

# ***THE IMPACT OF ENVIRONMENTAL TARGETS ON REGULATORY DECISIONS: A LABORATORY EXPERIMENT***

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## **Overview**

Renewables play an important role in the future energy mix. Therefore, markets have targets to increase the share of renewables in the final energy consumption. Depending on their potential, economic performance and characteristics, countries adopt different roadmaps to reach their target. For example, the European Union has a target of 20% of final energy consumption from renewables in 2020 and 27% in 2030 (European Commission, 2017), with each member state having its own target. However, the latest report shows that while Bulgaria, Finland and Croatia had already reached their 2020 targets by 2015, other countries including the Netherlands, France and the United Kingdom have a long way to go despite using the same or similar support schemes (European Commission, 2017).

With this work, we aim to contribute to the understanding of how different countries attempt to reach their environmental targets. Using laboratory experiments, we study the impact of regulatory decisions on market performance, which is measured by total cost, total pollution, price paid by consumers and green share of generation. We explore the impact of introducing a trajectory in the form of intermediate goals towards the achievement of a final green share target. Additionally, we analyse the effect of framing the same objective as either a green generation target or a pollution target.

We find that the participants reach the final target faster when they are presented only with this final target. Adding five-yearly intermediary targets for the green share slows down the increase of the green share of generation. Moreover, framing the same objective as either a pollution limitation target or a green share target affects behaviour: the former leads to an even faster increase of the green share of generation.

## **Methods**

We conduct laboratory experiments based on a system dynamics model that mimics an electricity market, where private thermal generators are simulated and invest based on profitability. The experiment simulates a 40 year period during which demand is held constant. The regulator intervenes by subsidising green generation and, if necessary, also thermal generation. The cost of subsidising 1 MW of green is twice the cost of subsidising 1 MW of thermal. The annual price paid by consumers is a function of the reserve margin and subsidies. There is priority dispatch for green generation.

In the experiments, university students act as regulators in an electricity market. Before starting, the basic principles of electricity markets, the task and the payoff structure are introduced to the participants using a video presentation. Then, the participants have a training period during which they familiarise themselves with the interface and the task. After the training period, the participants are informed that the final round on which their payoff is based is starting.

The experimental conditions concern the framing of the renewable target and the presence of a pollution objective. Concerning the first, subjects either only have a 50% final renewable generation target, or are also given five-yearly intermediate targets. Concerning the second, they may or may not be given annual maximum pollution targets. The intermediate targets for green generation and the annual pollution targets are chosen so as to represent the same path towards the final objective of 50% green generation. Table 1 summarizes the resulting 2x2 experimental design.

**Table 1: 2x2 experimental design**

	Final target	Final target with intermediate targets
Annual pollution targets	<b>Final_Pollution</b>	<b>Gradual_Pollution</b>
No pollution target	<b>Final_No pollution</b>	<b>Gradual_No pollution</b>

To reach their targets, participants decide each year how many MWs of thermal and green installed capacity to subsidize. The participant's overriding objective is to avoid blackouts because a blackout means the end of the game and receiving only the show-up payment. The payoff above the show-up fee is based on the achievement of the

green share target in year 40, the blackout risk and the price paid by consumers. We use a between-subject design<sup>1</sup>; therefore, depending on their condition, participants' payoffs are also influenced by the achievement of the intermediate pollution and/or green share targets.

## Results

The experiments were conducted with a total of 170 participants, with at least 40 participants in each group. For the preliminary analyses, we exclude the participants who faced a blackout, as well as four participants who clearly misinterpreted the instructions.

We choose four criteria to measure regulatory decisions' success: total cost, total pollution, average price and green share of generation in year 40.

*Total cost:* The total amount spent by the regulator to subsidize green and thermal installed capacity.

*Total pollution:* The total demand which is satisfied using thermal generation.

*Average price:* The average price paid by consumers.

*Green share of generation in year 40:* Green share of generation in the final year.

Table 2 summarizes the average performance across participants for each condition and criteria. The lowest total cost is achieved in the Gradual\_No pollution condition. When the participants are presented with annual pollution targets in addition to either a final or intermediate green share target(s), they pollute less, as expected. The price performance is particularly poor in the Gradual\_Pollution condition. We observe the highest green share in year 40 in the Final\_Pollution condition.

**Table 2: Preliminary results**

	Final_No pollution	Final_Pollution	Gradual_No pollution	Gradual_Pollution
Total cost	1550	1357	1279	1893
Total pollution	2142	2001	2345	2205
Average price	48	45	46	54
Green share of generation in year 40	0.64	0.73	0.64	0.67

## Conclusions

When making regulatory decisions, jurisdictions follow different strategies. Even if the adopted regulatory mechanisms are similar, markets obtain different results. This work compares the effects of annual decisions to achieve the objectives on total cost, total pollution, average price paid by consumers and green share of generation in year 40.

Our preliminary results indicate that the participants increased the installed green capacity faster when there are no intermediate reference points. Also, our findings points out that presenting the same objective in terms of pollution or in terms of share of generation affects behaviour, leading to different levels of performance. The green share targets result in a lower total cost but higher pollution than with the pollution targets.

While conducting a laboratory study with student participants raises the question of external validity, a limitation of this work, the insights derived form a useful starting point for further work.

## References

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<sup>1</sup> In a between-subject design, each participant experience only one experimental condition.