# A quantitative analysis of the merit order effect

## The case of PV in Italy

EU PVSEC 2013

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## 1- Introduction

### The purpose of the study

- **What is the net cost of Renewables?**

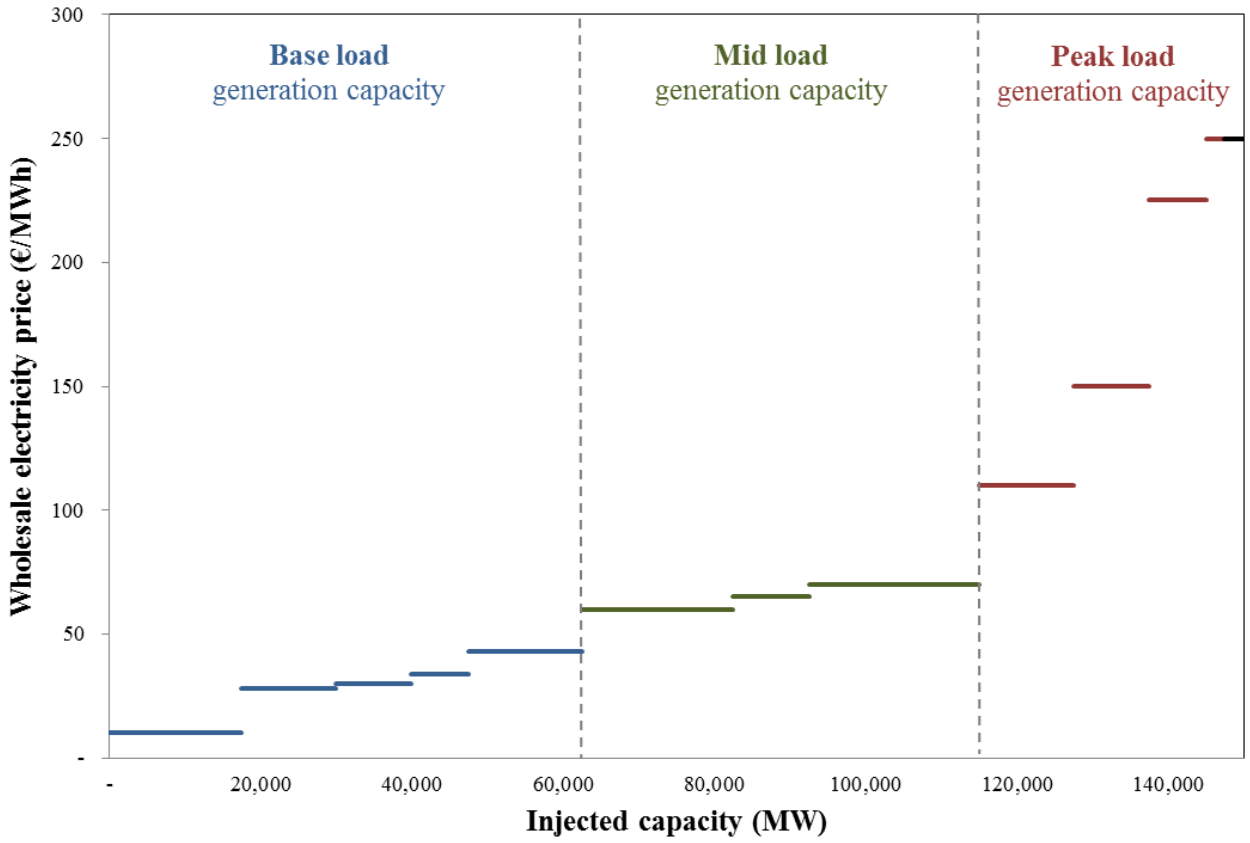
- **Costs**
  - Intermittency:
    - need for **priority of dispatch** (physical constraint)
    - Maybe also need for additional **spare peak capacities**
  - Small and distributed
    - Requires **grid reinforcement** works
  - High LCOE:
    - Operators need **support schemes**
- Impact on electricity market
  - Examples of **negative prices** recently

- **Benefit**
  - Applies a downward **pressure on spot prices** when the sun shines => gain for all the consumers
  - It is called the **Merit Order Effect**

- The debate about the cost of RE should balance the negative and positive monetary consequences

## 2- The Merit order Effect

### Merit Order Curve ("**MOC**")




- Demand is inelastic because consumers supplied on long term contracts
- In a market environment, at a given time **price is set by the most expensive power producer** able to satisfy the demand (i.e with the highest marginal costs).
- This price is imposed **to all other producers**.

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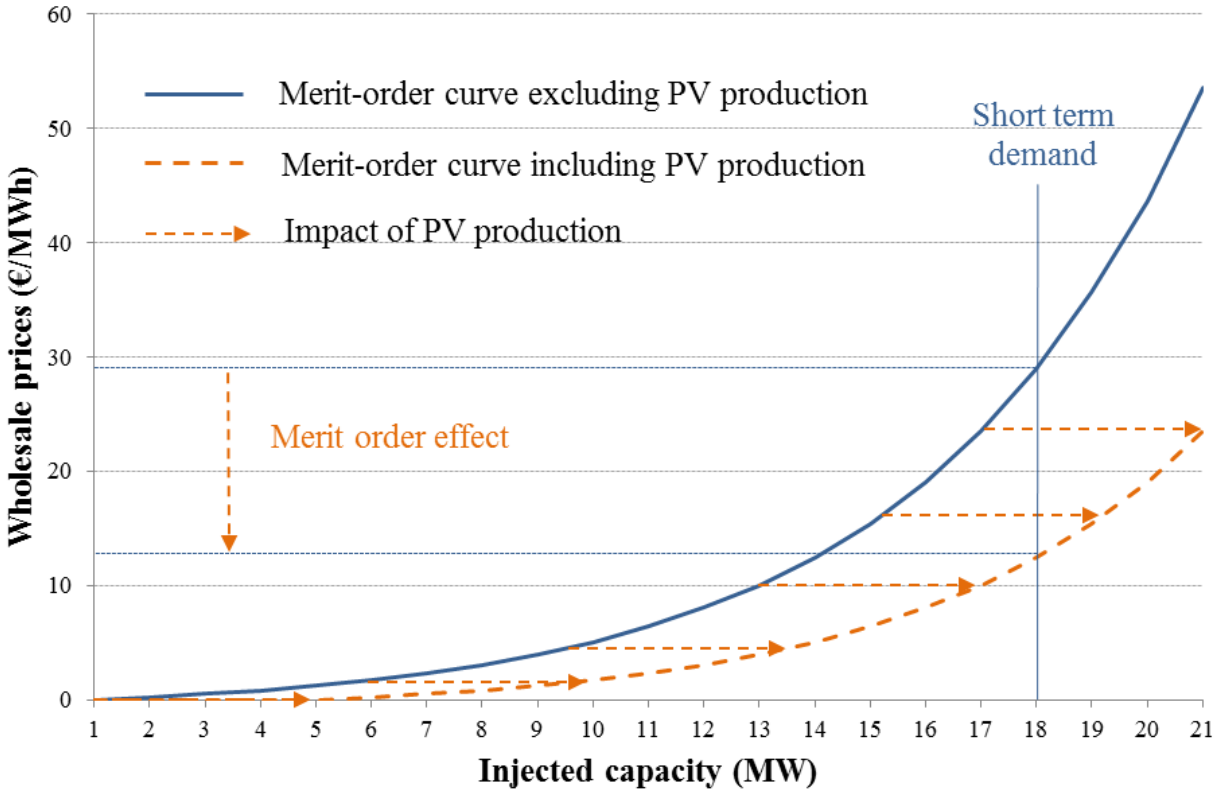
### The purpose of the study




- RE production shifts the MOC rightward => decrease in spot price for a given demand

## 2- Merit order Effect

### Set of assumptions and protocol: Why Italy

- PV is the predominent RE source in the country but acceptable penetration rate (**no negative prices**)
- Limited **interconnection** with neighboring countries, no self-consumption
- **Efficient market** with a diverse energy mix => easy to extract a Merit Order Curve
- All electricity is traded on the spot market. Spot mechanisms are **internalised** in LT contracts

## 3- Historical analysis

### Data collection and protocol

- **PV production** data
  - Irradiation and temperature from GeoModel,
  - since Jan 2003 (MFG then MSG satellite),
  - 15-minute time step transformed into hourly
  - Performance ratio including temperature
  - Monthly PV capacity provided by GSE
  - Split in 3 regions: North, Center & South

- **Total production** data from Mercatoelettrico

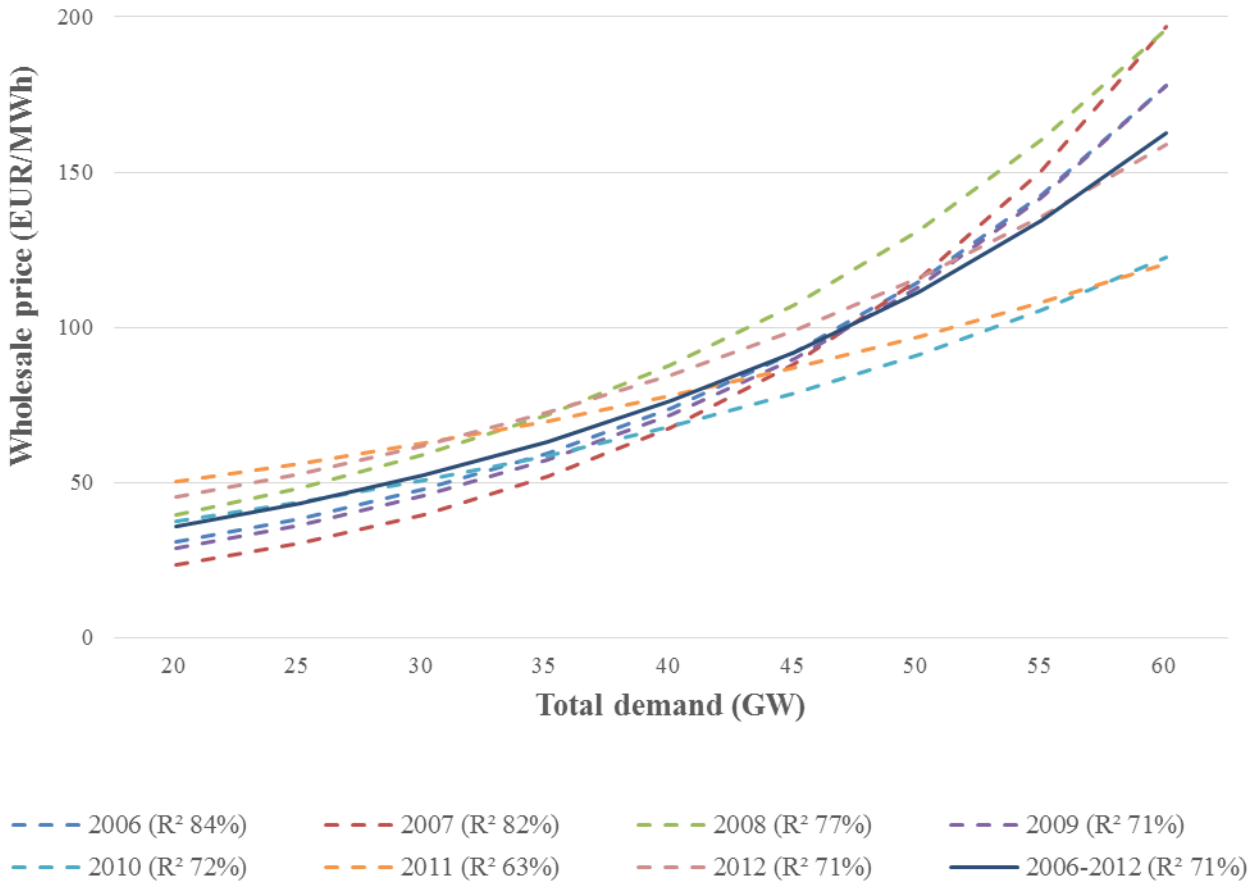
- Wholesale **electricity prices** from Mercatoelettrico

- **Constant MOC** referential: total production was retreated by intermittent PV production

- **Exponential** profile: the log of the spot price was correlated to the retreated production

## 3- Historical analysis

### Merit Order Curve

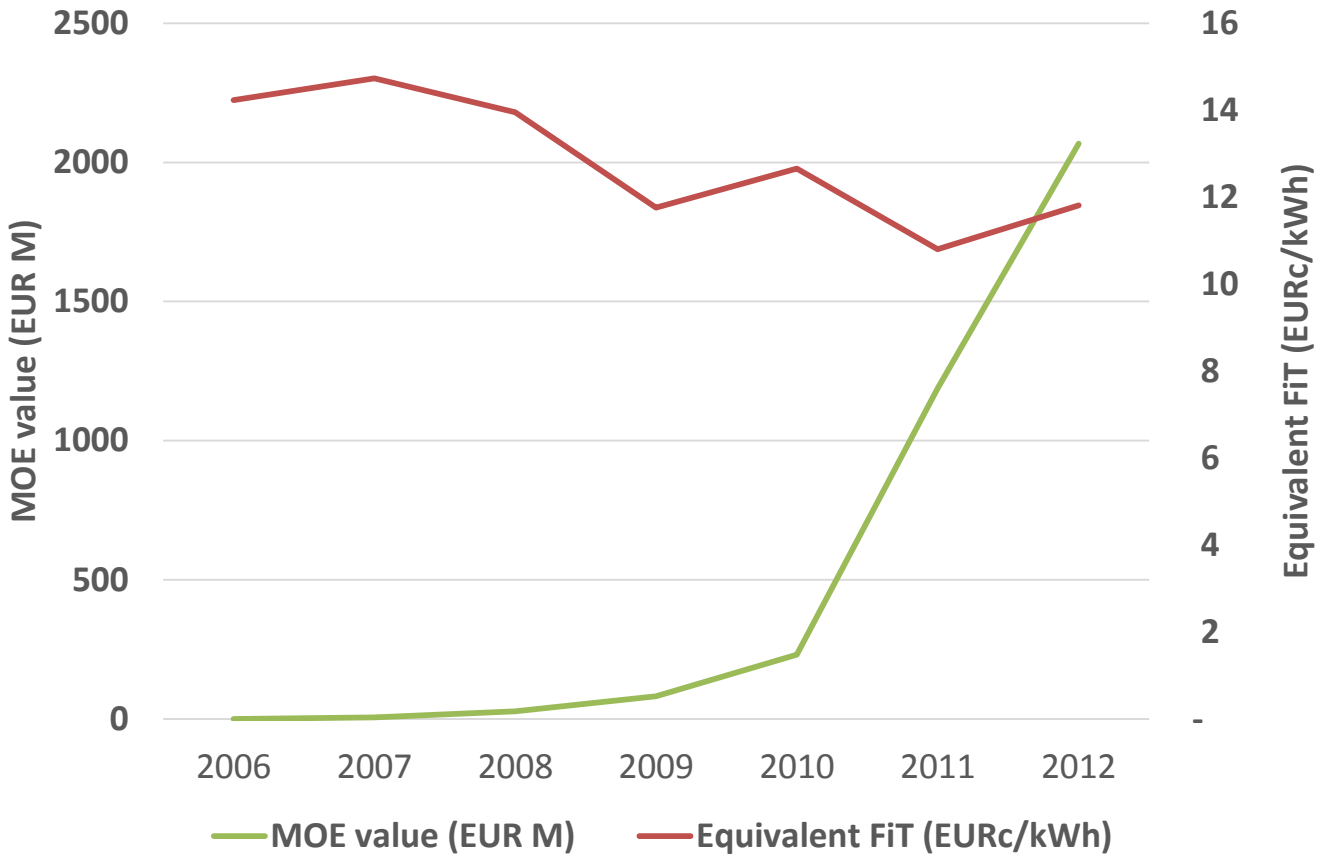



| Year | $R^2$ |
|---|---|
| 2006 | 84% |
| 2007 | 82% |
| 2008 | 77% |
| 2009 | 71% |
| 2010 | 72% |
| 2011 | 63% |
| 2012 | 71% |

**$R^2$>70%**

## 3- Historical analysis

### Results




Main findings:

- MOE is **several EUR Bn per year**
- MOE increases with installed capacities. Savings
- **« Merit Order Price » above 10c/kWh** available for subsidy (on top of spot price)
- MOP decreases with installed capacities

## 4- Statistical analysis

### Protocol

- **100 Monte Carlo** simulations of hourly yield throughout the year.
- Each data set (hourly production) follows an independent normal distribution
- We used the same MOC (on 2006-2012 data) so as to have comparable results
- We calculated the MOE
  - for each PV installation rate observed between 2006 and 2012
  - For each electricity demand profile observed between 2006 and 2012

## 4- Statistical analysis

Results

| Relative variations to 2006 MOP | | PV installed capacity | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
| Consumption profiles | 2006 | 0.0% | 1.7% | 1.6% | 1.8% | 0.6% | -6.2% | -2.0% |
| | 2007 | 2.3% | 3.4% | 3.1% | 3.2% | 2.0% | -4.7% | -1.1% |
| | 2008 | -4.9% | -1.1% | -1.5% | -0.8% | -2.3% | -8.1% | -3.8% |
| | 2009 | -17.2% | -17.2% | -17.5% | -17.7% | -18.5% | -23.9% | -20.7% |
| | 2010 | -9.6% | -9.6% | -9.9% | -9.9% | -10.9% | -17.1% | -14.0% |
| | 2011 | -16.8% | -17.4% | -17.3% | -17.6% | -18.3% | -24.4% | -21.1% |
| | 2012 | -11.1% | -8.8% | -9.7% | -8.8% | -10.1% | -15.8% | -12.6% |

- MOE does not varie much with penetration rate
- MOE varies materially with the demand profile

## 5- Conclusion

### Limits of the study and ideas for further improvements

- 5000 simulations led to comparable results than 7
- There is a direct relationship between demand and prices (decent correlation)
- MOE > EUR 2 Bn in Italy today
- MOP > 100 EUR/MWh produced by PV
- MOP does not depend much on PV penetration rate
- MOP is sensitive to the correlation between electricity demand and PV supply

- Next steps:
  - Include wind in our study
  - Run the Monte Carlo on irradiation rather than yield
  - Take account of self consumption, exports/imports
  - Calculate the MOE for other European countries
  - **TELL THE WORLD !**

## 5- Acknowledgments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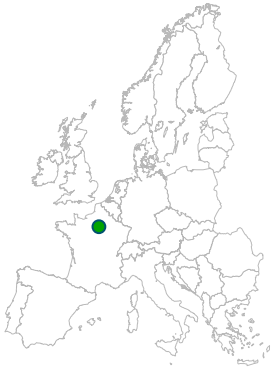
## www.green-giraffe.eu

### Paris



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