Multi-agent simulator of incentive influence on PV adoption

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Introduction

Policy making process
  Planning phase
  Implementation phase

Simulation Model
  Parameters influence
  Parameters Tuning

Conclusion and future works
ePolicy Project

- FP7 STREP Project funded under ICT tools for Governance and Policy Modeling.
- AIM: provide decision support systems for policy makers.
Policy Making Process

- Public policy issues are extremely complex, occur in rapidly changing environments and involve conflicts among different interests.
- Policy making in the energy sector accounts electric and thermal energy production, energy efficiency, transports.
- Energy policies strongly affect economic development sustainability and social acceptance.
- Increasing attention given to sustainable energy policies.
Energy Policies

- EU 20-20-20 initiative
  - 20% reduction of CO$_2$ emissions (w.r.t. 1990 levels)
  - 20% of energy produced by renewable sources
  - 20% increase of energy efficiency (w.r.t. 1990 levels)
- It should be perceived, and thus enforced, by national and regional energy policies.
Policy Making Cycle

- Four steps in the policy making process:
  - Traditionally performed in sequence
  - An integrated ICT tool for supporting the overall process is missing
- Focus on Planning and Implementation

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Planning phase

- In the planning step, strategic objectives are set, budget constraints are defined, geophysical constraints are considered.
- The policy makers should define the amount of planned activities.
  - Primary activities: energy plants (PV, biomasses, fossil fuels plants..)
  - Secondary activities: infrastructures (roads, power lines..)
- Both type of activities have impacts on the environment and costs.
- Building a plan means solving an optimization problem, satisfying constraints on impacts, costs, etc.
Implementation phase

- After the planning policy makers should transform plans into actions.
- We focus on renewable energy policies, in particular the photovoltaic (PV) case.
- Many instruments to implement a policy; in the energy case we have, to name a few:
  - Feed-in tariffs
  - Grants
  - Fiscal incentives
  - Low interests/guaranteed loans
  - Tax exemptions
  - Green Certificate
Implementation phase - Enforcing the policy

- Which instrument should we use and in which amount to achieve the planned (regional) objective?
  - Each instrument has a cost
  - The plants are installed by citizens and enterprises.
- We need to understand the social reaction to policy instruments
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Multi-agent simulation

Agent-based economic and social simulation aids the policy maker to evaluate the best implementation strategies
- Case study: Installed power from PV plants in Emilia-Romagna Region
Agent-based model

Two types of agents:

- The Region - provides regional incentives on top of national ones to foster the installation of PV panels
- House owners - perform a feasibility study, decide if the investment is profitable from an economic point of view
  - Agent parameters: surface of roof, budget, energy consumption, obstinacy..
  - Global parameters: price of electricity, average cost of PV plants, yearly increase of energy prices, national and regional subsidies.
Economic aspects are not enough..

If the decision to install a PV panel was a purely economic choice, one would expect that the better incentive tariffs the more power installed

Non-economic aspects must be considered to understand the relationship between incentives given and the installed PV power

(a) KW of installed PV power in Emilia-Romagna

(b) Italian national feed-in tariffs prices, in €/kWh
Agents decision algorithm

- Feasibility study - physical/financial constraints
- ROE estimation
- Social iteration - neighbours behaviour
- Knowledge diffusion - not every one who would install a panel knows about PV tech possibilities

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Parameters influence

▶ We wanted to recognize which are the factors with the greatest impact on the agents
▶ We ran several simulations varying the independent parameters in their valid ranges one at a time and keeping fixed the remaining ones
Parameters influence

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- We ran several simulations varying the independent parameters in their valid ranges one at a time and keeping fixed the remaining ones.

The parameters with greater influence on the results are those related to the social aspect of the simulation, together with the knowledge diffusion and the minimum ROE expected; the parameters related to PV technologies shown smaller effect.
Social interaction radius

- An agent chooses to install a PV panel also depending on the behaviour of his neighbours.
- The neighbourhood is defined as a circle of the simulation world.
PV panel price decrease

- The PV panels costs decrease due to technological advancements
  - Expressed as a percentage

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Starting knowledge diffusion

- The knowledge diffusion represents the percentage of agents who are aware of PV technology.
- Defined by the initial percentage and the yearly increase.
Parameters Fine Tuning

- After evaluating the parameters with greater influence, we want to fine tune them considering the regional data from the past.
- The purpose is to obtain a simulator able to forecast future trends.
- We are currently using a tool called irace\textsuperscript{1} to obtain an automatic optimal configuration for the most important parameters.

Parameters Tuning

Parameters Fine Tuning - First results

- The simulated trend follows the kW installed from real data
- There’s still a lot of work to do..
Conclusion

Future research:

- Simulation extensions
  - Combination of incentive instruments
  - More complex social interaction
  - Agents decisions based on forecasts about PV tech
- Simulation validation
  - Validating the simulator on real data
  - Scalability of results
- Parameters fine-tuning
  - Fine tune the simulation parameters with automatized mechanisms
Thank You!
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