



Developing a comprehensive renewable cost data collection process to support Italian policy makers

Luca Benedetti

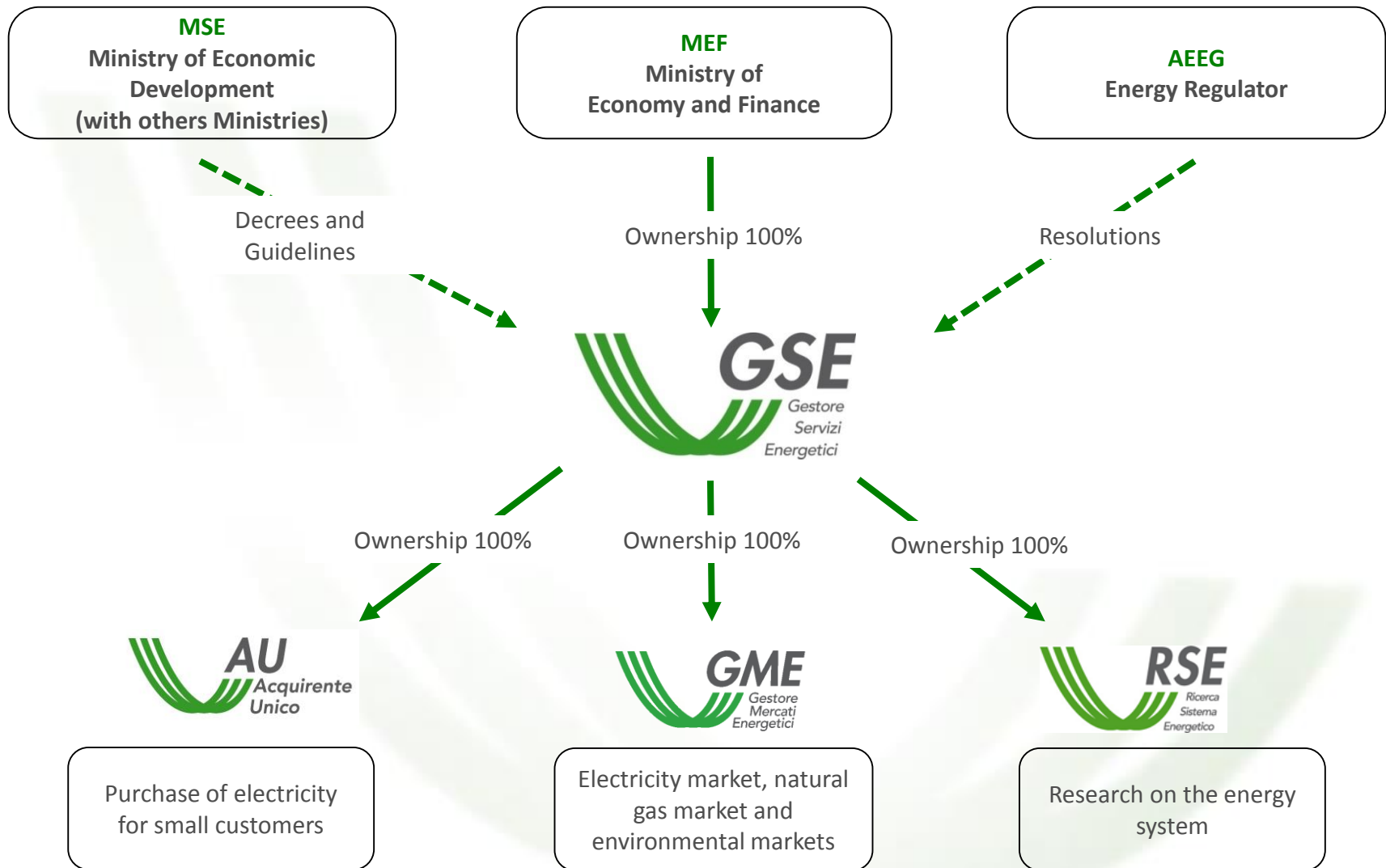
Head of Studies and Statistics Unit, GSE

IRENA-GSE

*Renewable cost data to support policy making:
Design, implementation and best practice*

12 December 2014

GSE - Italian Energy Services Operator



MISSION: GSE promotes the development of renewable energy sources and energy efficiency in Italy, granting economic incentives, managing energy services and supporting the policy makers

- Management of **support schemes** and **energy services** for **RES, CHP and Energy Efficiency (electricity, heating, transport)**: management of dematerialized applications, plants qualification and inspection, contracting, management of measures and incentives(services, etc.
- **Energy management**: participation in the electricity market (energy withdrawn in the context of incentives/services managed), forecasting of electricity production, management of unbalancing costs, calculation of curtailed wind power generation, etc. GSE aims to reduce renewables unbalancing costs so it is crucial accurate forecasting of non-programmable plants.
- **CO2 auctions** : we are in charge of auctioning Italian emission allowances on the European Common Auction Platform (CAP)
- Support to **institutional policy makers** and **public administration**
- **Studies, statistics, monitoring** on RES and EE: statistics, monitoring reports for the EU, analysis of economic and employment impacts, environmental effects, authorization procedures, generation costs in Italy and at international level, analysis and comparison of international policies
- **International activities**: participation in the main international associations (IEA, IRENA, RES4MED, etc.) and in the energy projects and studies funded (Concerted Action on RED, PV Parity, etc.)
- **Information and training**: promotion of RES and EE (workshops, reports and guides, training, etc.)
- **Support to Italian RES operators** (“Corrente” project) to contribute to improving the chain visibility and to introducing the operators into the international markets

- Monitoring cost data of RES technologies in Italy
 - Motivations and regulatory framework
 - Output analysis and Input data
- **GSE methodology for systematic cost data collection**
 - PV technology assessment
 - Other RES technology assessment
- **Cost data analysis and results**
 - PV costs evolution
 - Other RES costs
- **Example of other analyses arising from the same monitoring**
 - Supply chain
 - Jobs



Motivations and regulatory framework



Ministero dello Sviluppo Economico



- **Data** about **generation costs** of renewable energy in a specific market are crucial in **setting national policies, monitor the results** and it can be also a key issue for **sector deployment planning**
- In Italy the Ministry of economic development has entrusted GSE to implement a **monitoring activity on generation costs of renewable energy** in order to analyze the evolution of the competitiveness of RES technologies, economic and employment impacts of the deployment of renewables in the national industry, estimate effectiveness and efficiency of the supporting schemes also compared with other EU Member states

(Legal basis: Legislative Decree 28/2011, art. 40, Ministerial Decree 06/07/2012, art. 24)

Output analysis

Technology specific analysis



- Evolution of technology costs
- Evolution of generation costs
- Evolution of investments feasibility

System level analysis



- Setting of **support** level on **profitability** basis
- **Policy efficiency** analysis
- Evaluation of impacts on the **energy markets** and construction of bottom-up **energy scenarios**
- Monitoring of annual **investments** in the sector
- **Jobs** impacts (directs, indirects, induced)
- Gross **economic** impacts (AV, GDP, import-export...)

Monitoring cost data of RES technologies in Italy

Input data

Cost inputs



- **Investment costs** in the local markets
- **Operation and maintenance costs** in the local markets
- **Cost of fuels**

Technical inputs



- **Technical potential** of resources for each region
- **Efficiency** and availability of technologies

Financial inputs



- **Financial parameters** (WACC and financial leverage)

Energy Prices inputs



- **Energy remuneration and avoided costs**

Value chain inputs



- **Equipment manufacturers**
- **Cost of labour of the construction and operation phase**

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How to collect cost data: GSE approach

- **GSE** handles national **RES support schemes and other services** provided to RES operators. This allows **collecting information** on thousands of renewable power plant **investments** in internal databases.
- **GSE** is also involved in the **National Statistics System** (SISTAN) for the elaboration of RES statistics, and supports the Italian Ministry of Economic Development (MSE) in monitoring the achievement of RES 2020 targets and report to **European Commission, Eurostat, UNECE, IEA, IRENA, etc.**
- The **operators**, during the access phase to the support schemes and GSE's services or by GSE's statistical surveys, are asked to compile an on-line form with technology specific fields in order to assess a detailed breakdown of the **investment, O&M, fuel and financial costs**. At the same time GSE acquires information about **type, manufacturers, performances and supply chain** of adopted technologies and also about **labor intensity** through some specific indicators.



GSE methodology for systematic cost data collection

PV: On-line form on GSE website, from 2007

investment cost and breakdown

Al fine di consentire l'effettuazione del monitoraggio tecnologico previsto all'articolo 15, comma 1 del DM 19/02/07

- Fornitura Moduli:	7436	←
- Fornitura Inverter:	1286	←
- Resto della fornitura, installazione e progettazione:	4531,94	←
Costo totale dell'impianto:	13253,93	←
Costo Specifico:	4432,75	←

Investment
cost [€]

Modules
cost [€]

Inverter
cost [€]

Other
costs [€]

- Also, information on modules and inverters manufacturer are requested

- Description of PV database: a huge information flow was collected from 2007

Technology	Number of plants	Capacity [MW]
PV	548.667	17.613

Other RES: On-line technology specific form on GSE website, from 2013

Example for a biogas power plant - 300 kW

investment cost and breakdown

Costo totale di investimento (€):

1800000

di cui per (in percentuale):



Realizzazione dei digestori

30,00%

Gruppo di

generazione (%):

30,00%

Altre Apparecchiature

Meccaniche (%):

5,00%

Opere Civili (%):

15,00%

Componenti Elettrici e

sistema di controllo (%):

10,00%

Sistemi di

abbattimento delle

emissioni (%):

4,00%

Sviluppo dell'iniziativa (%):

6,00%

Fuel requirement and cost

		Tipologia Matrice	Descrizione Matrice	Fabbisogno Matrice (t/anno)	Costo Approvvigionamento Matrice (€/t)
		Prodotto origine biologica	Pastone di mais	440	100
		Prodotto di origine biologica	Granella di mais	495	190
		Sottoprodotto di origine biologica	Stocco di mais	65	25
		Sottoprodotto di origine biologica	Residuo di campo	155	15
		Sottoprodotto di origine biologica	Liquame bovino	7298	0
		Sottoprodotto di origine biologica	Letame bovino	408	0
		Sottoprodotto di origine biologica	Melasso	120	180
		Sottoprodotto di origine biologica	Glicerolo	120	180
		Sottoprodotto di origine biologica	Sottoprodotti lavorazione del mais	150	150
		Sottoprodotto di origine biologica	Distiller	150	150

O&M cost

Costo annuo stimato di O&M (€/Anno):

100000

di cui per (in percentuale):

Esercizio e manutenzione (%):

50,00%

Gestione (%):

50,00%

Financial parameters

Percentuale di capitale proprio (%):

10%

Percentuale di capitale di debito

(%):

90%

Durata del debito

(Anni):

10

Costo medio del capitale di

debito (%):

4,5%

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Fuel requirements

			Descrizione Matrice	Fabbisogno Matrice (t/anno)	Costo Approvvigionamento Matrice (€/t)
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Investment
cost [€]

%
Digester

%
Emission
reduction

%
Project
development

%
Civil works

%
Electric
components

%
Generation
group

%
Other mech.
devices

Financial parameters

Percentuale di capitale proprio (%):

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Durata del debito

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Realizzazione (%):

Componenti Estime e sistema di controllo (%): 10,00%

Gruppo di generazione: 4,00%

Sistemi di abbattimento delle emissioni (%): 6,00%

Altre Apparecchiature Meccaniche: 6,00%

Operazioni: 6,00%

Sviluppo dell'iniziativa (%): 6,00%

Fuel requirement and cost

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+ Aggiungi Matrice Organica

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		Sottoprodotto di origine biologica	Foraggio di campo	55	20
		Sottoprodotto di origine biologica	Foraggio bovino	198	20
		Sottoprodotto di origine biologica	Foraggio bovino	108	20
		Sottoprodotto di origine biologica	Foraggio asino	120	20
		Sottoprodotto di origine biologica	Foraggio caprolo	120	20
		Sottoprodotto di origine biologica	Sottoprodotti lavorazione del mais	150	150
		Sottoprodotto di origine biologica	Distillato	150	150

Annual
cost
[€/year]

%
O&M

%
Administra
tion

O&M cost

Costo annuo stimato di O&M (€/Anno):

100000

di cui per (in percentuale):

Esercizio e manutenzione (%):

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		Sottoprodotto di origine biologica	Glucosio	120	180
		Sottoprodotto di origine biologica	Glucosio	120	180

%
Equity

%
Debt

Duration of
Debt

%
Cost of
debt

O&M cost

Costo annuo stimato di O&M

Esercizio e manutenzione (%):

50,00%

Gestione (%):

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Financial parameters

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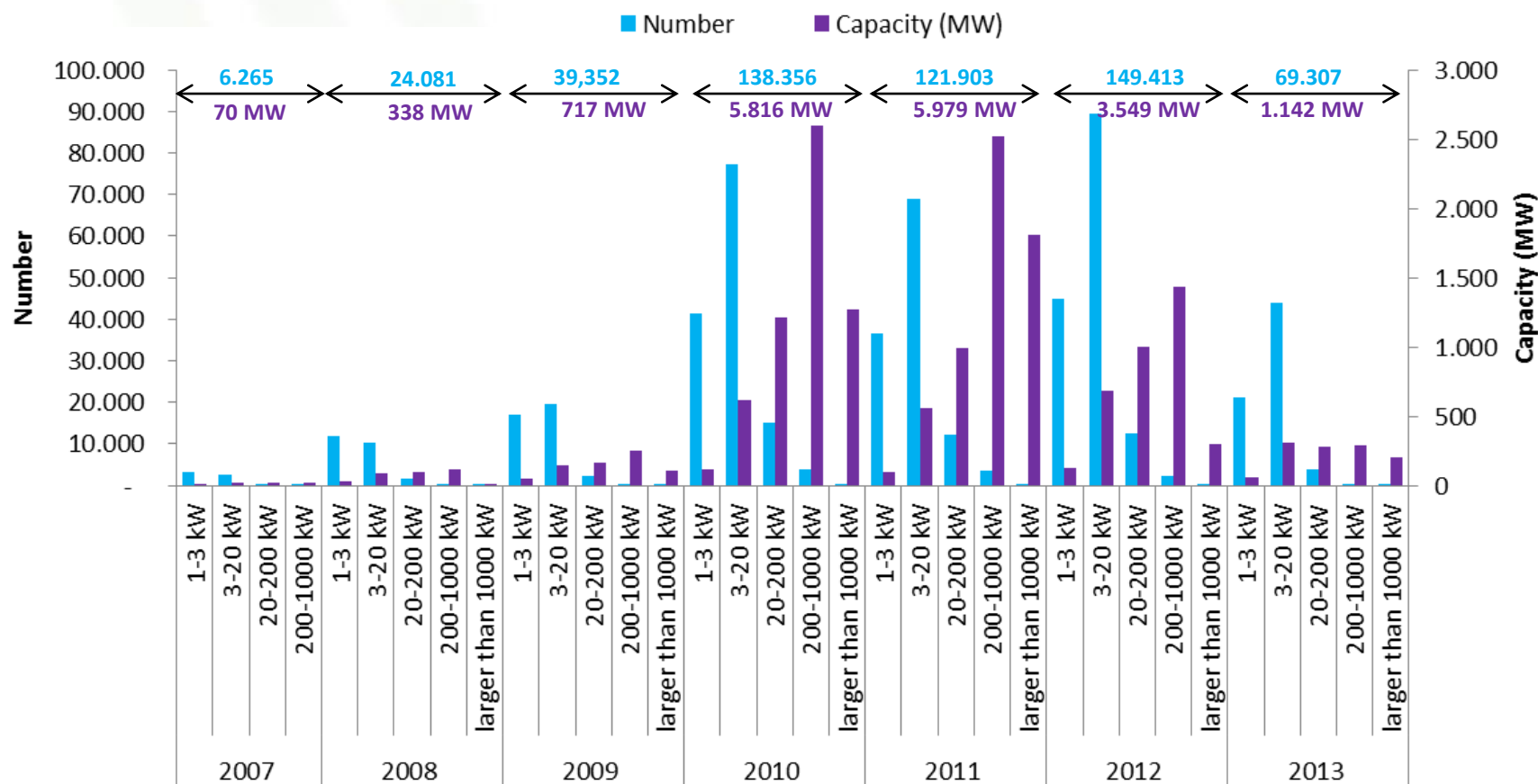
Cost data analysis and results: PV

Description of PV database

- A huge information flow was collected from 2007

Technology	Number of plants	Capacity [MW]
PV	548.667	17.613

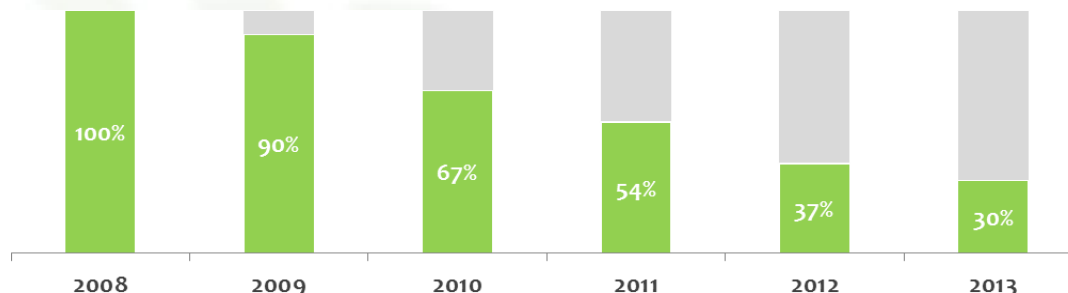
A detailed **filtering activity** (out of range values, non standard technologies, not newly built power plants, etc.) was carried out, excluding – from the cost analysis – about 38.000 initiatives for a capacity of 1,7 GW.



Cost data analysis and results: PV

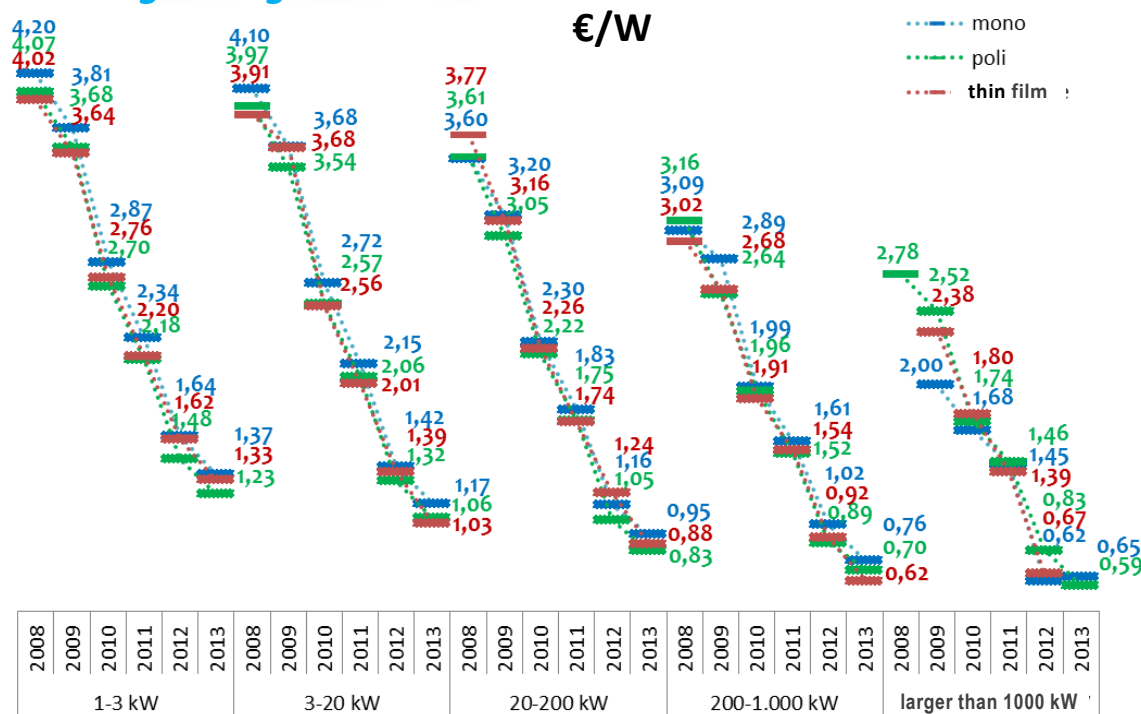
Evolution of PV costs: Modules

Evolution of average module cost with respect to 2008 cost



- In 2013, the average module cost was about 30% of 2008 cost

Technologic insight

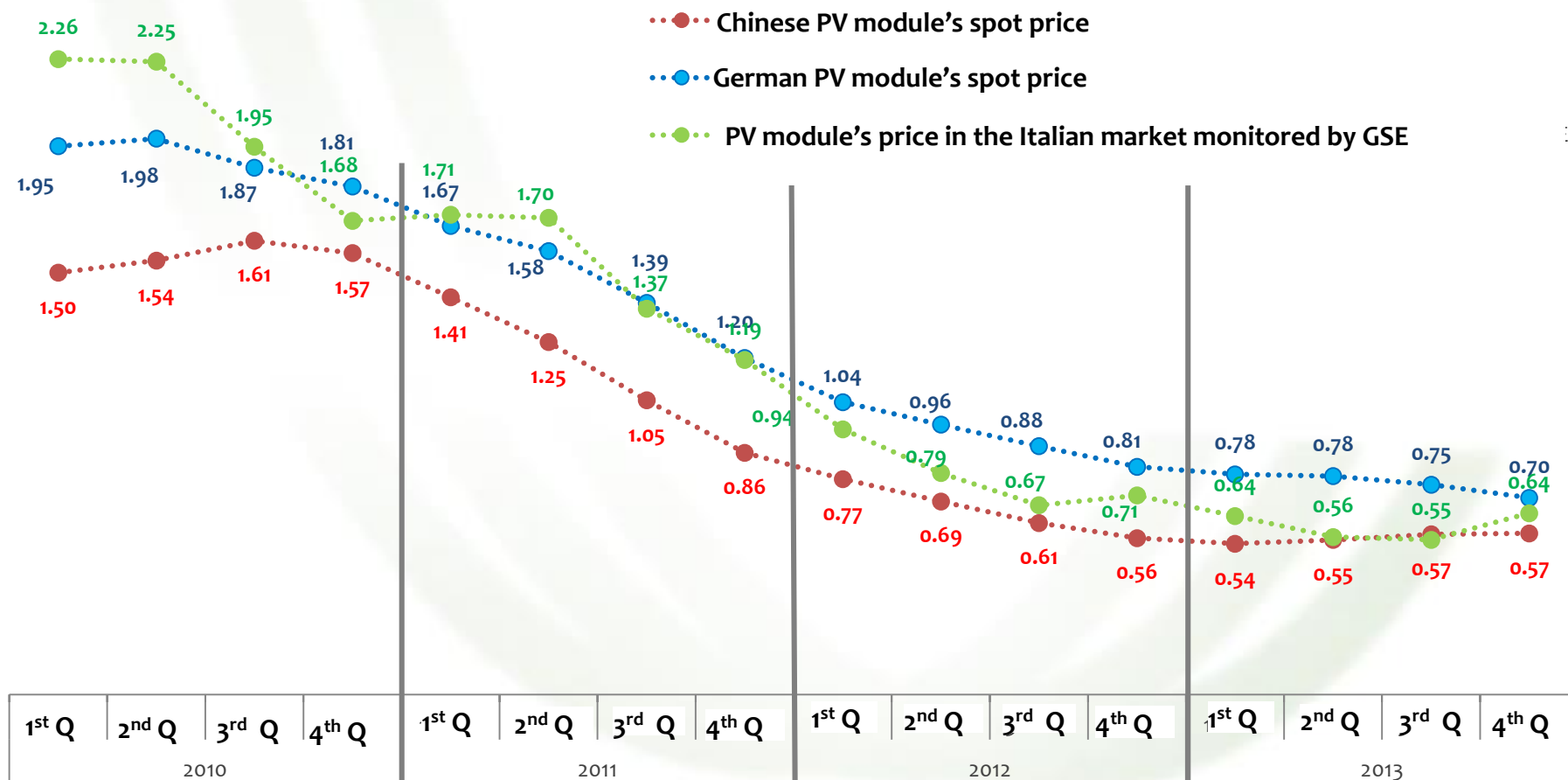


- Fast decrease of modules cost for all technologies
- For large-scale plants, a more pronounced cost decrease is observed
- Significant difference in specific €/W cost by power class due to the distribution chain scale effect

Cost data analysis and results: PV

International comparison

Comparison between spot prices of PV modules manufactured in China and in Germany and the module's price in the Italian market (€/W)

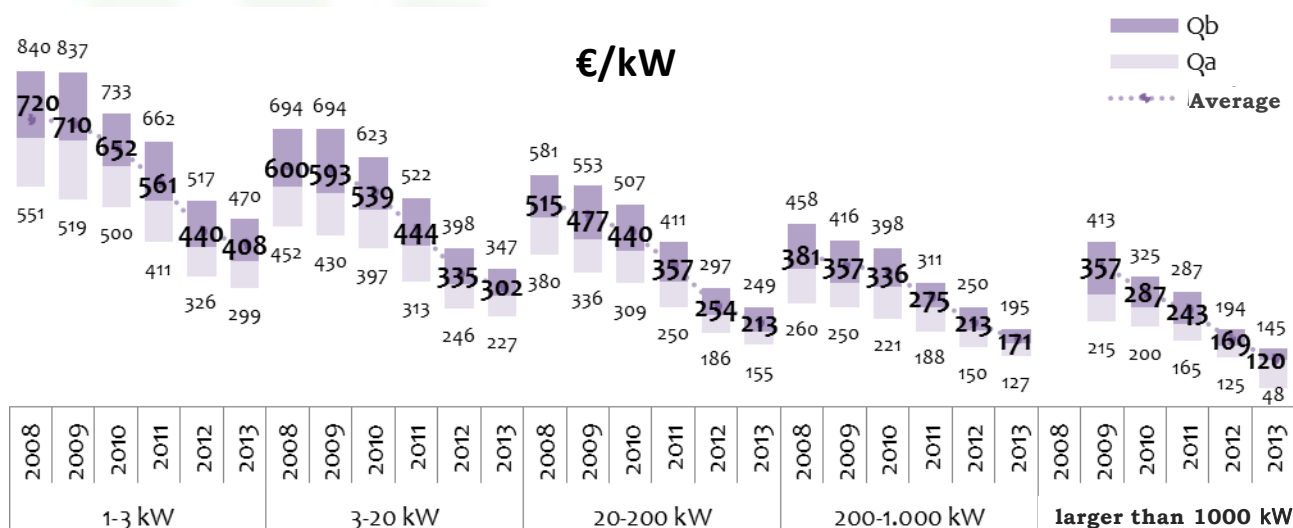


It can be considered as a clue of the reliability of the GSE monitoring

Cost data analysis and results: PV

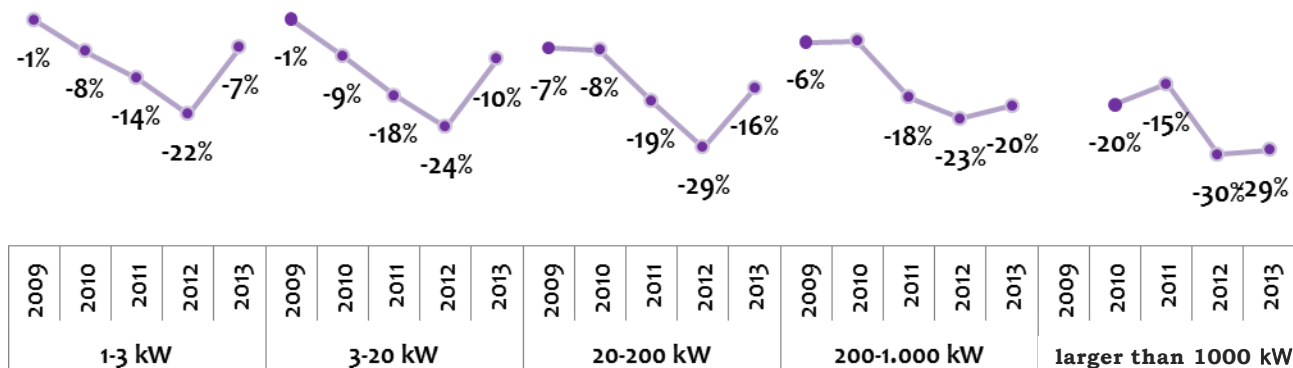
Evolution of PV costs: Inverters

Evolution of average inverter cost



Qa : interval between 1° quartile and median value ; Qb : interval between 3° quartile and median value

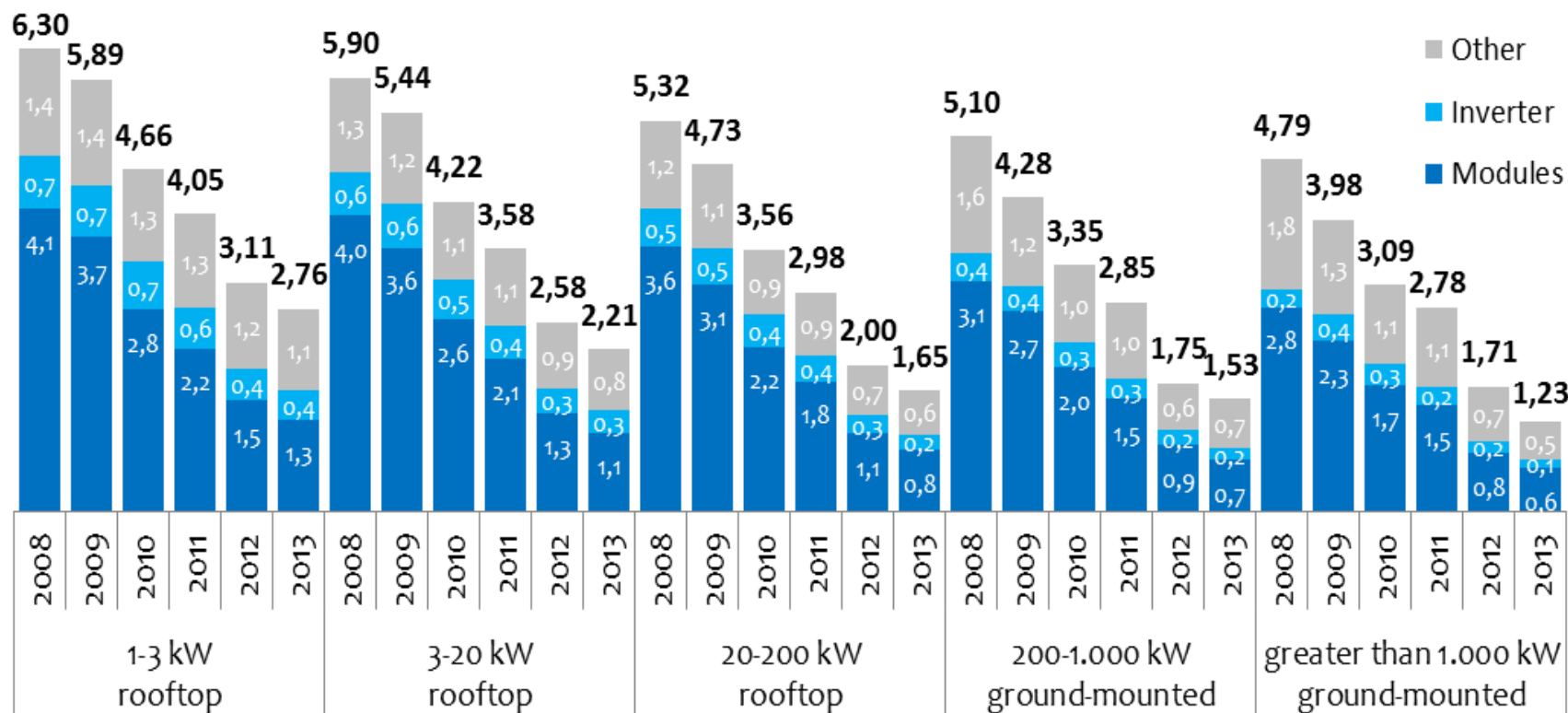
Annual decrease of inverter cost



- Significant difference in specific €/kW cost by power class, more than modules, due to technological scale effect
- Fast decrease of inverter cost, though slightly slower than modules
- Relevant annual decrease, reaching about 30% in 2012 (with respect to 2011)

Cost data analysis and results: PV

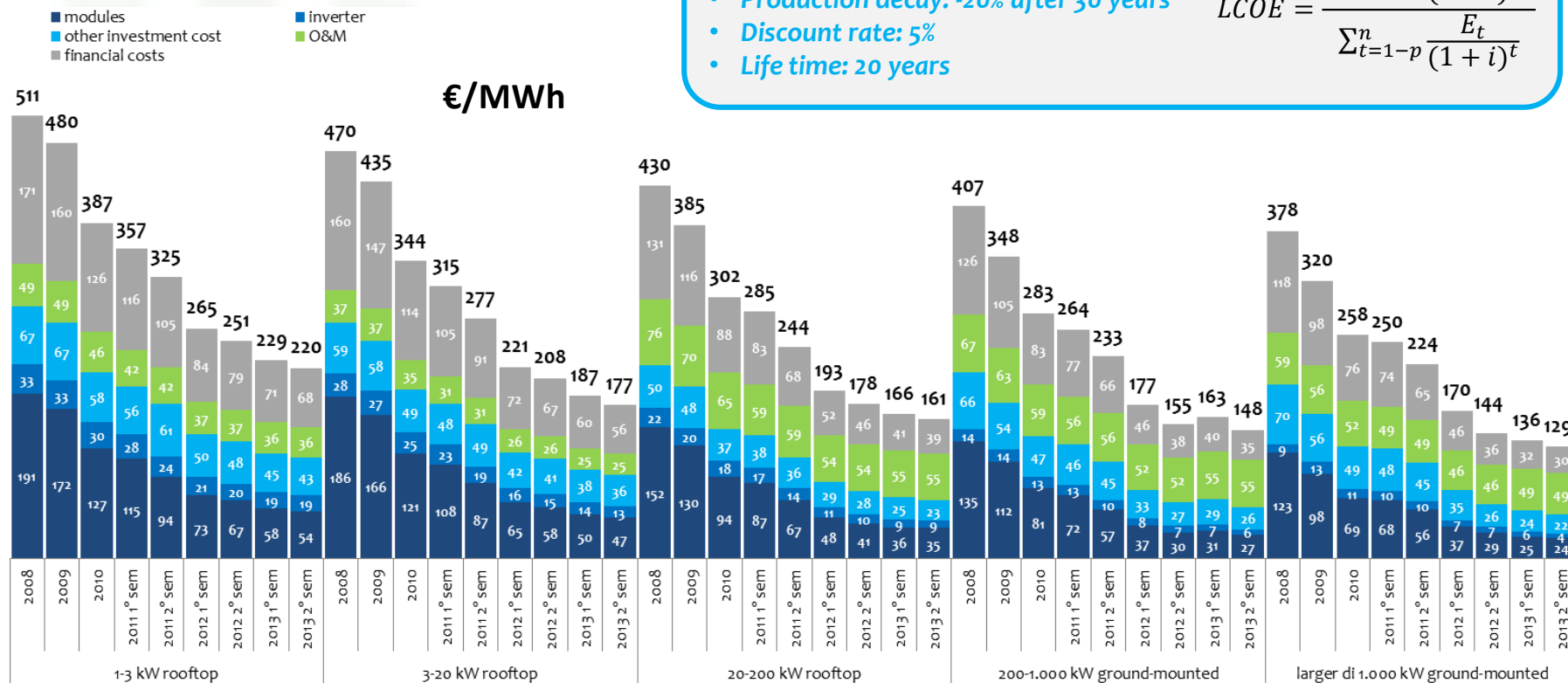
Evolution of PV costs: investment (€/W)



- Fast decrease of investment costs (**20% of average annual reduction**), especially for large PV plants
- In 2013, the cost of 1-3 kW residential PV plants was **44% of the cost in 2008**
- In 2013, the cost of 1 MW ground-mounted PV plants was **25% of the cost in 2008**

Cost data analysis and results: PV

Evolution of PV generation cost



Hypotheses:

- Full load hours: 1300 KWh/kW
- Production decay: -20% after 30 years
- Discount rate: 5%
- Life time: 20 years

$$LCOE = \frac{\sum_{t=1}^n \frac{I_t + O\&M_t}{(1+i)^t}}{\sum_{t=1}^n \frac{E_t}{(1+i)^t}}$$

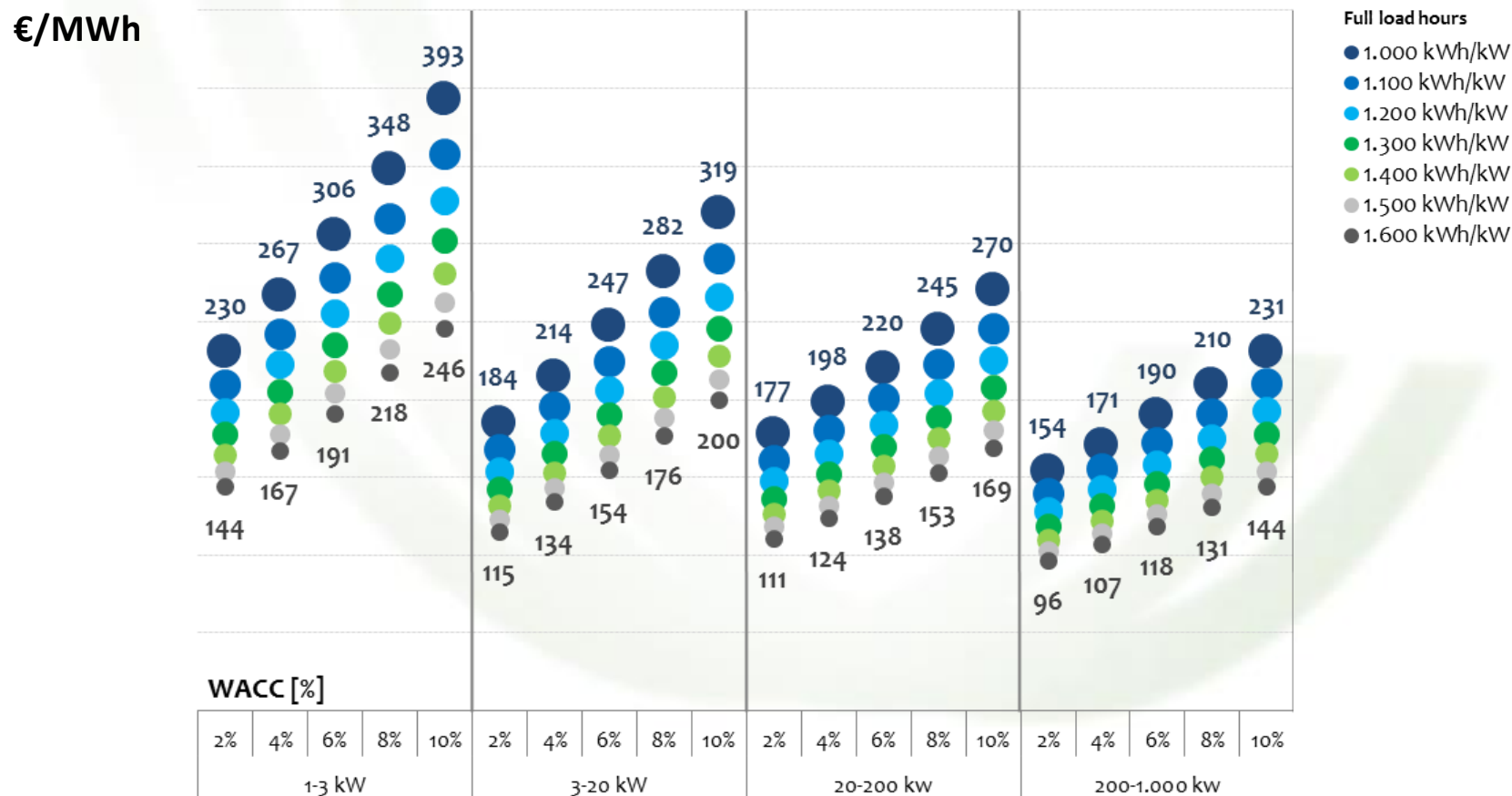
- Fast decrease of generation costs , following the evolution of investment costs
- In 2013, the generation cost of 1-3 kW residential PV plants was **43% of the cost in 2008**
- In 2013, the generation cost of large-scale ground-mounted PV plants was **34% of the cost in 2008**

Cost data analysis and results: PV

LCOE sensitivity

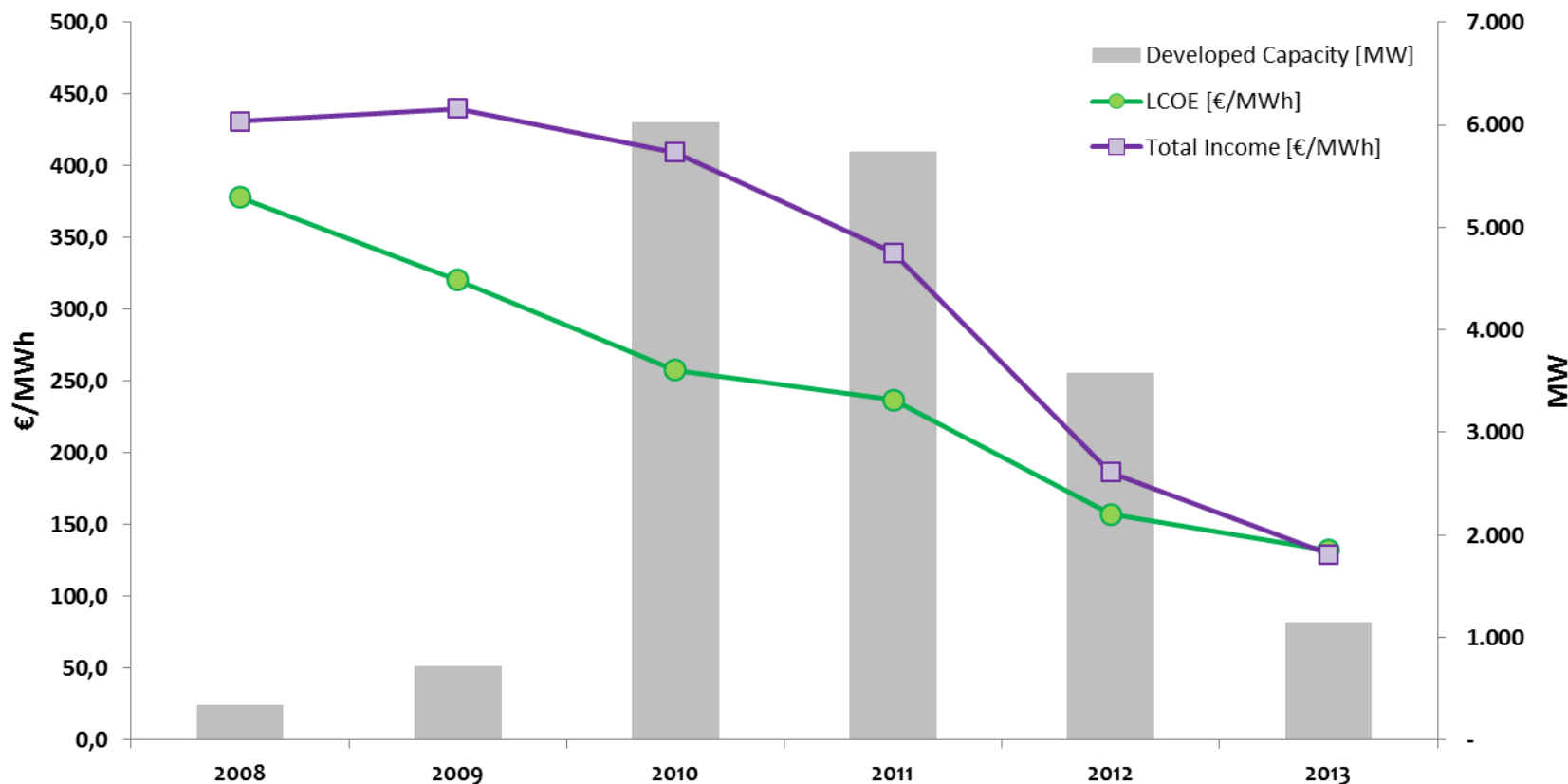
- Further analysis reveals the **strong sensitivity** of generation cost to **discount rate** and **energy production**

Rooftop plants built in 2013



Cost data analysis and results: PV

Comparison between the evolution of generation costs and total revenues

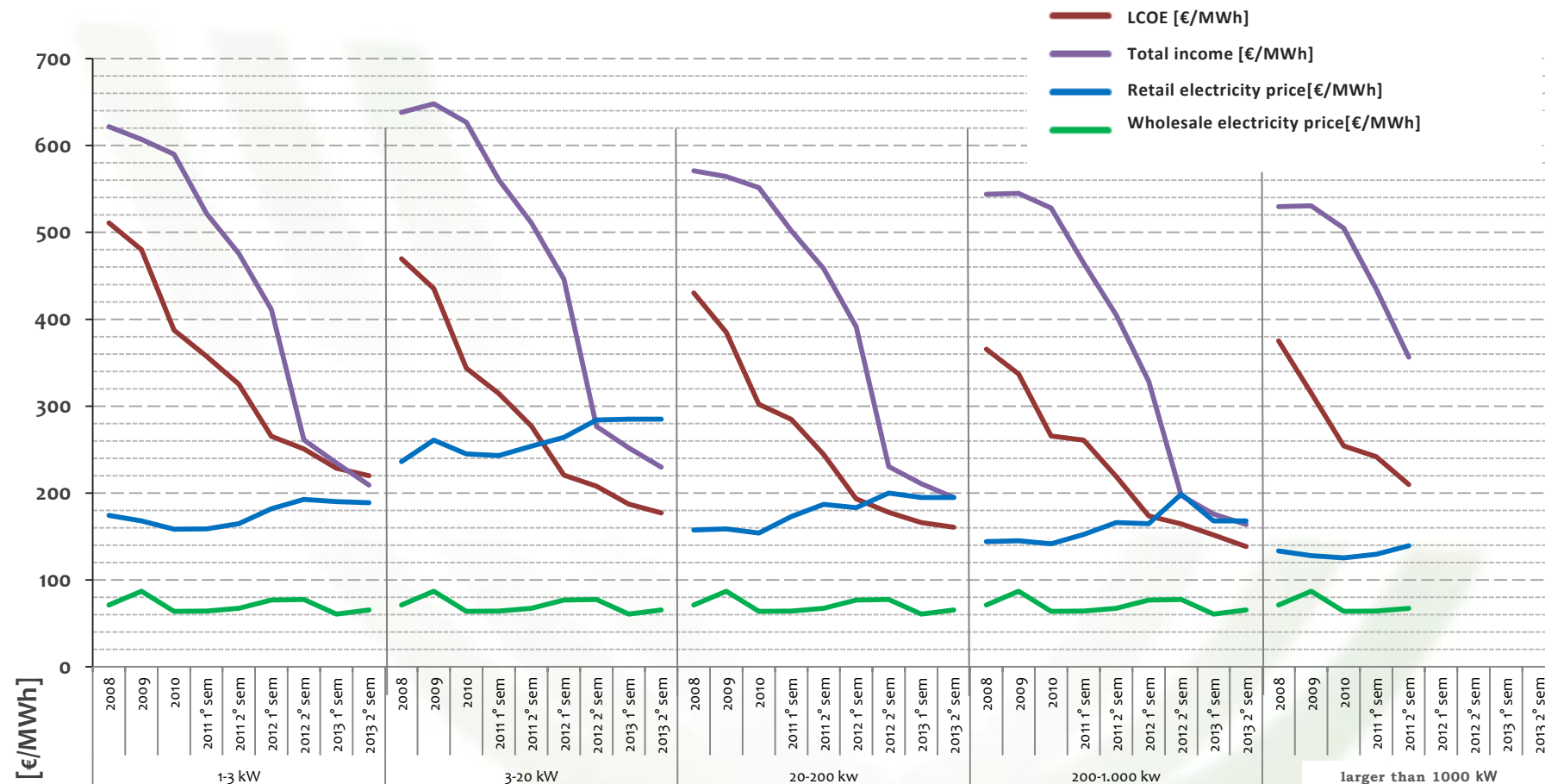


Generation costs and total income refer to ground-mounted PV plants with $P > 1$ MW, while developed capacity includes all plants.

- The **fast decrease of generation costs** in 2008-2010 was **not combined with the same rate of reduction of energy remuneration**, thus determining the economic conditions for a great development in 2010-2011

Cost data analysis and results: PV

Evolution of PV competitiveness



- We are **close to grid parity** (red and blue) and **far from market parity** (red and green)

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Cost data analysis and results: other RES

Description of GSE other RES cost database

- The other RES cost data collection includes investments developed starting from 2012.
- In October 2014, the database includes **875 power plants** for a total capacity of **397 MW**

Technology	Number of plants	Capacity [MW]
Wind on shore	446	229
Hydro reservoir	5	4
Hydro run on river	206	101
Hydro on aqueduct	36	3
Biogas	108	26
Biomass (included WTE)	72	33
Landfill gas	2	1
Total	875	397

Cost data analysis and results: other RES

Preliminary Analysis of other RES cost database

- The table contains a sample report of investment data relative to individual initiatives that result representative of the average conditions

	Technology				
	WIND	HYDRO run on river	GEO	BIOGAS Silage & Manure	BIOMASS wood pellet
Technical data					
Electric power [KW]	16.000	400	20.000	300	200
Load factor (%)	30% (range:20%-32%)	49%	92%	80%	80%
Annual energy production [MWh]	42.048	1.700	161.184	2.102	1.395
Economic lifetime (years)	20	20	25	20	20
Discount rate	5,0%	4,8%	6,4%	5,4%	5,2%
Costs					
Investment cost [€ mln]	22,9	1,8	84,8	2,0	1,0
Specific investment cost [€/mln /MW]	1,4	4,4	4,2	6,5	5,2
O&M cost [€/ MW per year]	40.625	113.636	138.000	333.000	394.472
Fuel cost [€/t]				45 (only for silage, 13% of total fuel)	210
Fuel cost [€/year]				100.000	176.400
LCOE					
Fuel cycle cost [€/MWh]	-	-	-	48	126
O&M cost [€/MWh]	15	26	17	48	56
Investment cost [€/MWh]	45	84	44	79	62
LCOE [€/MWh]	60	111	61	174	245

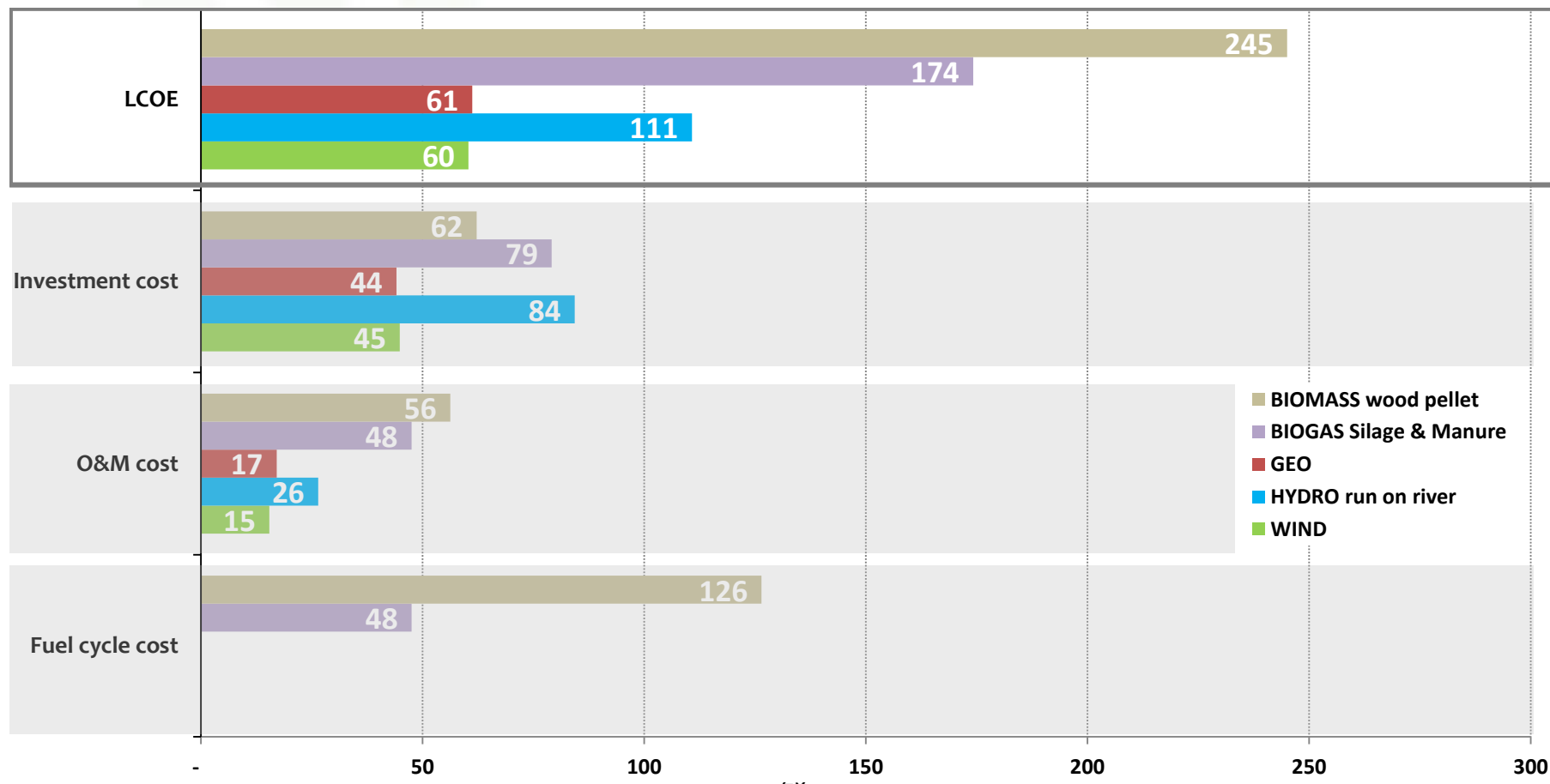
Cost data analysis and results: other RES

Preliminary LCOE analysis of other RES technologies

In this LCOE calculation, the following assumptions were considered:

- No inflation rate applied
- O&M and fuel costs are assumed constant for the overall lifetime

LCOE comparison between different RES technologies [€/MWh] (preliminary results)



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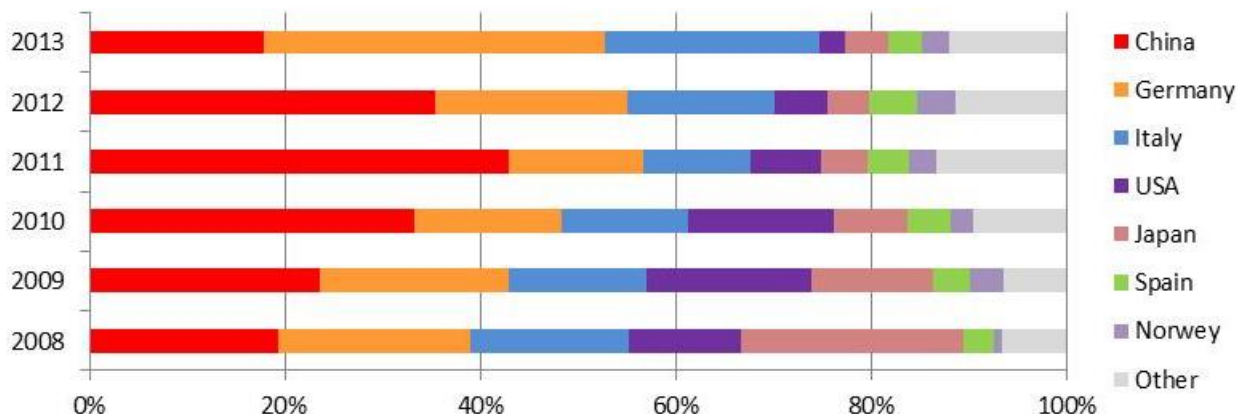
Cost data analysis and results: PV

Evolution of PV supply chain

Modules



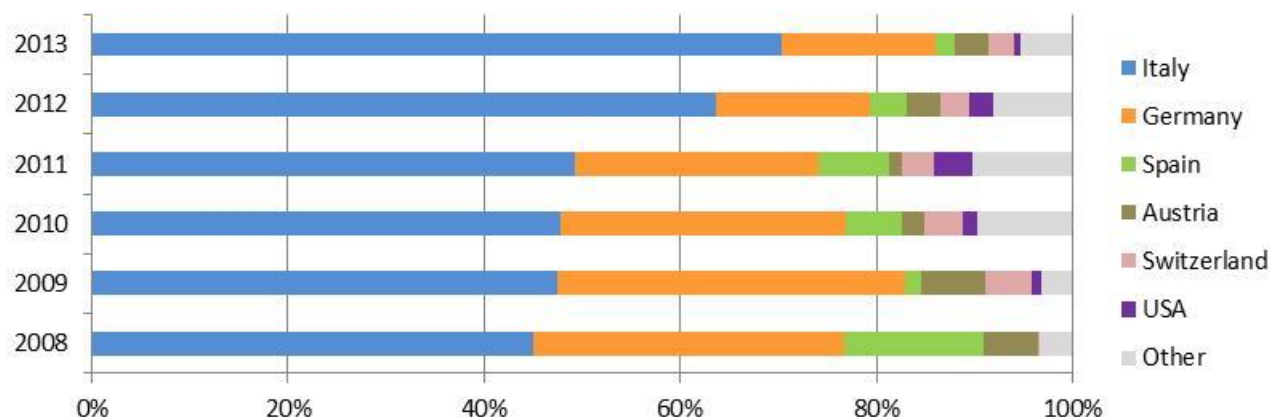
Country of origin of the manufacturer companies (as % of annual capacity)



- China and Germany had the highest market share, especially in 2010-2012, when most capacity was installed
- In 2013, the Italian share showed a slight recover, reaching 22%

Inverters

Country of origin of the manufacturer companies (as % of annual capacity)



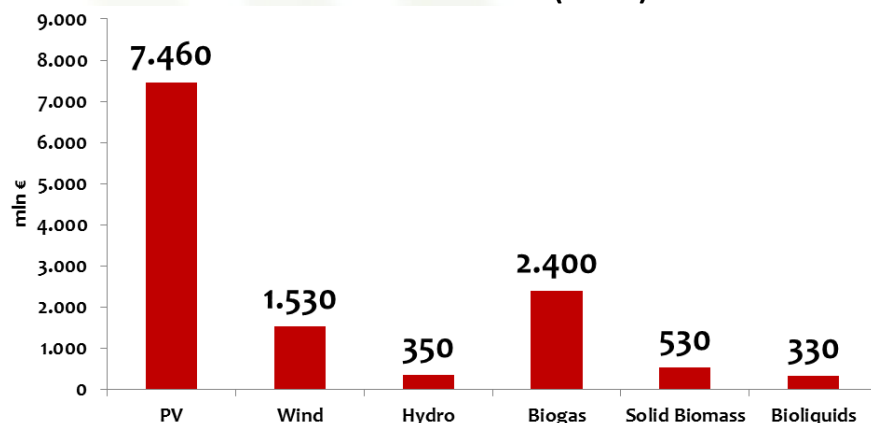
- The Italian industry has always had a high market share, further growing between 2008 and 2013

Other monitoring activities: investments and jobs

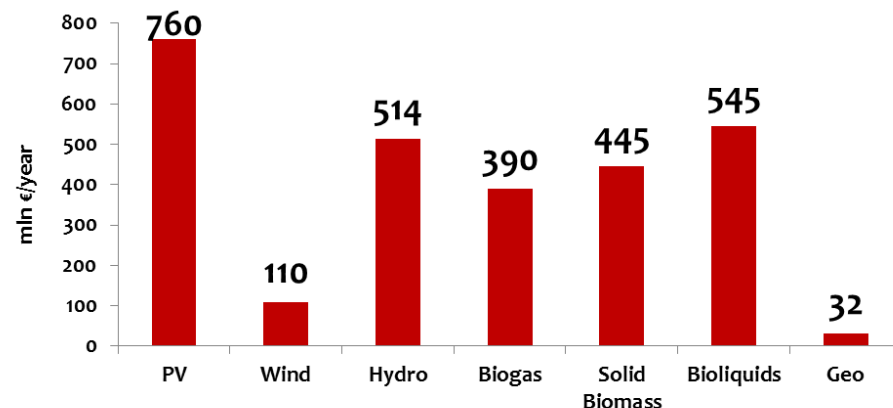
Jobs in the RES-E sector

According to Legislative Decree n.28/2011, GSE assesses economic and employment impacts of RES development

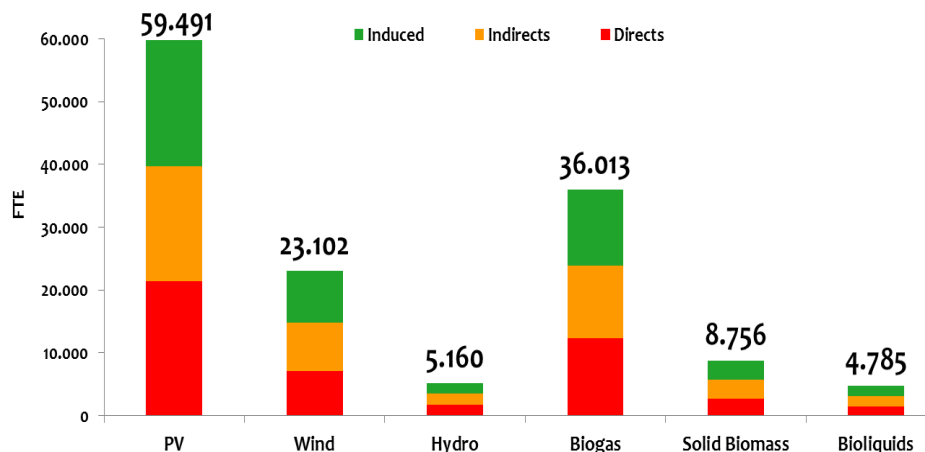
RES - E Investments in 2012 (mln €)



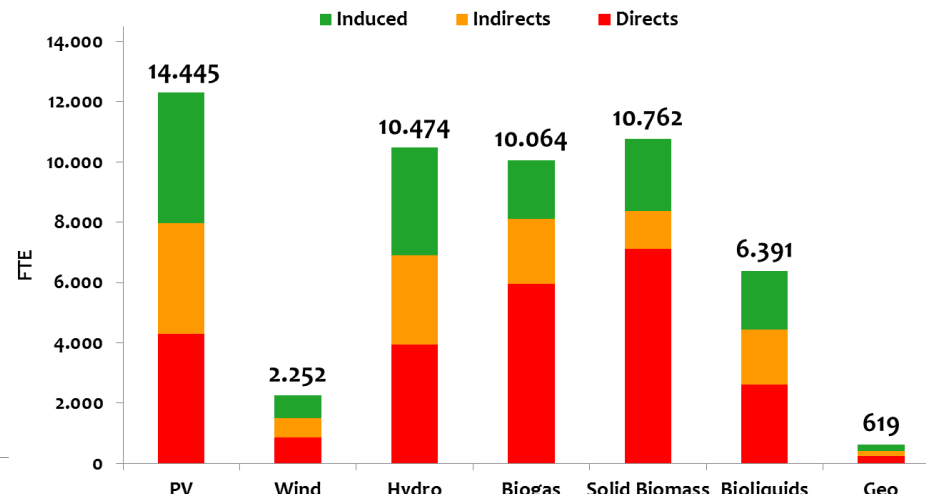
Total O&M expenditures in existing plants in 2012 (mln €/year)



Employment impacts due to investments in new plants in 2012 (FTE)



Employment impacts due to total O&M expenditures in existing plants in 2012 (FTE)



Thank You For Your Attention

luca.benedetti@gse.it