Towards a comprehensive policy for RES-E: Policy Design And Social Welfare Analysis

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Aim

Problem: The governance of Renewable Energy Sources for Electricity (RES-E) in Europe beyond 2020 is still under debate. The European Commission has only indicated that national level targets will be abolished beyond 2020, and that most RES-E support schemes should take the form of competitive bidding. It still remains to be seen whether these choices will lead to the desired policy outcomes such as competitiveness, affordability, and sustainability in the long-term.

The research objective is to develop a structured approach to the design and assessment of policies for the stimulation of RES-E in Europe.

(1) to identify a set of necessary and sufficient policy design elements to incentivize RES-E in Europe, and
(2) to introduce a modelling framework for analyzing the impact of the policy design elements on the socio-technical system.
(3) to assess the impact of policy choices related to Renewable Energy Sources – Electricity (RES-E) support schemes on social welfare.

The design elements (policy choices) assessed are

- *price warranty versus quantity warranty*,
- electricity market revenue accounted for *ex-post or ex-ante*,
- and *technology specificity versus technology neutrality* .

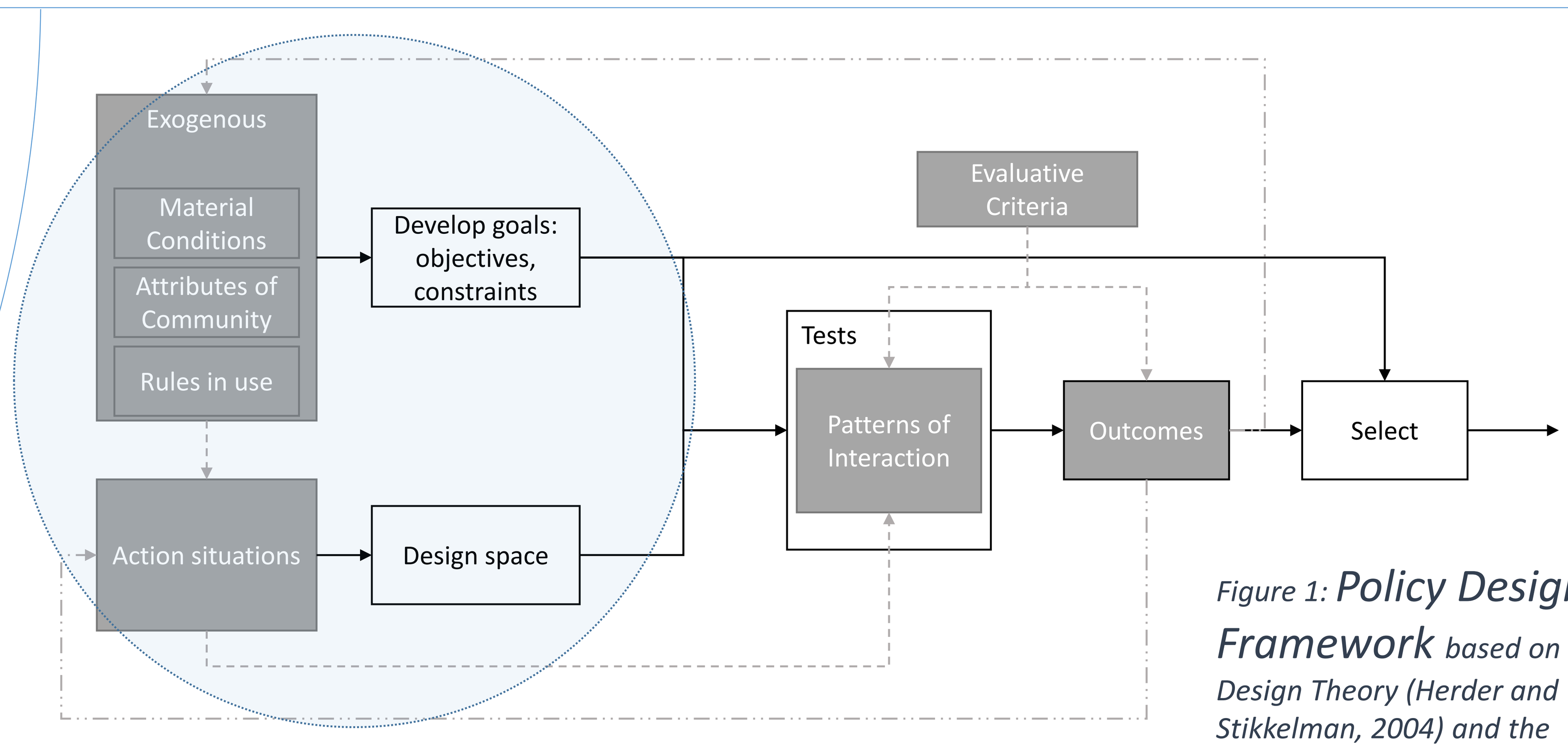


Figure 1: Policy Design Framework based on Design Theory (Herder and Stikkelman, 2004) and the Institutional Analysis and Development Framework (Ostrom, 2005).

The impacts of design elements are assessed in terms of the following three performance indicators:

- Policy effectiveness, measured as the average cost of subsidy in Eur/MWh over the total lifetime of the simulation.
- Change in welfare for the producer, government, and consumer, and consequently the total social welfare, measured over the entire lifetime of the simulation.
- Generation portfolio: the capacities of each technology installed at each tick in the simulation.

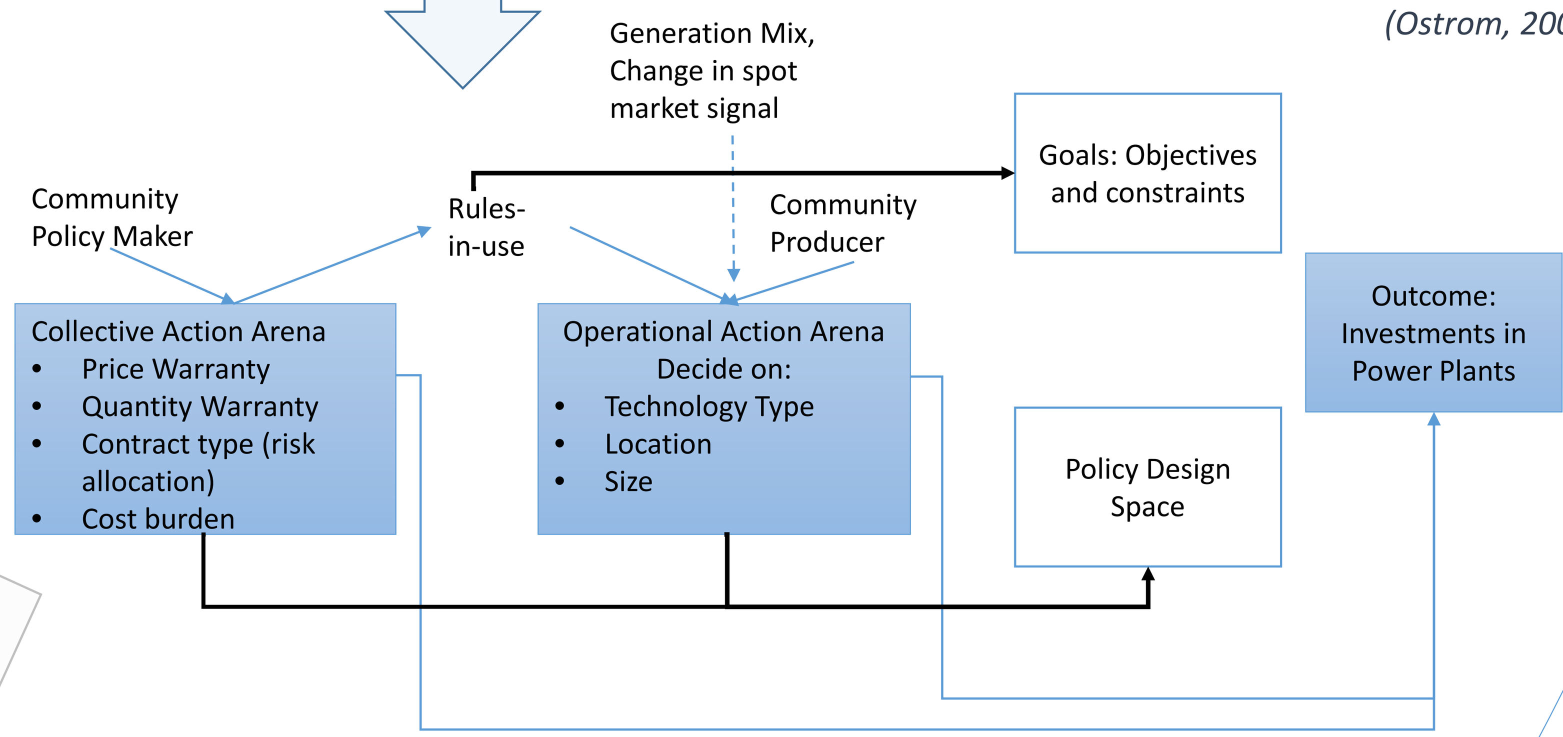


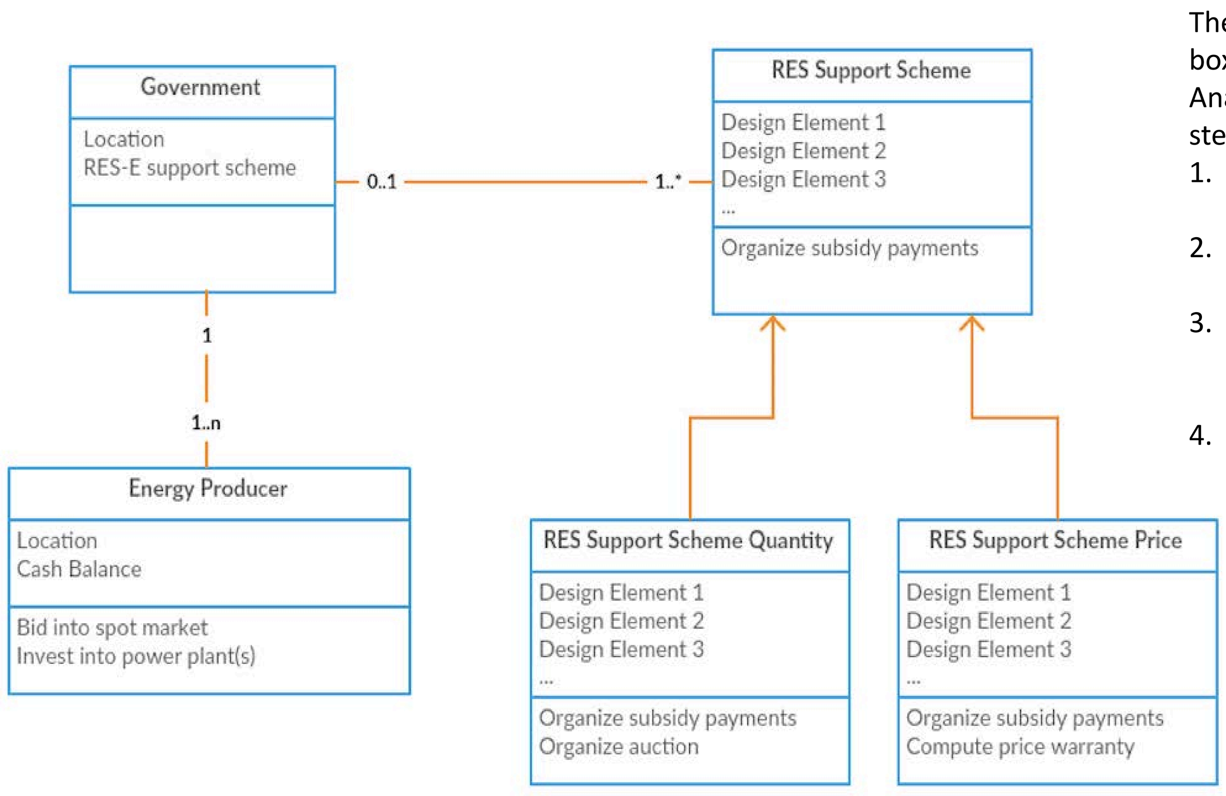
Figure 2: Specification of Policy Design Framework for RES-E Support

Scenario Guide

Scenario Name	Price vs. Quantity Warranty	Electricity market price setting	Technology specificity
P_Ante	Price warranty	Ex-ante price setting	Technology neutral
P_AnteTS	Price warranty	Ex-ante price setting	Technology specific
P_Post	Price warranty	Ex-post price setting	Technology neutral
P_PostTS	Price warranty	Ex-post price setting	Technology specific
Q_Ante	Quantity warranty	Ex-ante price setting	Technology neutral
Q_AnteTS	Quantity warranty	Ex-ante price setting	Technology specific
Q_Post	Quantity warranty	Ex-post price setting	Technology neutral
Q_PostTS	Quantity warranty	Ex-post price setting	Technology specific

Method

Figure 3: Class Structure of an Agent Based Model based on Design Elements



The Policy Design Framework is essentially a design framework, represented in bold clear boxes in Figure 1, whose different steps are informed by components of the Institutional Analysis and Development (IAD) Framework, depicted in grey boxes in Figure 1. The main steps in the design process involve:

1. Identify design goals and constraints: Specified usually by the policy maker, in this case, for instance, RES-E targets.
2. Identifying the design space: The action situation in the IAD framework outlines potential actions that participants can take, and outcomes an action could lead to.
3. Tests: Agent based modelling is used to simulate patterns of interactions between the participants, based on design objectives, constraints and design variables discerned in the previous steps.
4. Outcomes and Selection: The outcomes from the simulation help identify which configurations of design variables (design elements) lead to what outcomes.

Figure 3 above is a structural representation of the agent-based model by means of a UML class diagram. The structure of the model indicates the main agents are the energy producer and the government (or regulator). It also shows that RES-E Support Scheme is a class, whose attributes are the design elements identified in the previous step. Different representations of the RES-E Support Scheme can be inherited, and contain processes that are functions of the design elements.

- The main algorithms in the model comprise a market clearing algorithm, and an investment algorithm.
- Agents make short term decisions as bidding into the market, and long term decisions such as investments, based on NPV evaluations for each investment.
- The model runs for 50 ticks, each tick representing a year.

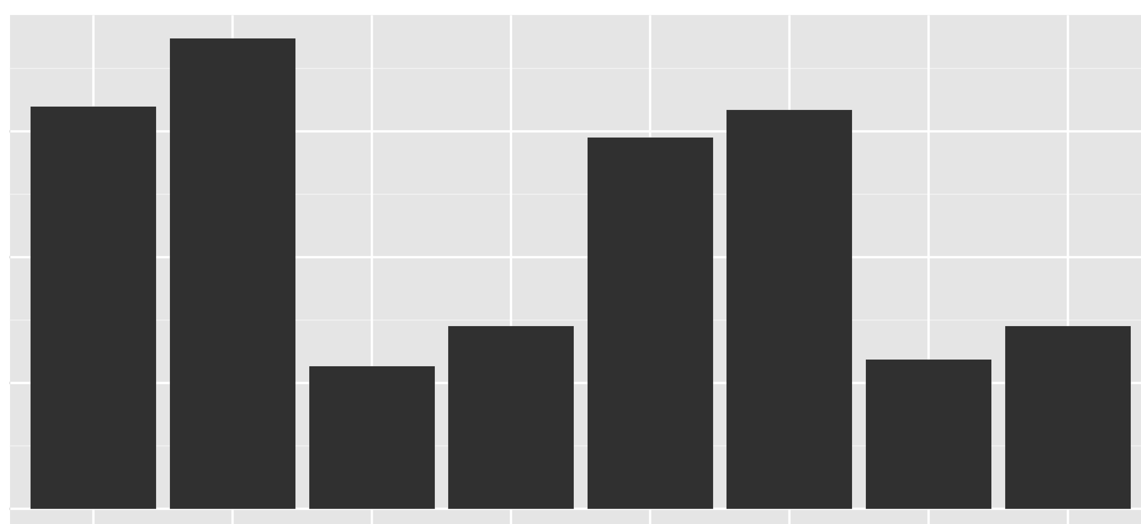


Figure 4: Policy Cost Effectiveness measured in Eur/MWh across the lifetime of the simulation for each policy scenario

Results

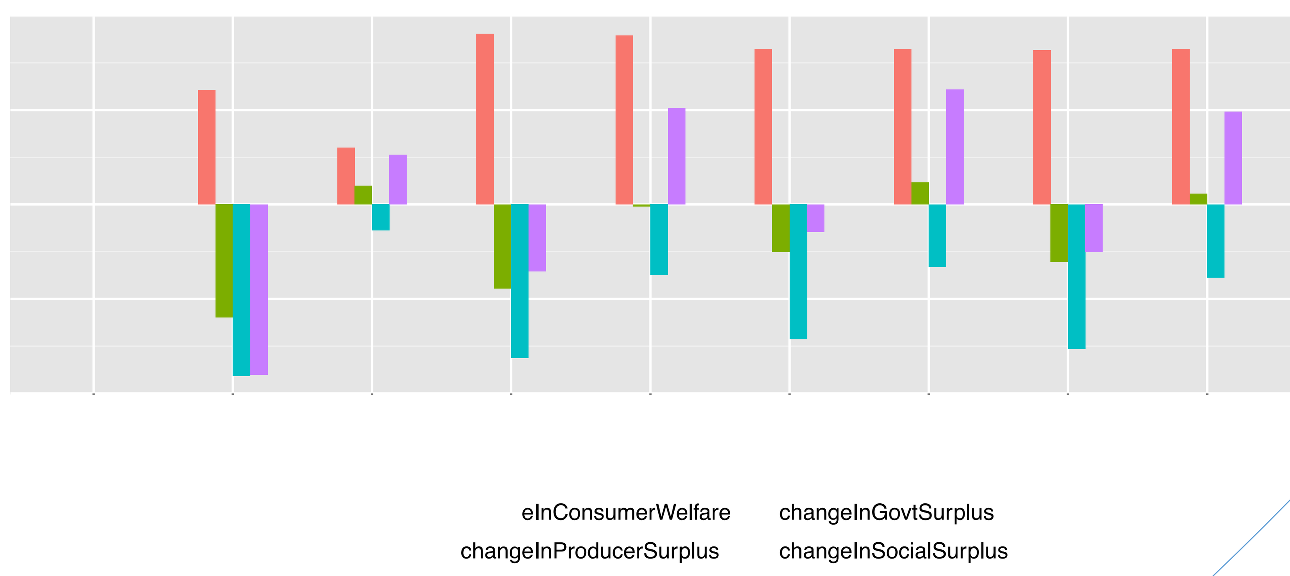


Figure 5: Change in Social Welfare measured in Eur across the lifetime of the simulation for each policy scenario. The change is measured by comparing with a No Policy Scenario.

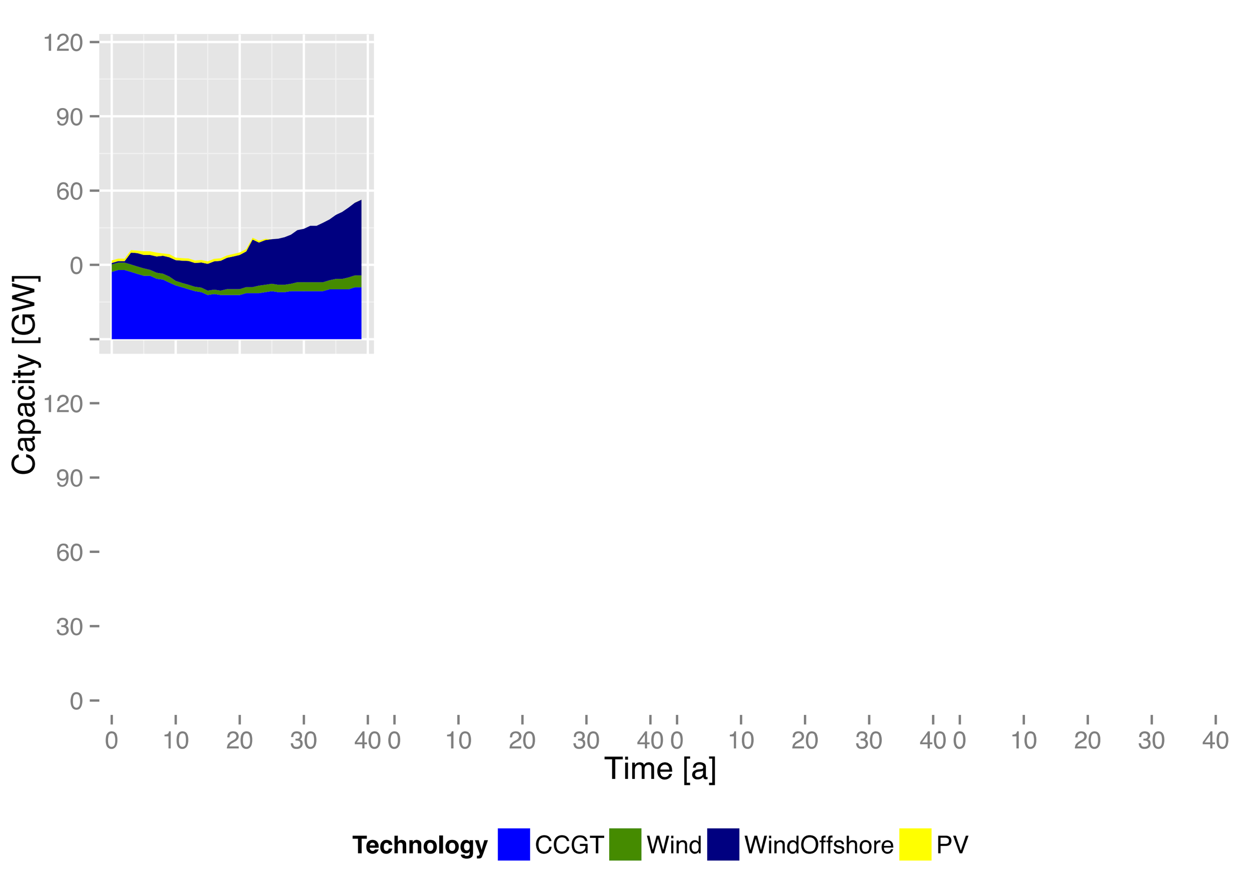


Figure 6: Generation Portfolio shows the capacity of each technology in GW across time, the ticks representing years [2015 to 2055]

Conclusion

- *Quantity-warranty schemes are more cost-effective than price-warranty schemes*, unless there are interconnections or storage in the power system.
- *Technology- neutrality is less cost-effective than technology-specificity* in the Netherlands, subject to renewable generation targets.
- *Ex-ante accounting* for expected electricity market prices *accrues greater subsidy costs than* accounting for electricity prices *ex-post*. This however is sensitive to the accuracy of expectations of future electricity prices, and the risk-rate which agents attribute to uncertainty in future electricity prices.
- The design element configuration that leads to the *highest increase in social welfare* is the combination of *quantity-warranty, ex-ante accounting for electricity prices, and technology-specificity.*

Herder, Paulien, and Rob M. Stikkelman. 2004. "Methanol-Based Industrial Cluster Design: A Study of Design Options and the Design Process." *Industrial & Engineering Chemistry Research* 43 (14): 3879–85. doi:10.1021/ie030655j.
Ostrom, Elinor. 2005. *Understanding Institutional Diversity*. Princeton, New Jersey: Princeton University Press.