Comparing social costs of energy supply decarbonization: electrification versus green-fuels (biomethane)

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AIEE Symposium, 15 December 2021

UNIVERSITÀ COMMERCIALE
LUIGI BOCCONI

The title

- Energy supply: focus on thermal uses
- Decarbonization: abatement of CO2 emissions
- Social costs: Costs charged to society (without distinguishing among different stakeholders and using shadow prices)
- Electrification
  - Meeting thermal uses by means of electricity conversion
- Green fuels
  - Biomethane

Objective

Starting point (why this topic)

- Biomethane is a “scarce” renewable source to be efficiently allocated among different competitive uses

- Efficient allocation
  - Allocation providing the lowest abatement cost of CO2 emissions
- How to check efficient allocation. Two steps:
  - First step: in thermal uses (“high-efficiency cogeneration”), is biomethane more efficient than electrification?
  - Second step: if so, allocating biomethane to thermal uses is more efficient than allocating it elsewhere (e.g. transportation)?
- This presentation focuses on the first step
  - Necessary condition to go to the second step

Application and solutions

Application

- A medium-large-sized industrial customer close to a small-medium sized urban district
- This application is not “site-specific” but projected by the authors on the basis of their experience

Simulated solutions

- Solution 1 (base case: CHP + DH, without abatement)
- Solution 2 (electrification, with abatement)
- Solution 3 (new CHP + DH + biomethane, with abatement)

Efficiency: levelized abatement costs:

- Through electrification: Solution 2 vs. Solution 1
- Through biomethane: Solution 3 vs. Solution 1

Methodology: levelized cost of abatement

$$DC_{CO2_{i-1}} \cdot (E_{CO2_1} - E_{CO2_i}) \sum_{t=1}^{T} \frac{1}{(1+r)^t} = (I_i - I_1) + (C_i - C_1) \sum_{t=1}^{T} \frac{1}{(1+r)^t}$$

I_i = Investment cost of solution i net of CO2 external cost (i = 2 o 3)

I_1 = Investment cost of solution 1 net of CO2 external cost

DC_{CO2} = "breakeven" level of damage per tCO2

C_i = Annual social cost of solution i net of CO2 external cost (i = 2 o 3)

C_1 = Annual cost of solution 1 net of CO2 external cost

E_{CO2_1} = emissions under solution 1

E_{CO2_i} = emissions under social solution i

Levelized abatement cost: Unit CO2 damage cost assuring that discounted social revenues (reduced damage cost) are able to cover the discounted social cost of CO2 abatement

General and specific assumptions

About Applications and Solutions

- All quantity variables are referred to 1GWh of final consumption of thermal energy
- Industrial self-consumption of electricity and exported electricity (in case of cogeneration) are accounted for as a negative cost (avoided supply cost and generation cost respectively)

Renewable supply

- Based on “virtual markets”
- Abatement (use of carbon neutral energy sources) is proved by means of the purchasing of renewable Guarantee of Origin (GO)
- In Solutions 2 and 3, subsidies to renewable producers are accounted for
- The cost of purchasing bioGO is not accounted for in social costs (all-inclusive tariffs)
- In Solution 3,Cogeneration allows to save biomethane which is carbon neutral. This advantage is accounted for through lower emissions achieved elsewhere

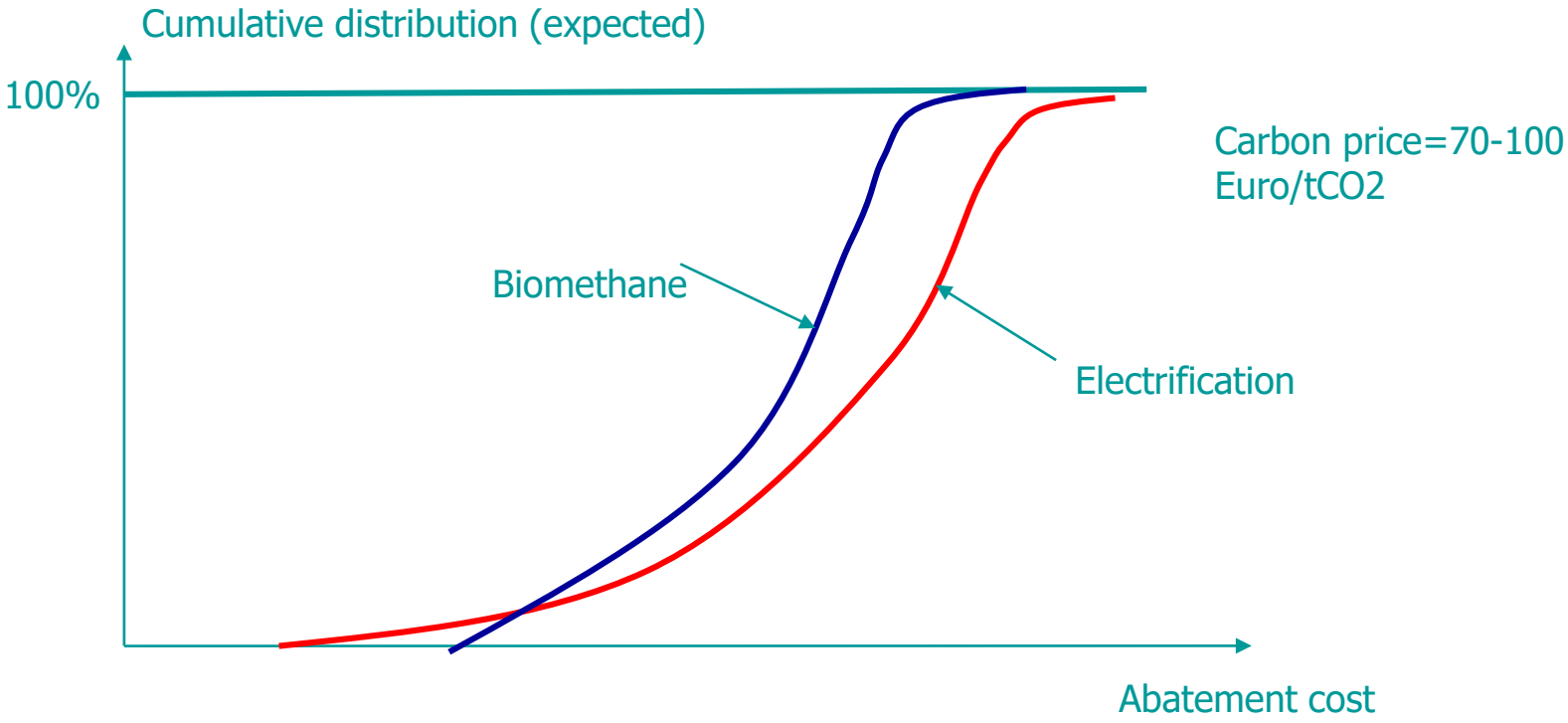
Carbon Permits (CP) Energy Savings Certificate (ESC):

- The cost of purchasing carbon permits are not considered as it is a component of the damage cost (see previous slides)
- Negative costs related to ESC are not considered as well, as they are already charged to final consumers (through distribution tariffs)

Results

Electrification Biomethane

		Solution 2 vs. Solution 1	Soluzione 3 vs. Solution 1
		Base case	Base case
Levelized cost of CO2 abatement per unit of thermal energy	Euro/tCO2	**83,6**	**40,4**



Conclusions

- Firstly, in thermal sector, the use of biomethane would seem to be more efficient (lower abatement costs) than electrification (legitimating further work focusing on inter-sectorial analysis)

- Secondly, the abatement cost appears to be lower than current (and expected) carbon price
  - From the social point of view, using biomethane would be better than purchasing the right to emit CO2 (at least, on the basis of the estimates here presented)

- Finally, the first interpretation of the current regulation in Italy would seem to be consistent with these results (but further specification are needed also in the light of the inter-sectorial analysis mentioned above)