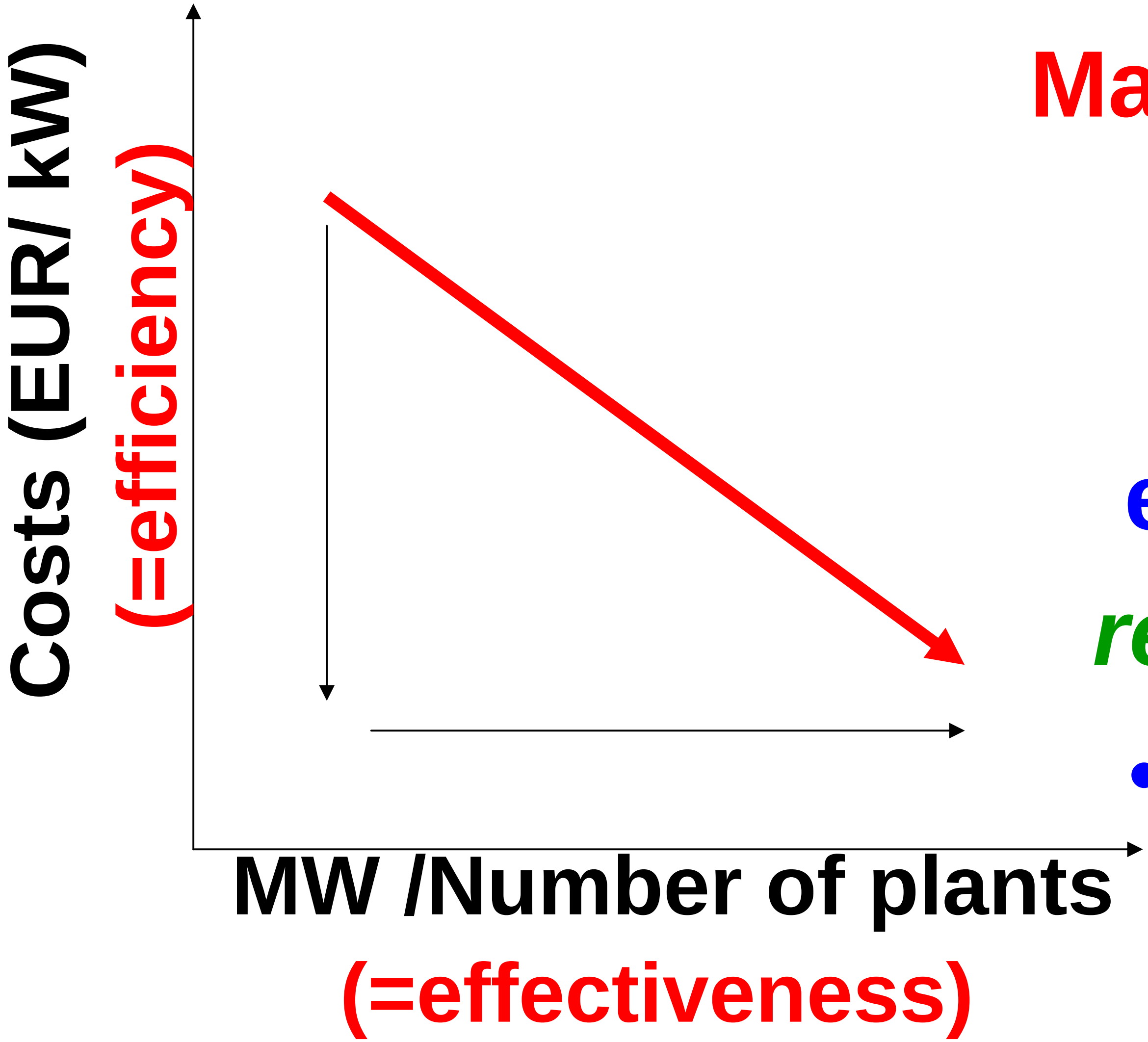
Transfer costs for consumer / society (sometimes also called additional / premium costs for consumer / society) are defined as ***direct premium financial transfer costs from the consumer to the producer due to the RES-E policy compared to the case that consumers would purchase conventional electricity from the power market.***

Improved national policies *versus* **BAU**



8. PERFORMANCE OF STRATEGIES: AN EMPIRICAL ANALYSIS

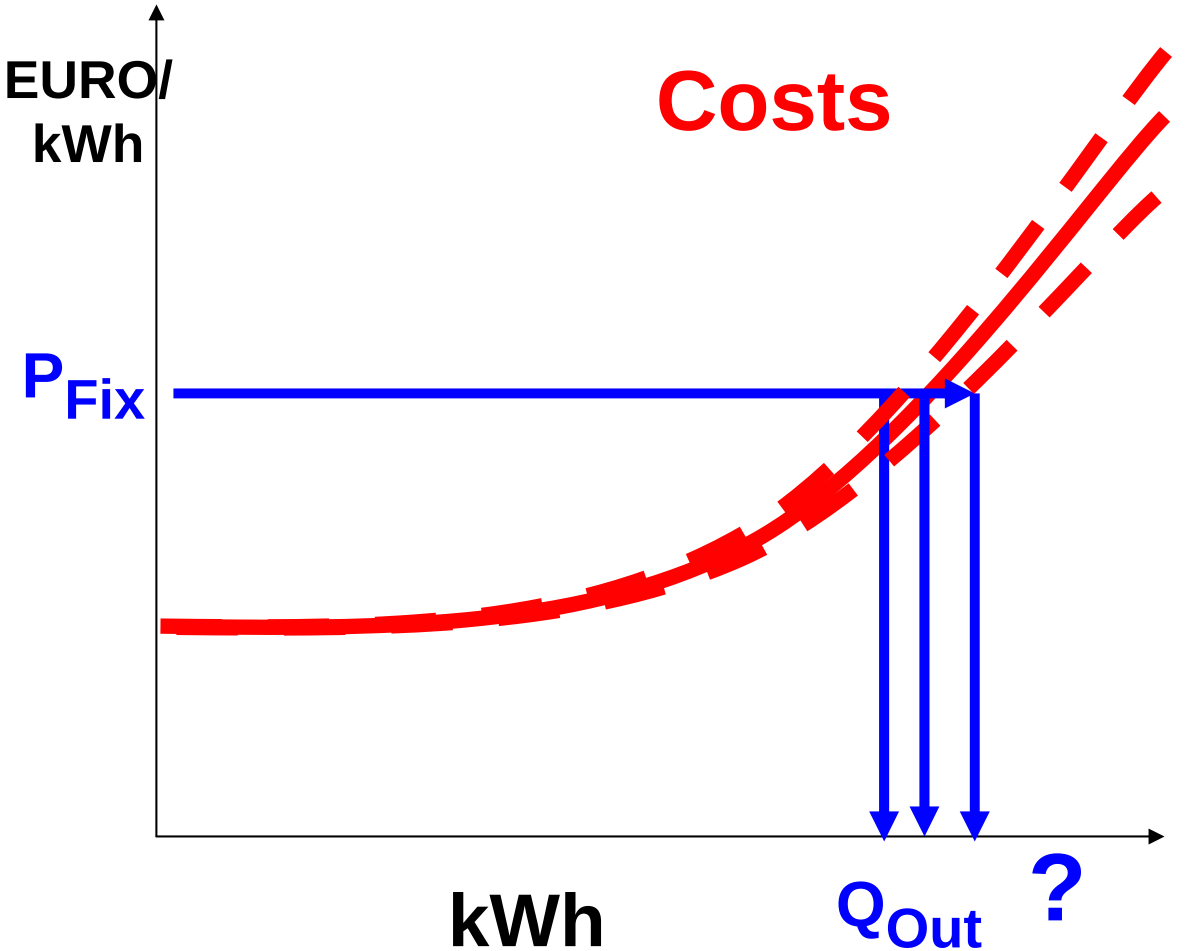
REQUIREMENTS TO SUCCESSFUL STRATEGIES



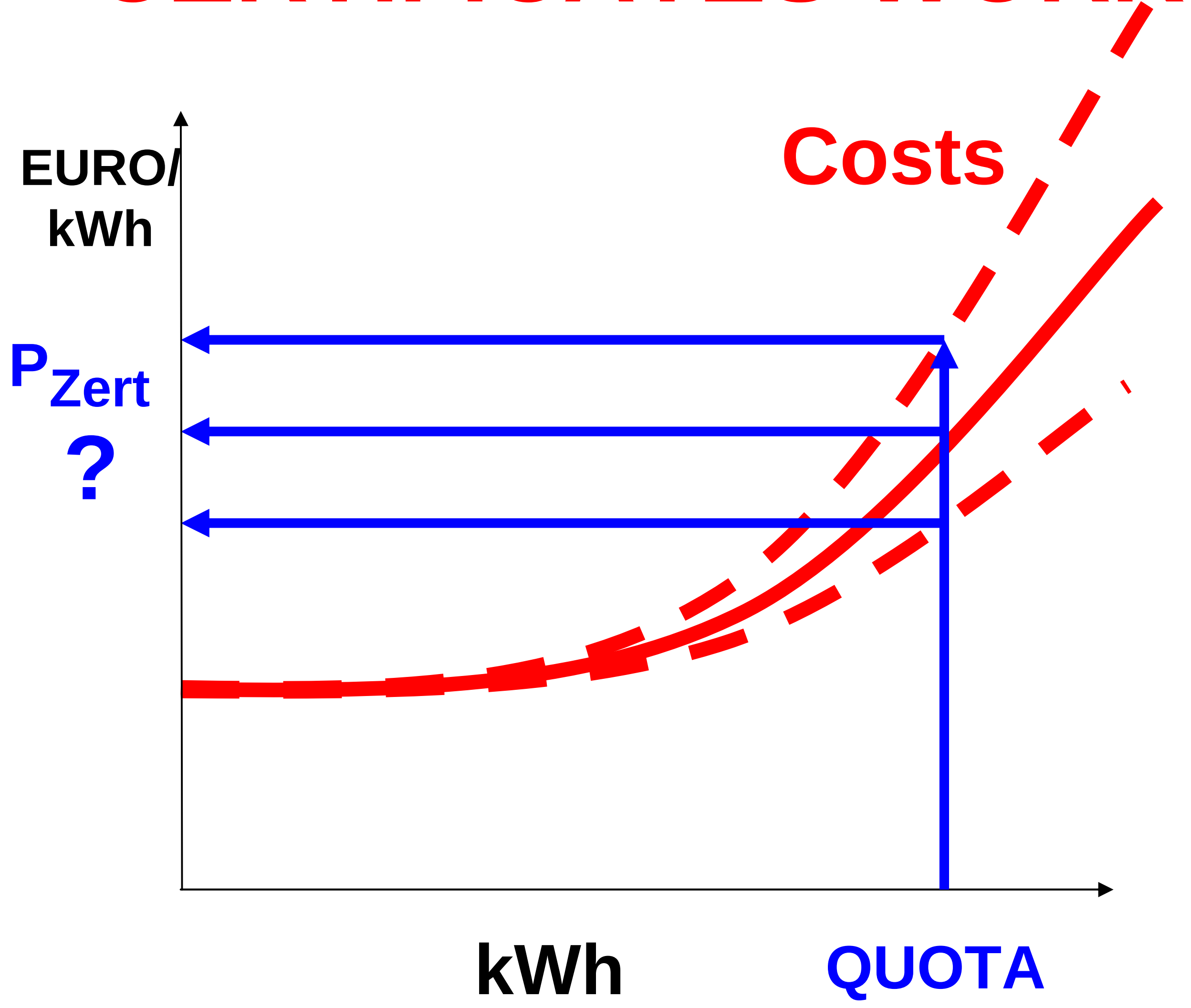
Major objectives:

- **increase the amount of electricity from *renewables* and**
- **reduce costs!**

HOW FEED-IN TARIFFS WORK



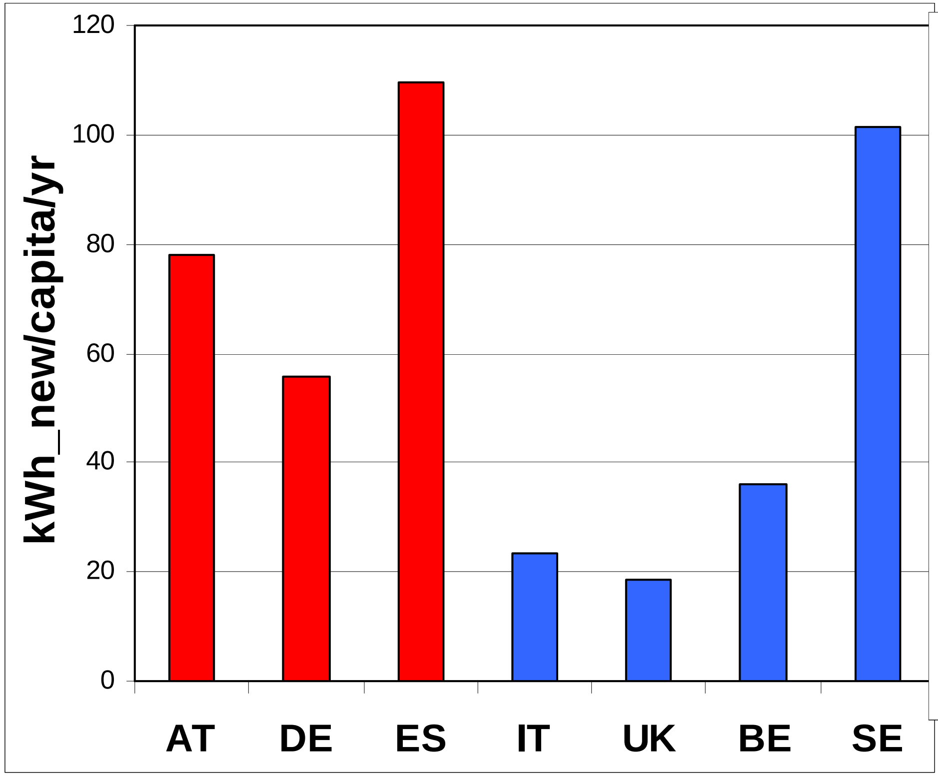
HOW QUOTA-BASED TRADABLE GREEN CERTIFICATES WORK



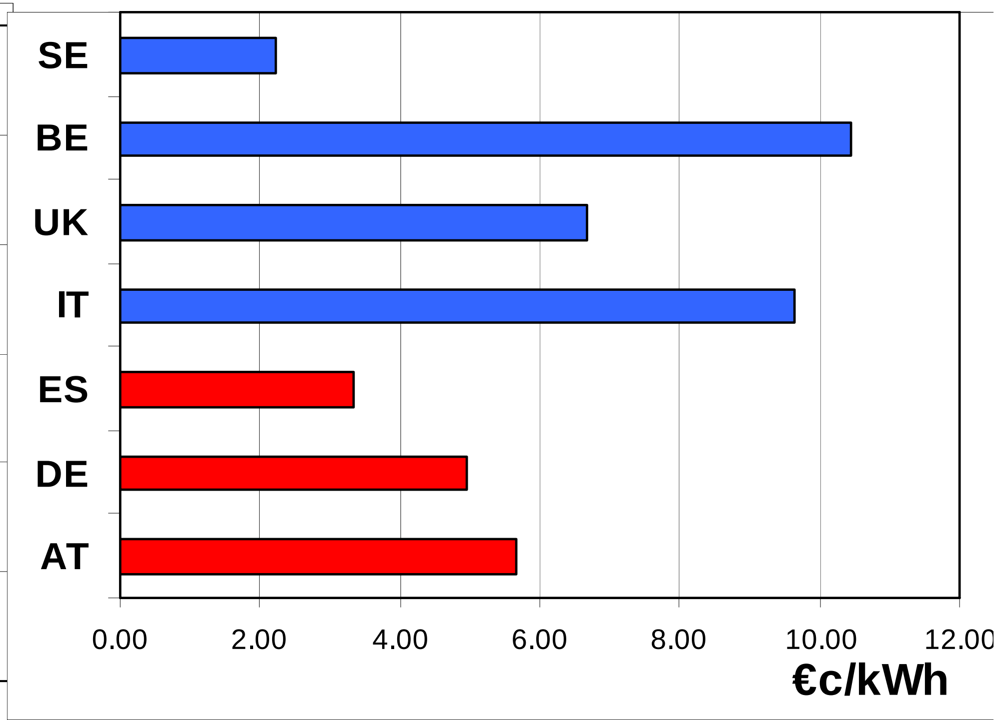
LESSONS LEARNED:

COMPARISON OF STRATEGIES

Effectiveness:

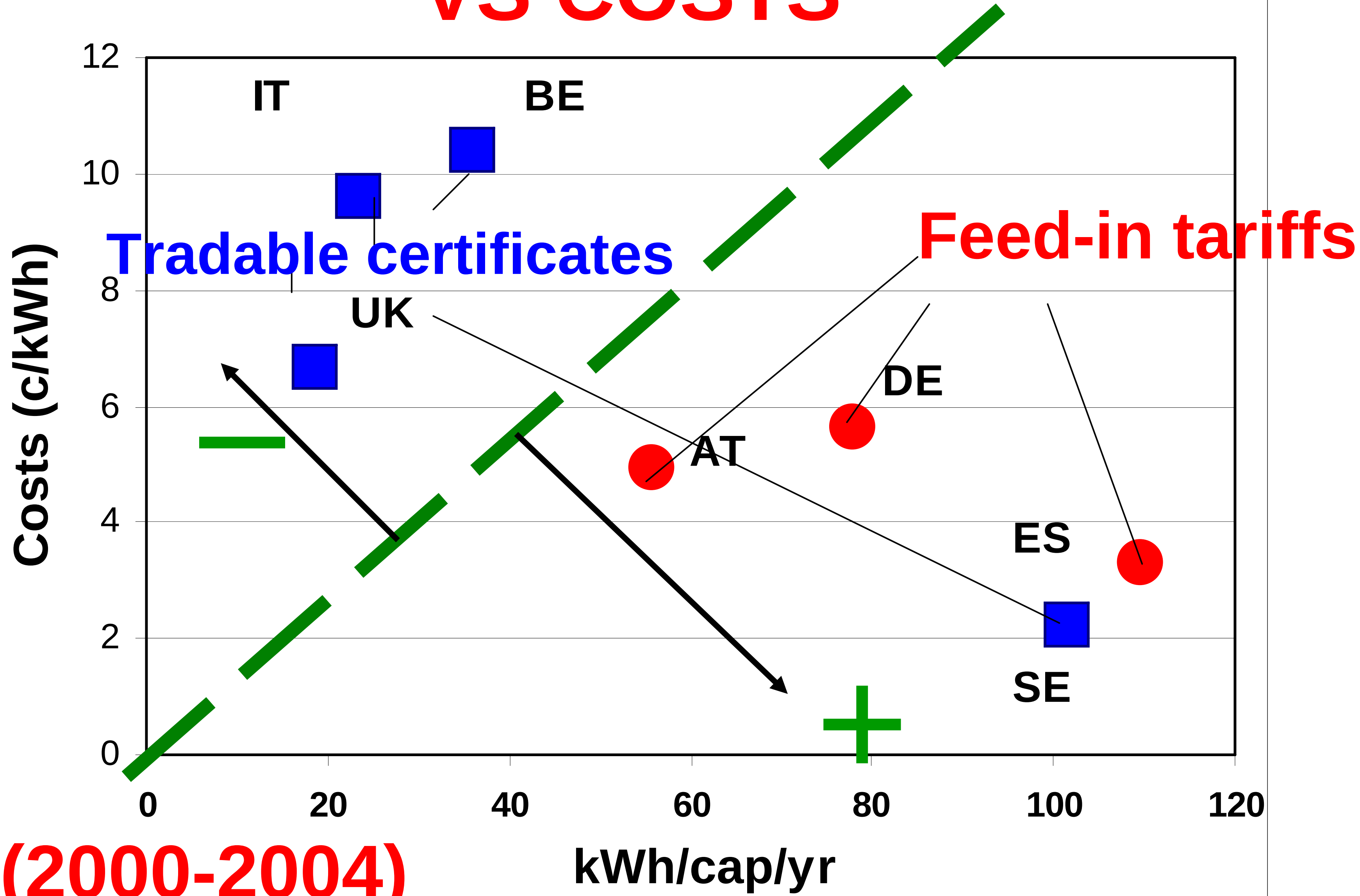


Costs:



(2000-2004)

EFFECTIVENESS VS COSTS



(2000-2004)

SUCCESS CRITERIA FOR FIT's

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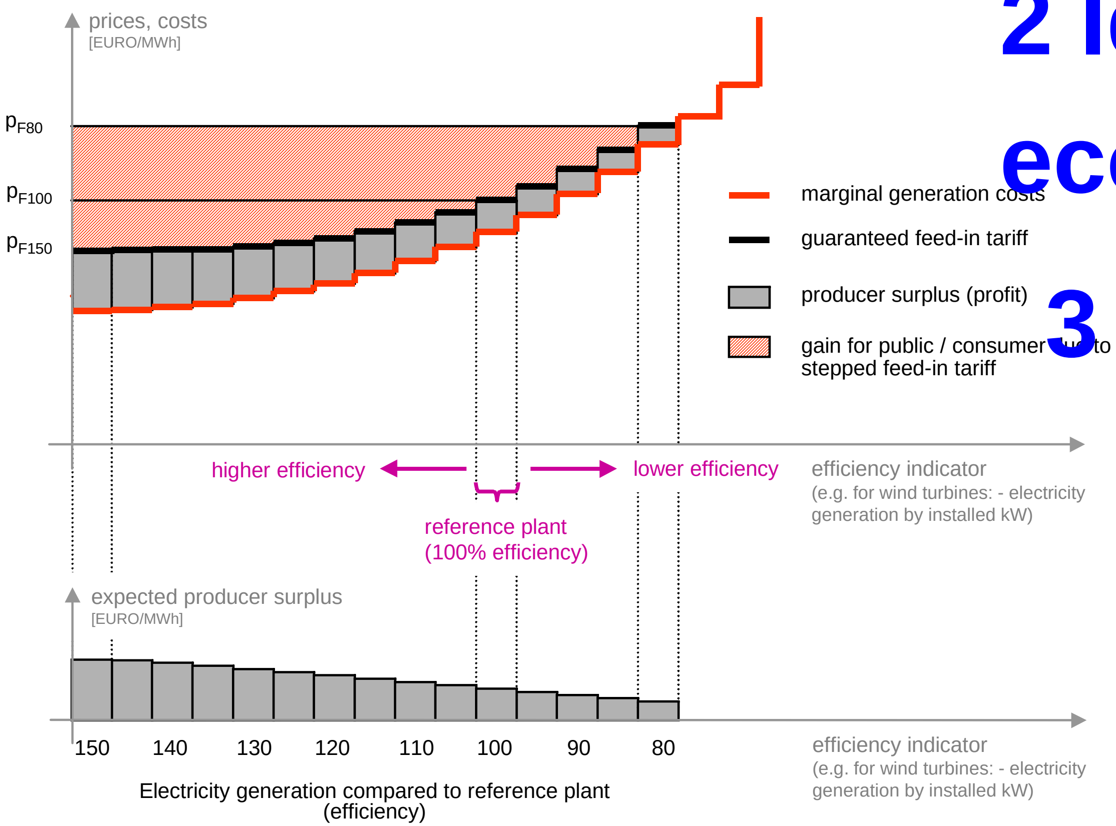
1 Use a stepped FIT and calculate starting values carefully

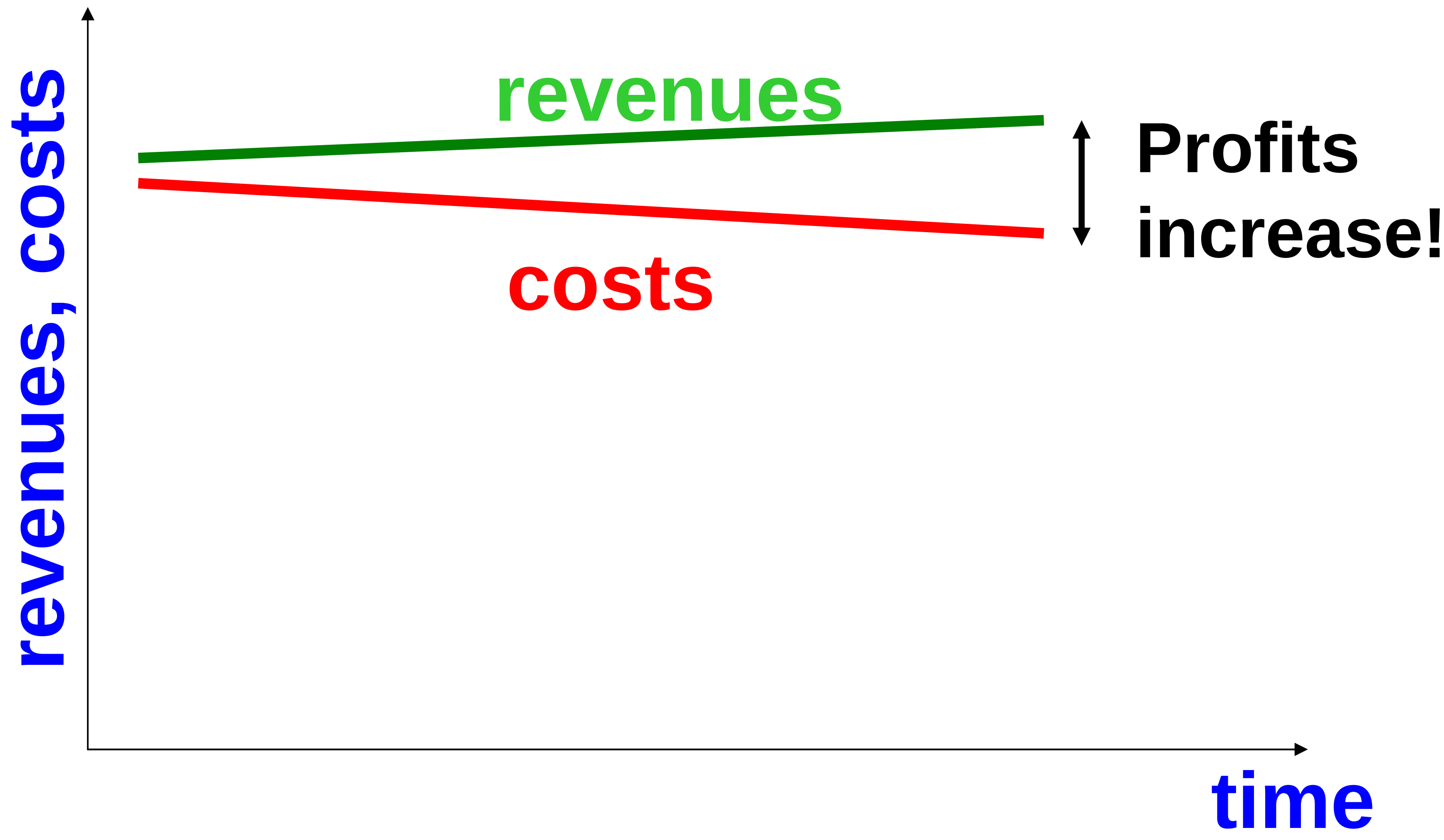


2 Identify ecological bonus

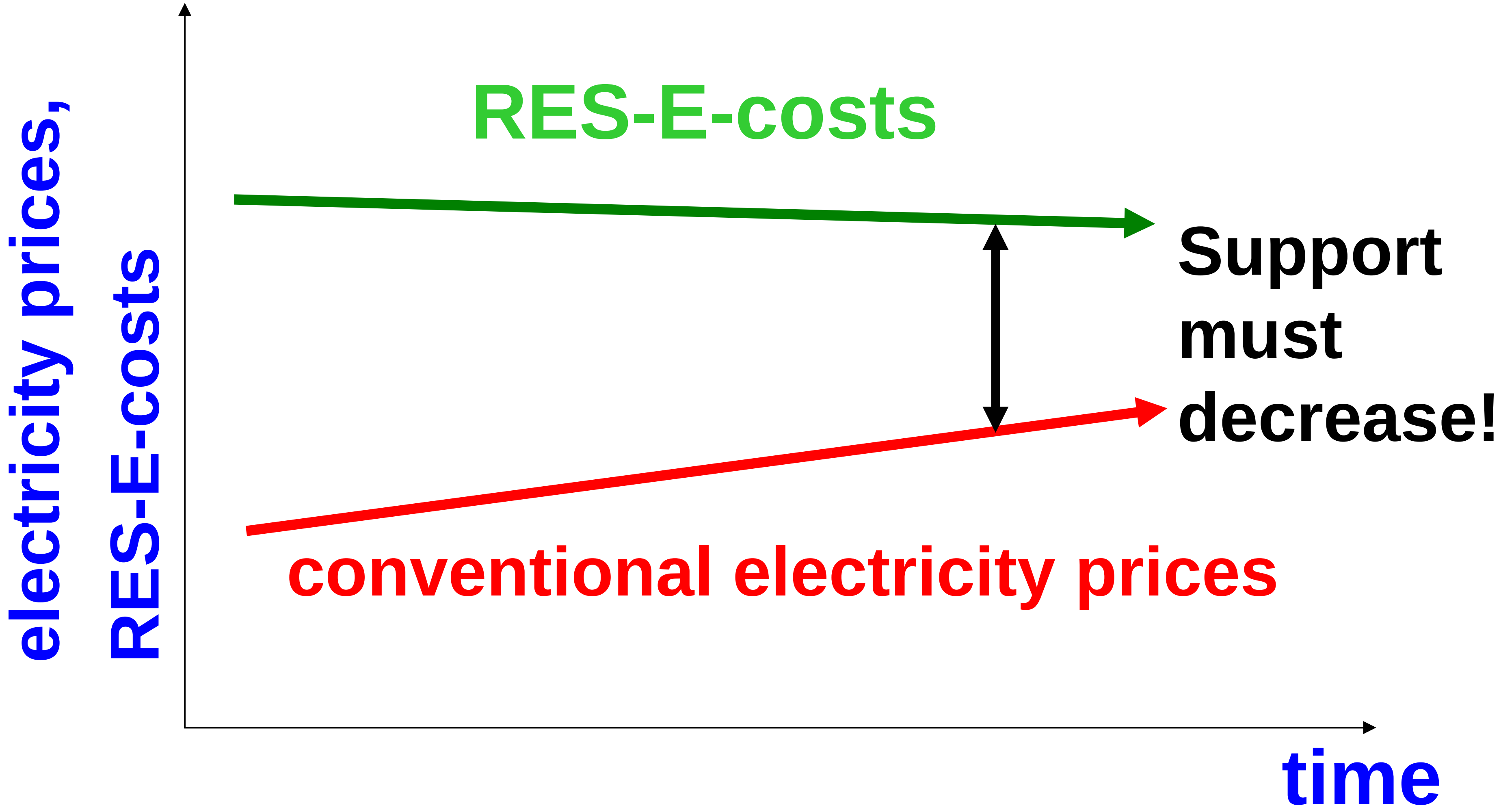
3 Decrease over time, link to conv. electr. market prices

MAJOR PITFALL OF FITs:

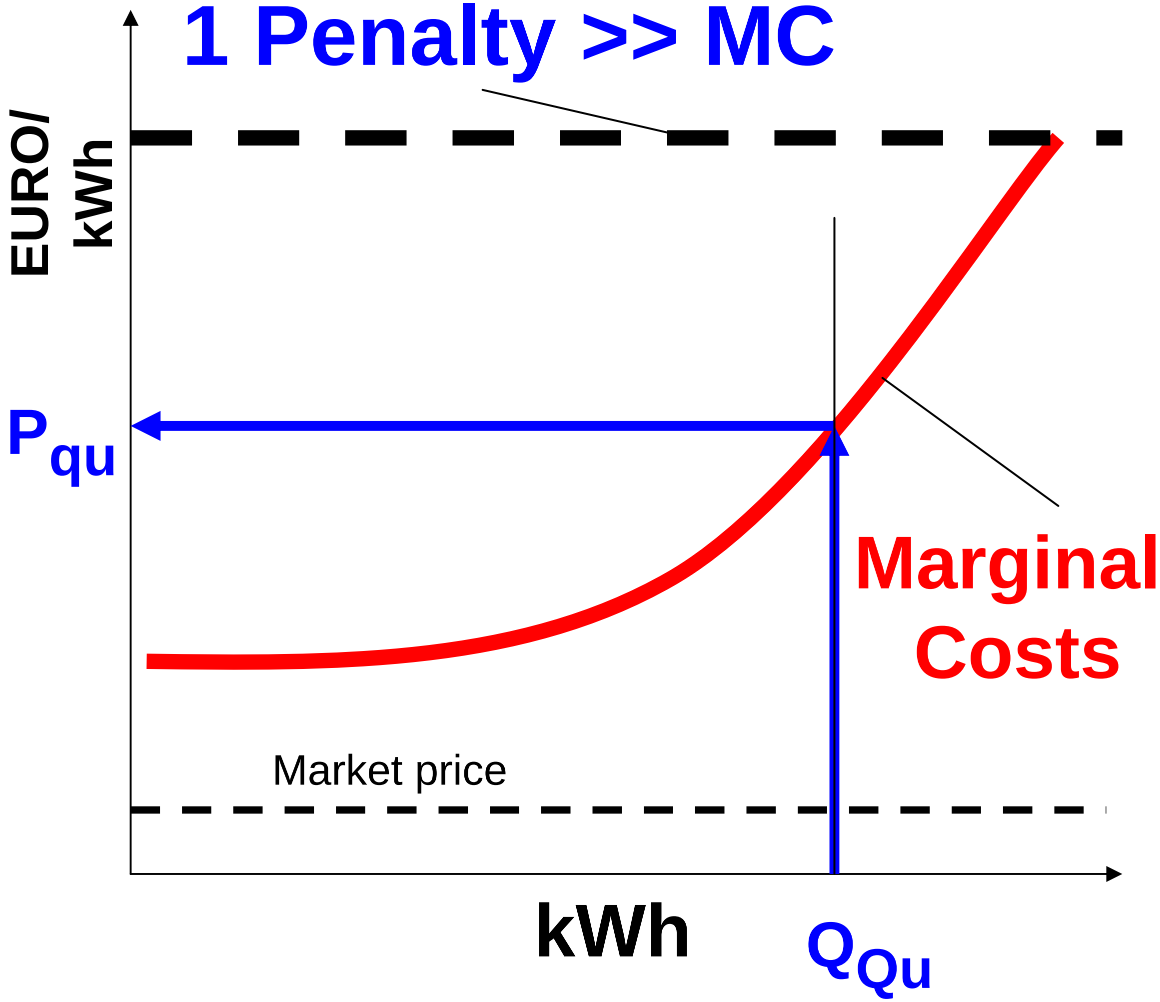
The example of wind



DYNAMICS:


electricity prices,
RES-E-costs
RES-E-costs
Support
must
decrease!
conventional electricity prices
time

SUCCESS CRITERIA FOR QUOTA-BASED TGC's



2 Ensure long-term planning horizon!

3 Focus on new plants

4 Allow banking

MAJOR PITFALLS FOR QUOTA-BASED TGC's

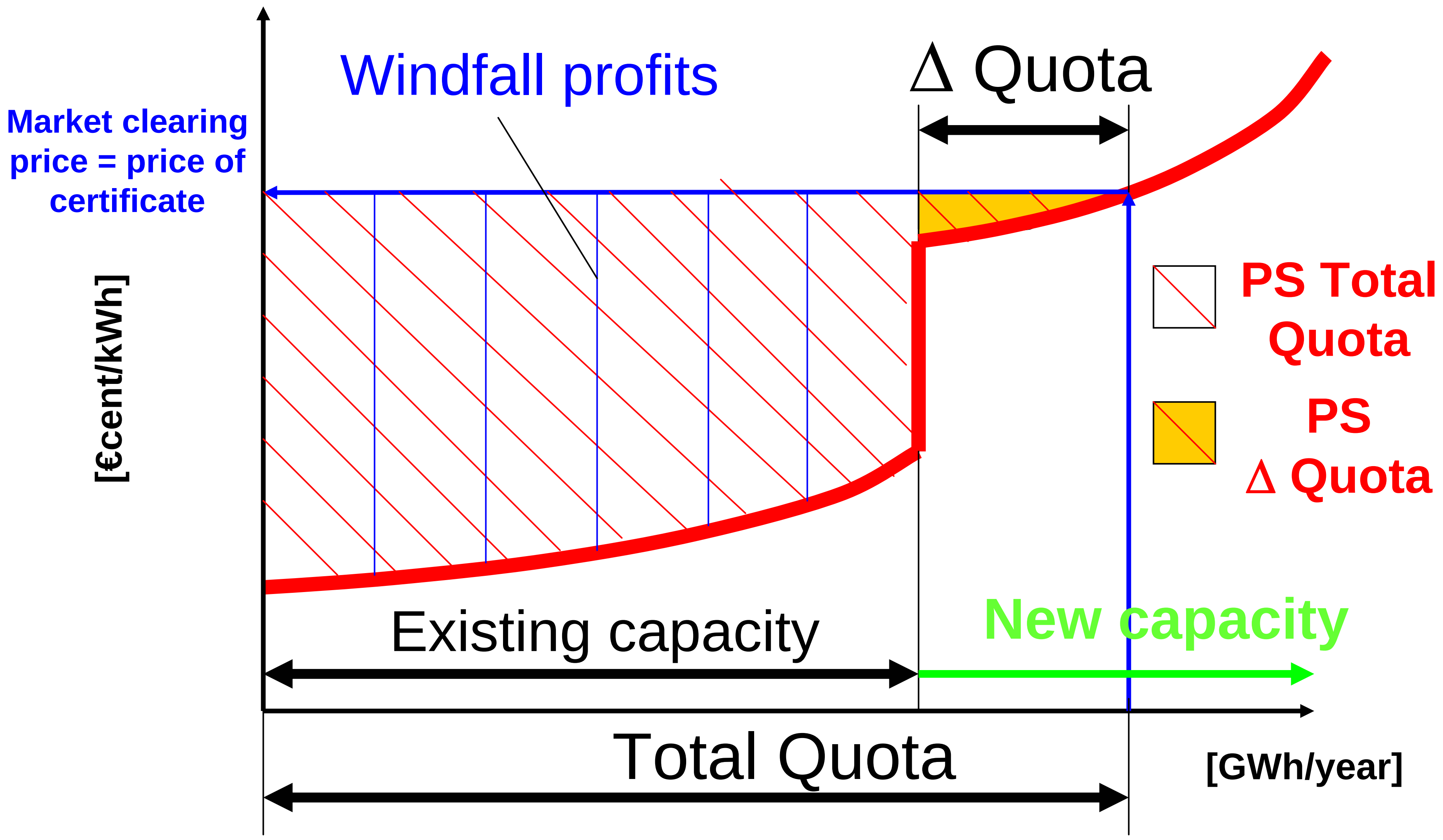
1 Market to small: e.g. in a small country for one technology with very limited potential -> Non-Liquid because every single plant is known (e.g Flanders (BE))

2 Penalty is to low (e.g. UK)

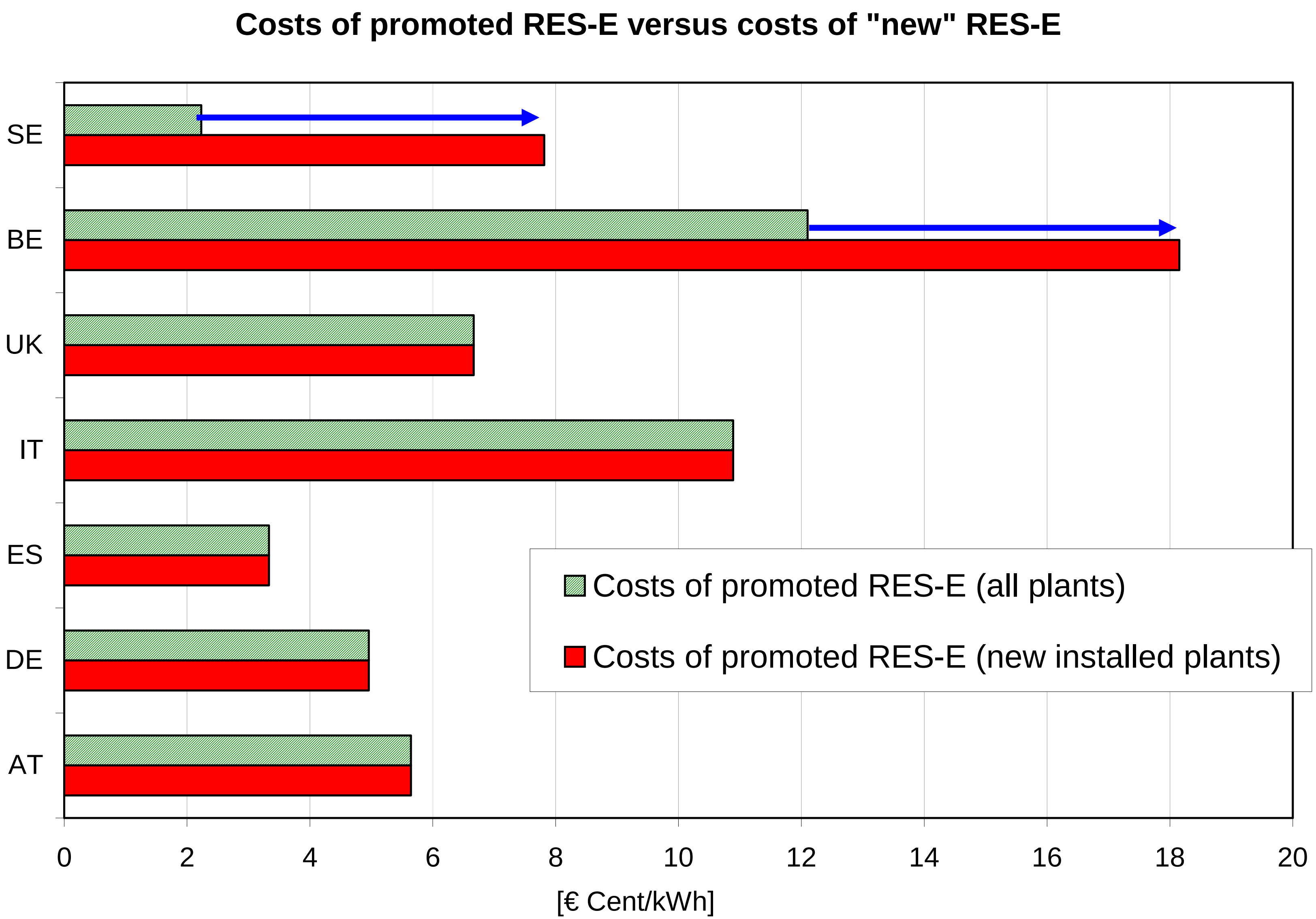
3 Short planning horizon (e.g. UK 2003, Italy)

4 The problem of windfall profits for (existing) capacities (e.g Flanders (BE), Sweden)

QUOTA: EXISTING VS NEW CAPACITY



Costs of promoted kWh vs costs of new kWh



9. COMPETITION ?

- conventional electricity market: To maximize profits utilities merge to avoid competition
- hard to imagine that a European-wide TGC market will work disconnected from these large incumbents
- TGC markets: Why should competition work if it does not in the conventional electricity market?
- Utilities/generators are in favour of TGC because they can make much more money and control the market, the construction of new plants much better

9. COMPETITION?

- Competition among manufacturers exist
- Most important argument for TGCs: it is assumed that they foster competition between generators
- Objective of competition -> competitive prices
- competitive prices:

  Prices = marginal costs (of generation)
- Currently (except Sweden):
  certificate prices > average feed-in-tariffs
- No indicator for real competition in many TGC markets!

10. CONCLUSIONS (1)

- **Careful design of a strategies:**
  by far the most important success criteria!
- **There should be a clear focus on NEW capacities!**
-
-

IMPROVE THE CURRENT SYSTEMS!

- **component!**

10. CONCLUSIONS (2)

- Instead of harmonisation: Stimulate/Foster competition between promotion schemes/between countries: Which system/where provides new RES-E capacities at lowest costs for society?
- Exchange of lessons learned: Improvement of strategy design must build on learning from each other: e.g. Feed-in-cooperation DE and ES -> Why not a similar “Club” of TGC – countries?
- Currently, a well-designed (dynamic) FIT system provides a certain deployment of RES-e fastest and at lowest costs for society
- However, for sustainable policy -> parallel focus on demand-side conservation of high priority!

10. CONCLUSIONS (3)

In the long run?

- Re-regulation?
- Priority production from renewables should persist
- Ecological bonus of the magnitude of external cost relief could prevail “eternally” (at least as long as no environmental taxes are introduced)
- However, for sustainable policy -> parallel focus on demand-side conservation of high priority!

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