unibz

Freie Universität Bozen
Libera Università di Bolzano
Free University of Bolzano

Bioenergy & Biofuels LAB

Embedding commodity price variation in the economic evaluation of biofuels projects: the example of a Power-to-Gas biomass-to-biomethane process under the Italian biomethane subsidy scheme

Lorenzo Menin*, Stefano Piazzi, Daniele Antolini, Marco Baratieri

Bioenergy & Biofuels Lab, Free University of Bozen-Bolzano

* Presenting and corresponding author

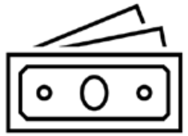
9th International Conference on Sustainable Solid Waste Management

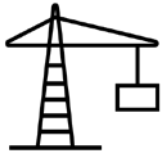
Corfu, June 2022

Why?

1. Estimate whether energy recovery projects are economically **attractive investment** opportunities
2. Assess whether financial support (**subsidization**) is required to reach adequate returns
3. Quantify the magnitude of the **lack of competitiveness** of the energy products in comparison with conventional fossil-derived energy products

General aim: assess comparatively **most efficient ways to employ private and public funds** in waste treatment or bioenergy projects

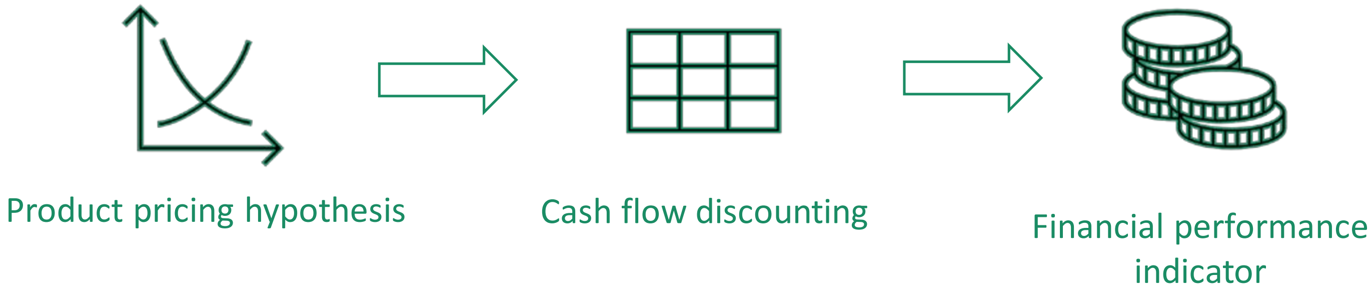




Cash flow discounting: project performance

1. Project **net present value** (NPV): discounted cumulative cash flow (€)
2. **Return on investment**: ratio between total project earnings and initial investment (%)

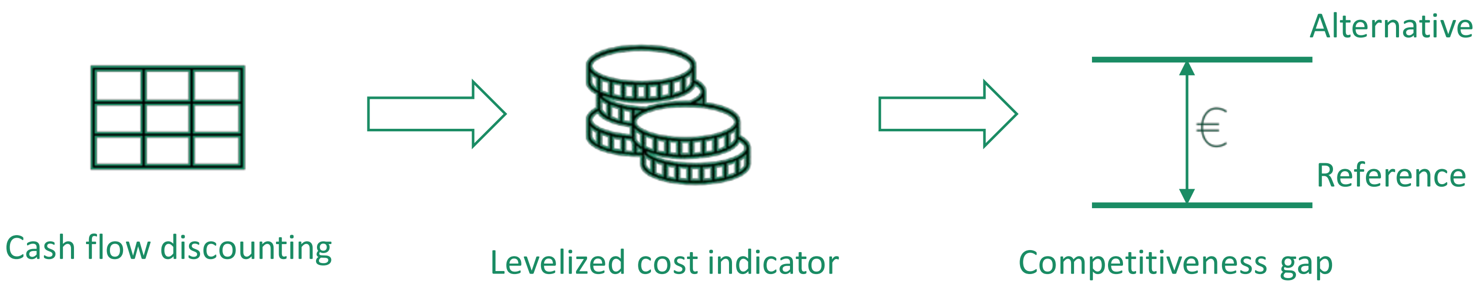
Both relying on an estimation of project revenues, in turn relying on a **product pricing hypothesis**



Cash flow discounting: product competitiveness

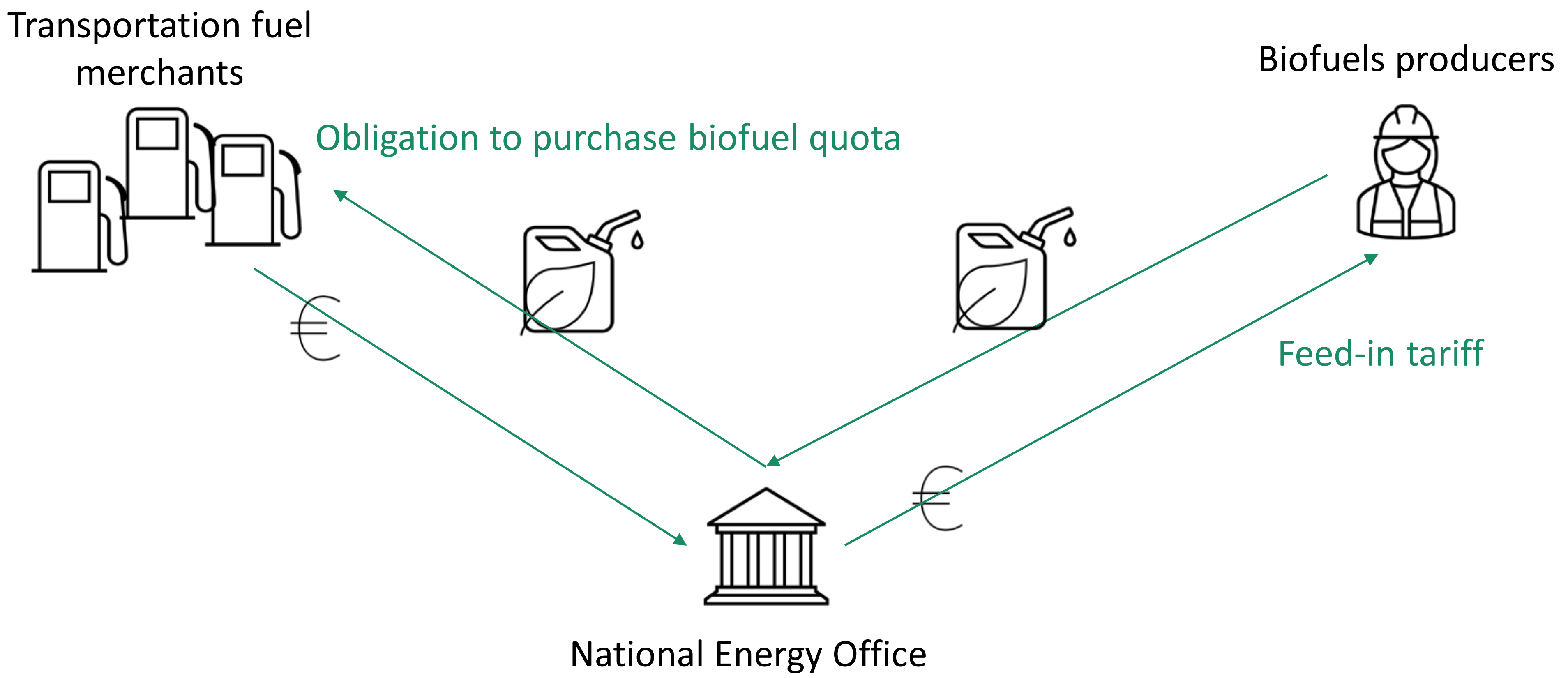
1. **Minimum selling price** or **levelized cost of product** : total project costs distributed over the total project output (€/MWh)

Measure of **competitiveness gap** also relies on a **pricing hypothesis** for the reference product (benchmark)



Commodity price-based subsidization mechanisms

The importance of product pricing hypotheses: the Italian biomethane example



Commodity price-based subsidization mechanisms

The importance of product pricing hypotheses: the Italian biomethane example

Market-based feed-in biomethane tariff (FIT) paid to producers:

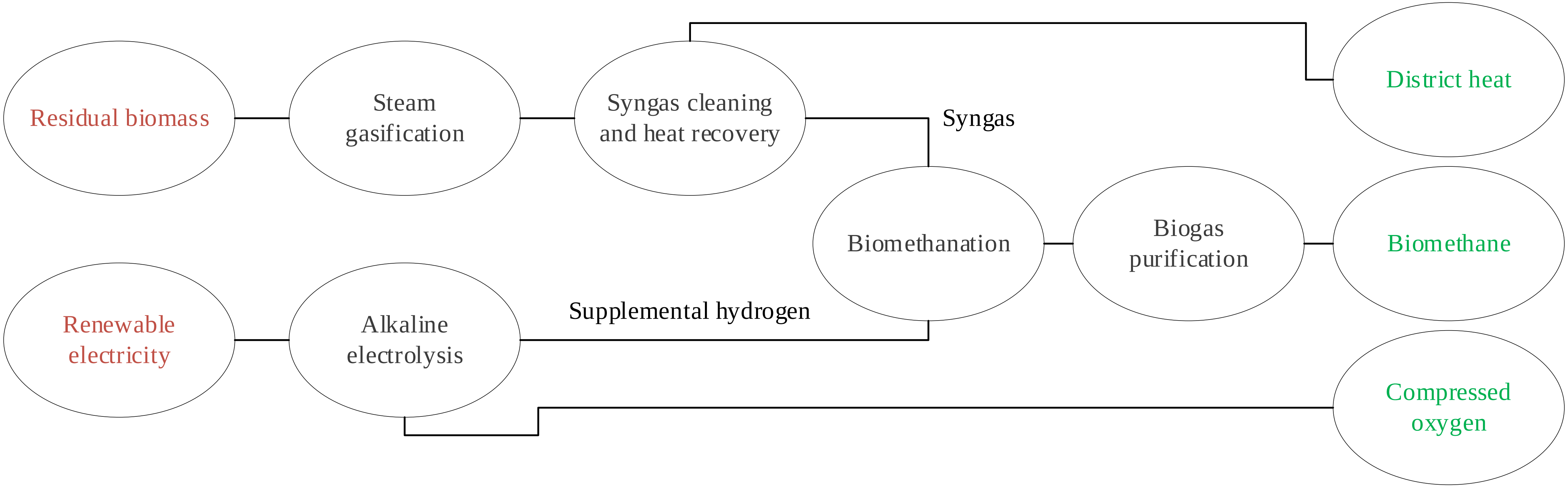
Monthly natural gas spot price component + flat subsidy

$$FIT = 95\% \left(\underbrace{P_{NG,spot}}_{\text{Natural gas spot price on national exchange}}\right) + 64.26 \frac{€}{MWh}$$

Direct causal relationship between natural gas spot prices and operator revenues

Power-to-Gas integrated biomass-to-biomethane

Power-to-Gas integrated processes for higher biomethane yields

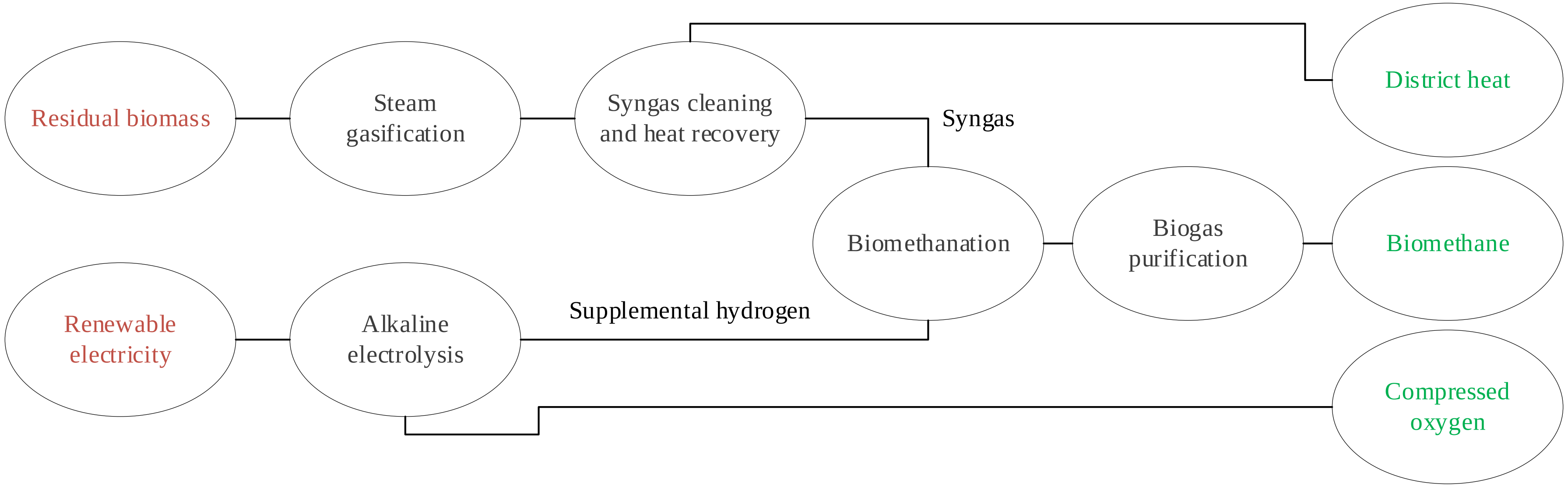


Menin L, Asimakopoulos K, Sukumara, Rasmussen N B, Gavala H N, Skiadas I V, Patuzzi F, Baratieri M. Competitiveness of syngas biomethanation integrated with carbon capture and storage, power-to-gas and biomethane liquefaction services: Techno-economic modeling of process scenarios and evaluation of subsidization requirements. Biomass and Bioenergy 2022. https://doi.org/10.1016/j.biombioe.2022.106475

Key economic factors in integrated process

Revenue side: biomethane **feed-in tariff**

Cost side: **stored electricity** and biomass **cost**



Menin L, Asimakopoulos K, Sukumara, Rasmussen N B, Gavala H N, Skiadas I V, Patuzzi F, Baratieri M. Competitiveness of syngas biomethanation integrated with carbon capture and storage, power-to-gas and biomethane liquefaction services: Techno-economic modeling of process scenarios and evaluation of subsidization requirements. Biomass and Bioenergy 2022. https://doi.org/10.1016/j.biombioe.2022.106475

Power-to-Gas integrated biomass-to-biomethane

Key economic factors in integrated process

Revenue side: biomethane **feed-in tariff**

Related to natural gas spot price through **incentive mechanism** (previous slides)

$$FIT = 95\% \left(P_{NG,spot}\right) + 64.26 \frac{€}{MWh}$$

Cost side: **electricity cost**

Related to natural gas spot price through role of gas-fired electricity in **grid electricity pricing**

$$LCOE_{CCGT,7\%} = 1.2277 \times P_{NG,spot} + 30.7\ \$\ MWh^{-1}$$ (a)

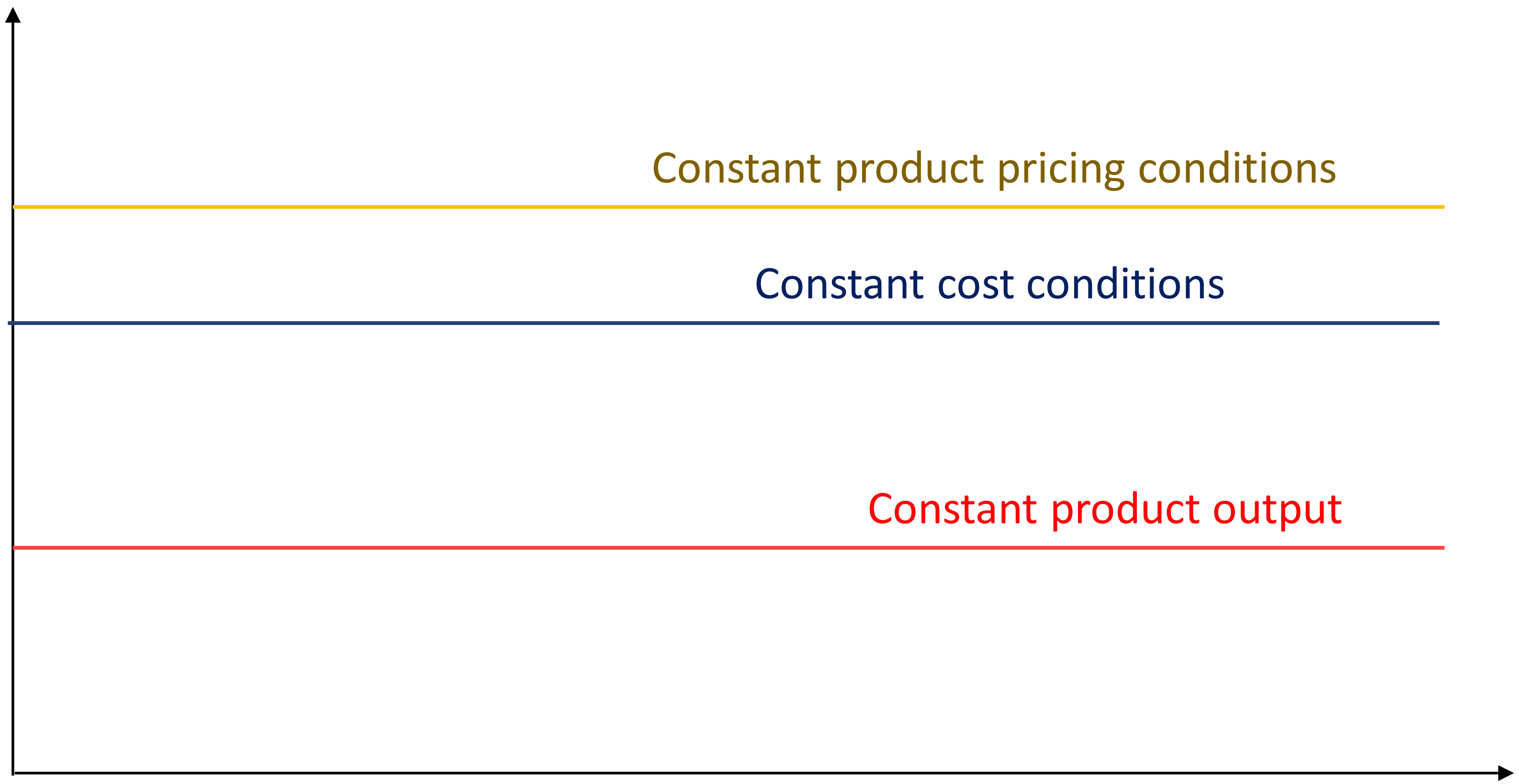
[Levelized cost of gas turbine combined cycle according to IEA, 2020]

What is the effect of the variation of the underlying natural gas spot price?

(a) 1 USD = 0.92 EUR (April 2022)

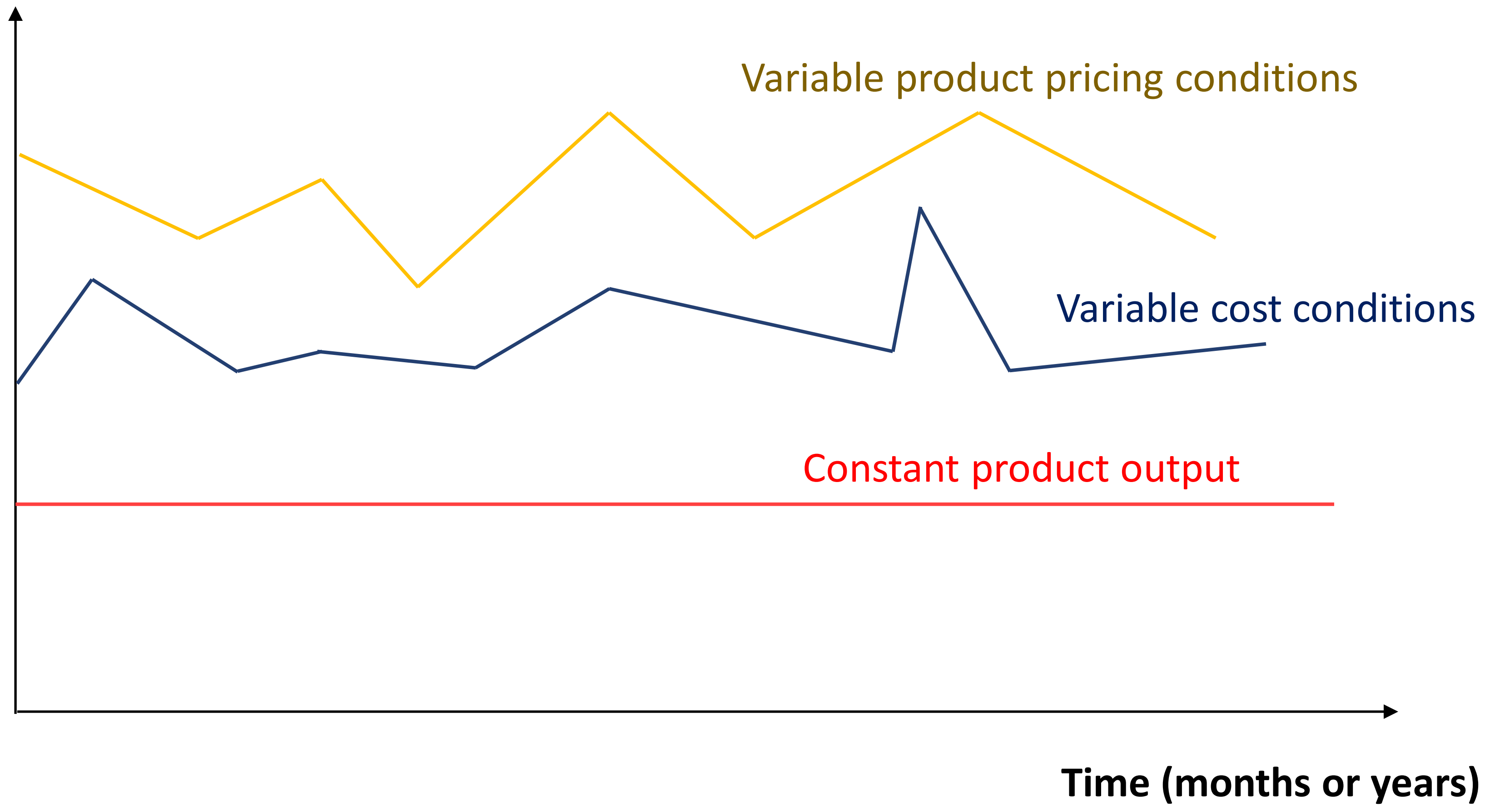
Effect of natural gas price variation on feed-in tariffs

The role of variable economic conditions

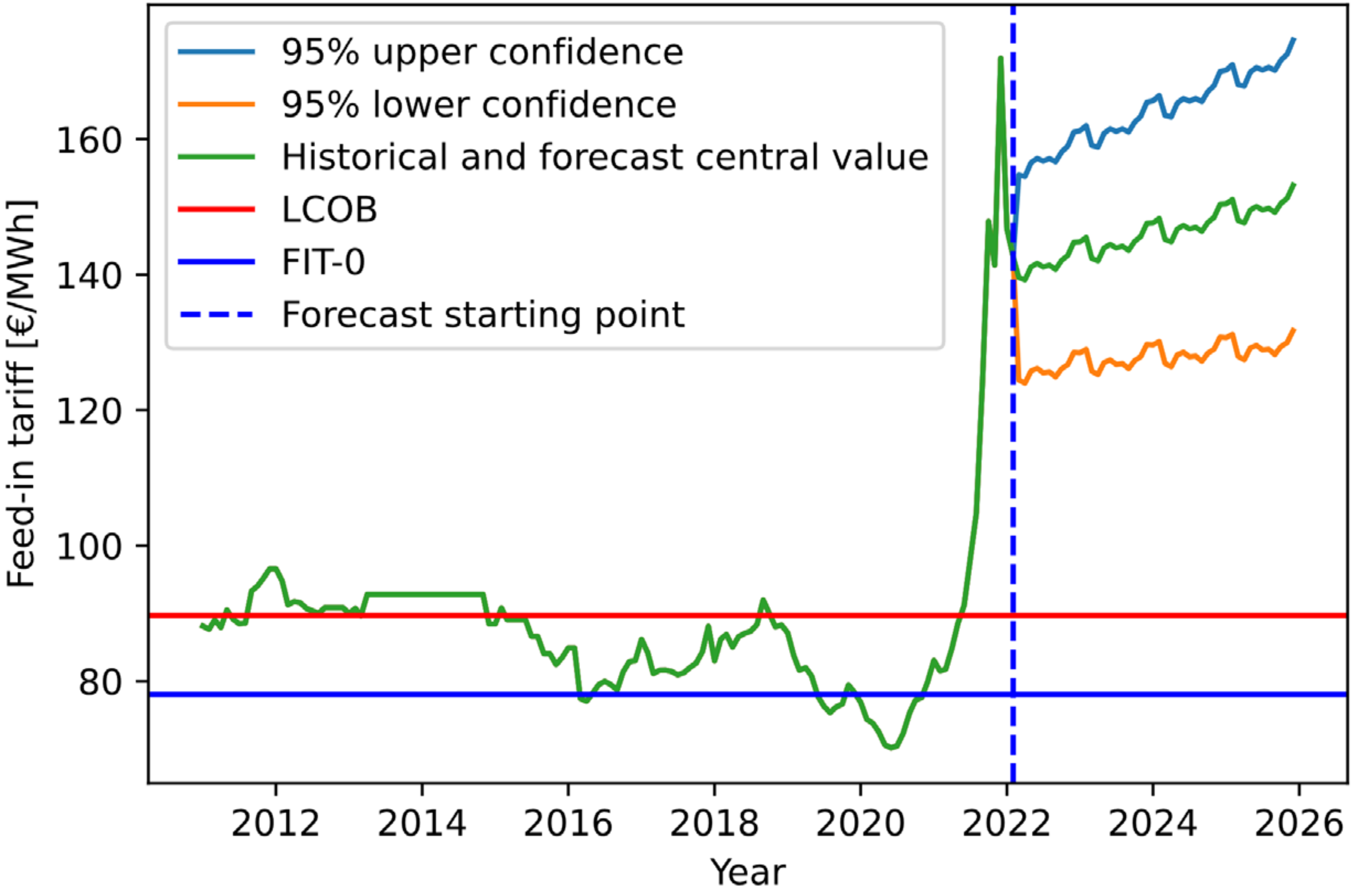


Effect of natural gas price variation on feed-in tariffs

The role of variable economic conditions



Effect of natural gas price variation on feed-in tariffs



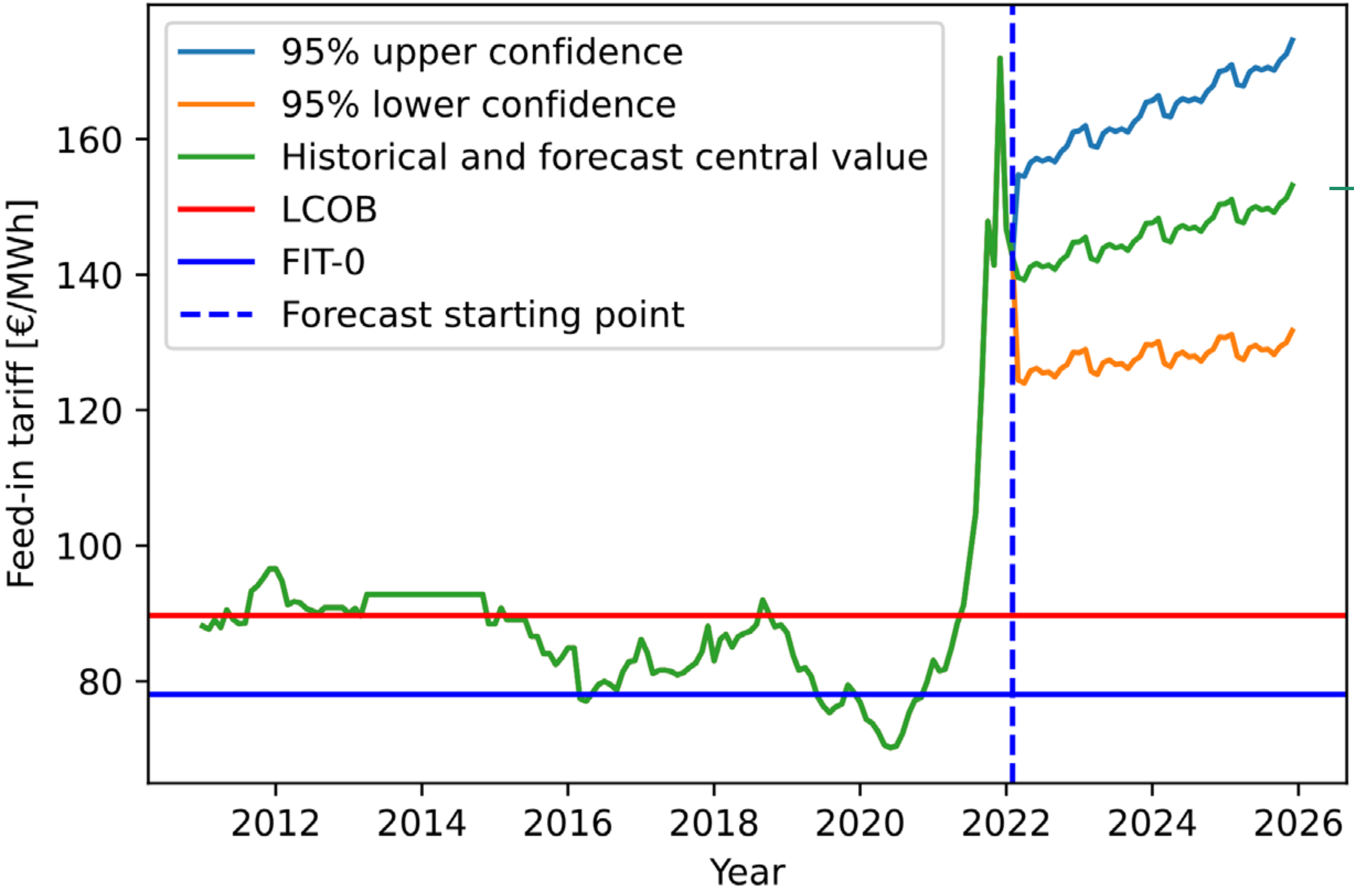
Time series development

National spot-market natural gas prices supplemented with a **simple exponential smoothing forecast time series**

Variable product pricing

Apply time series instead of constant feed-in price to assess its effect of project performance

Effect of natural gas price variation on feed-in tariffs



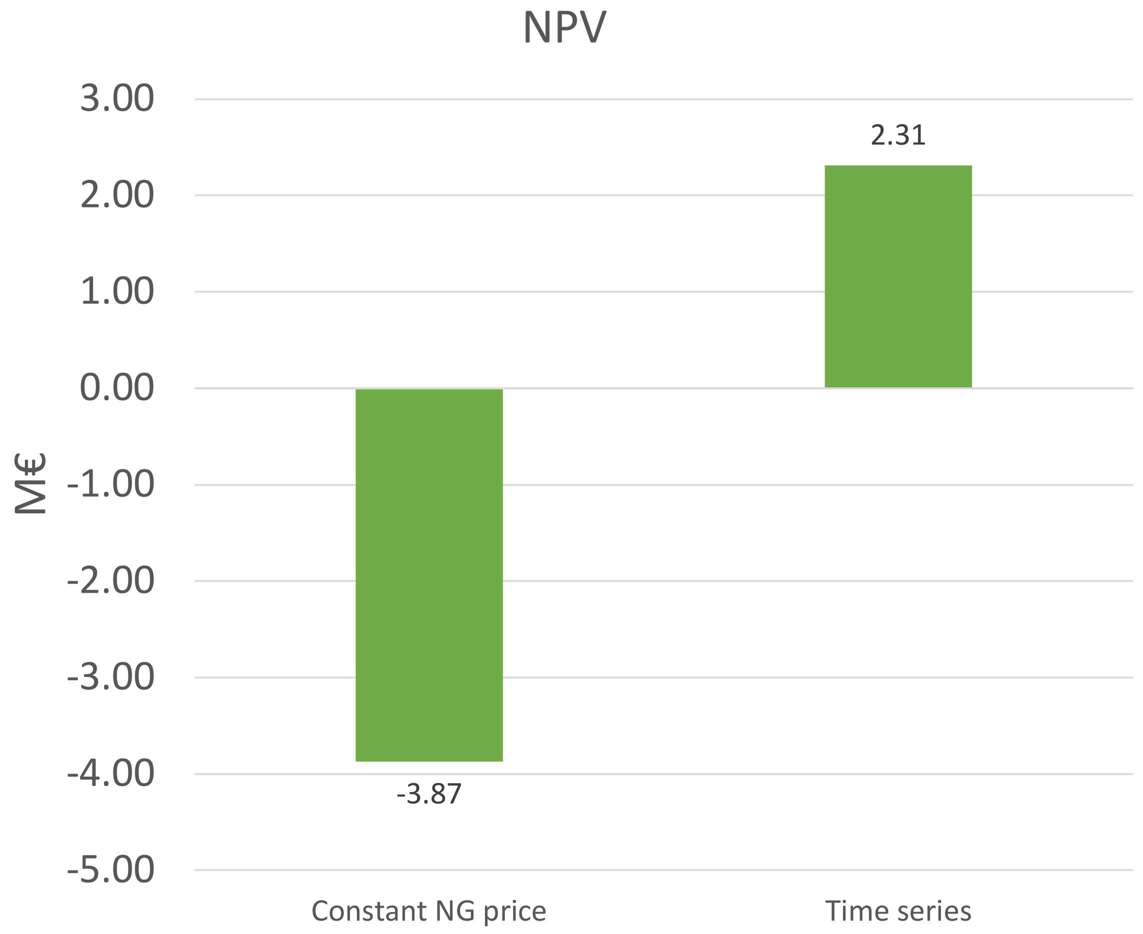
Feed-in price estimated time series

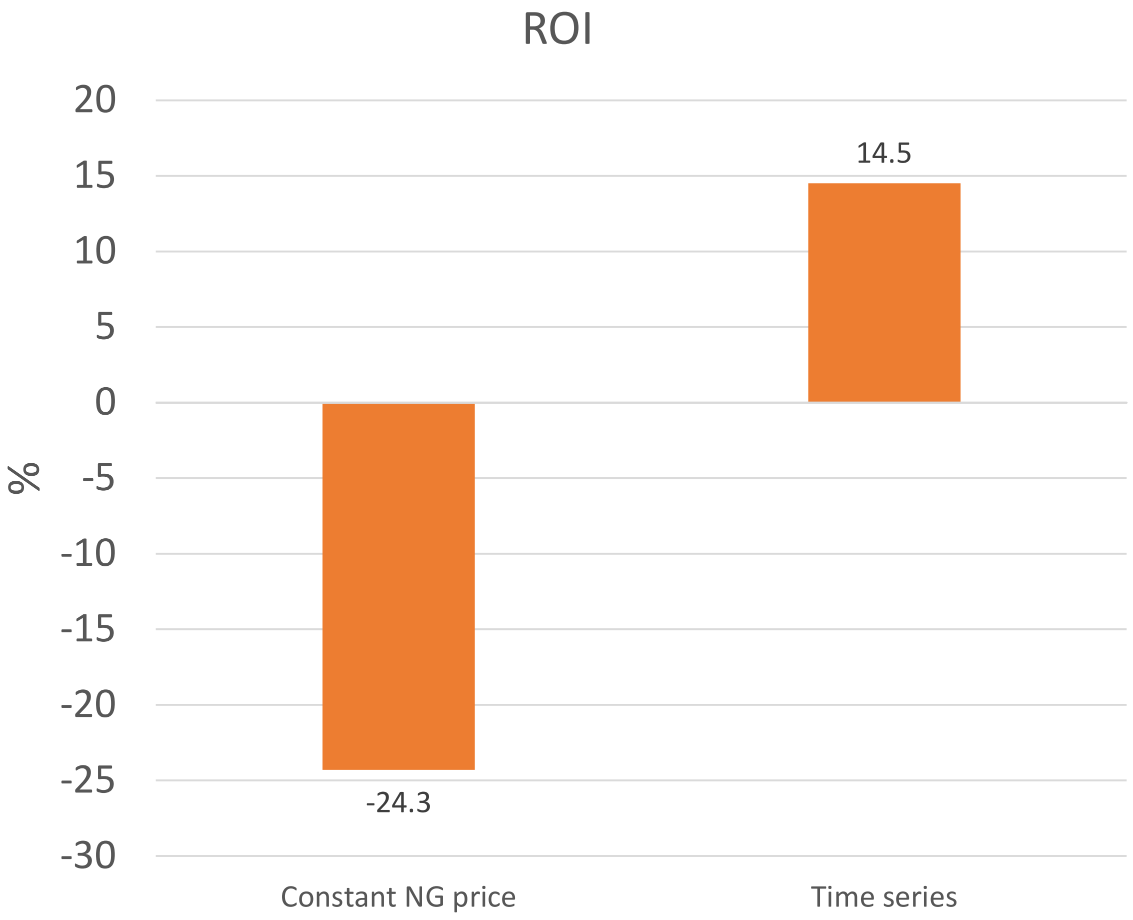
Levelized cost of biomethane

Feed-in tariff at the time of the previous investigation (78 €/MWh)

Effect of natural gas price variation on feed-in tariffs

Results: variation in project performance





Effect of natural gas price variation on stored electricity cost

Moving from a gas-based to an electricity-based subsidization scheme: relating the levelized cost of biomethane to two electricity cost levels

$$FIT = f\left(P_{NG,spot}\right) + premium$$

$$FIT = f\left(C_{electricity}\right) + premium$$

Effect of natural gas price variation on stored electricity cost

Moving from a gas-based to an electricity-based subsidization scheme: relating the levelized cost of biomethane to two electricity cost levels

Causal cost correlation extracted from previous techno-economic assessment: levelized cost of biomethane against bi-level electricity cost

$$LCOB = A + B \times HLCOE + C \times LLCOE$$

- LCOB: Levelized cost of biomethane
- HLCOE: Higher cost level, applied to all other electrical loads
- LLCOE: Lower cost level, applied to **electrolysis** electrical load

Menin L, Asimakopoulos K, Sukumara, Rasmussen N B, Gavala H N, Skiadas I V, Patuzzi F, Baratieri M. Competitiveness of syngas biomethanation integrated with carbon capture and storage, power-to-gas and biomethane liquefaction services: Techno-economic modeling of process scenarios and evaluation of subsidization requirements. Biomass and Bioenergy 2022. https://doi.org/10.1016/j.biombioe.2022.106475

Effect of natural gas price variation on stored electricity cost

Simplified estimation of levelized costs of grid electricity

Relative penetration of renewable generation sources

$$r_{RES} = \frac{f_{RES}}{f_{RES} + f_{NG}}$$

Higher cost level

Weighted average cost of grid electricity as a function of gas-fired and renewables levelized cost at a 7% interest rate on capital

$$HLCOE = LCOE_{RES,7\%} \times r_{RES} + \left(LCOE_{CCGT,7\%} + CC\right) \times \left(1 - r_{RES}\right)$$

Lower cost level

Levelized cost of renewable electricity at a low rate of return on capital (3%)

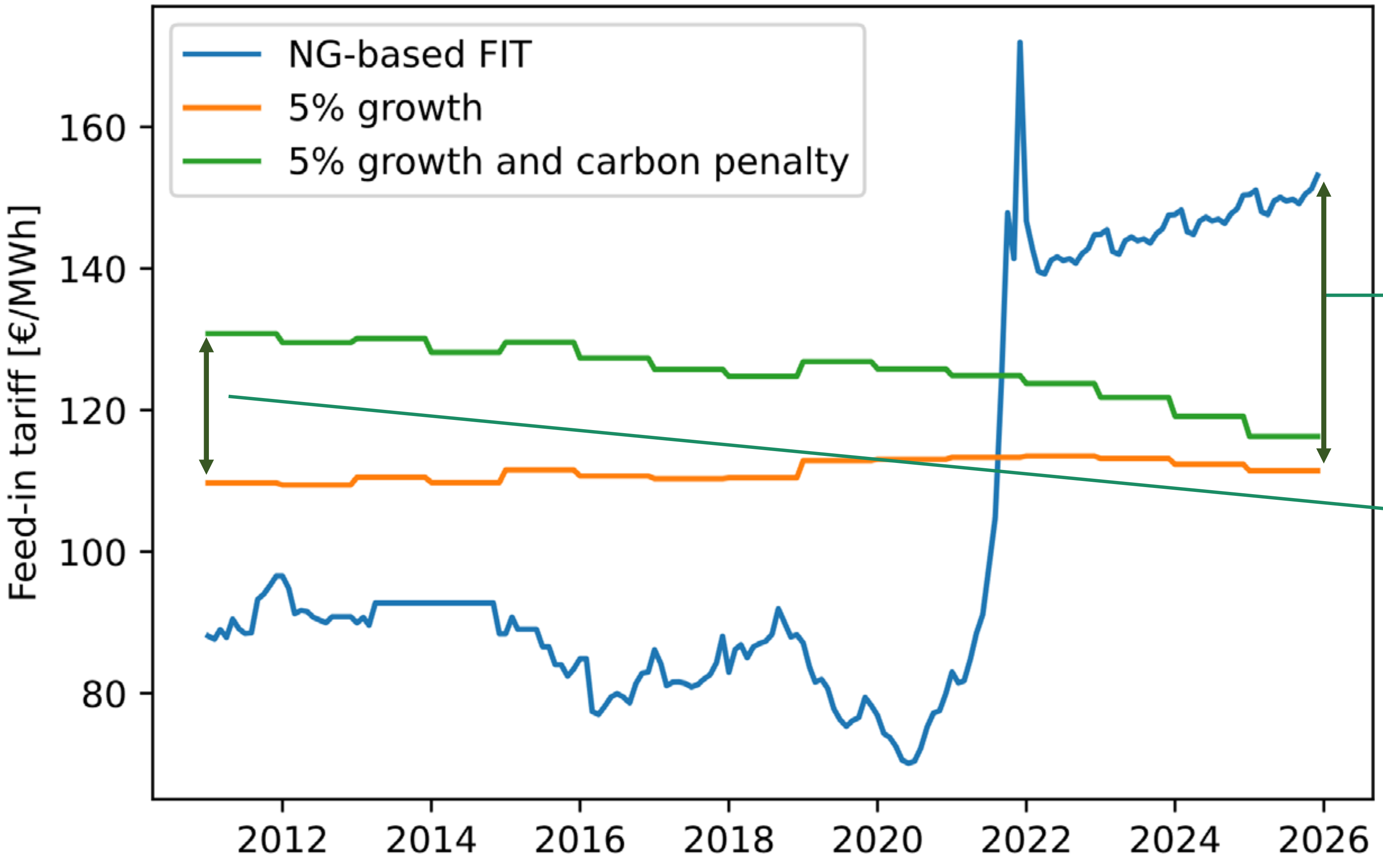
$$LLCOE = LCOE_{RES,3\%}$$

Hypotheses:

- three levels of renewable sources penetration into the energy mix (5%/y, 10%/y, 15%/y)
- introduction of a carbon tax on gas-fired generation (equivalent to 50 $/MWh)

Effect of natural gas price variation on stored electricity cost

Results: variation in projected feed-in tariff

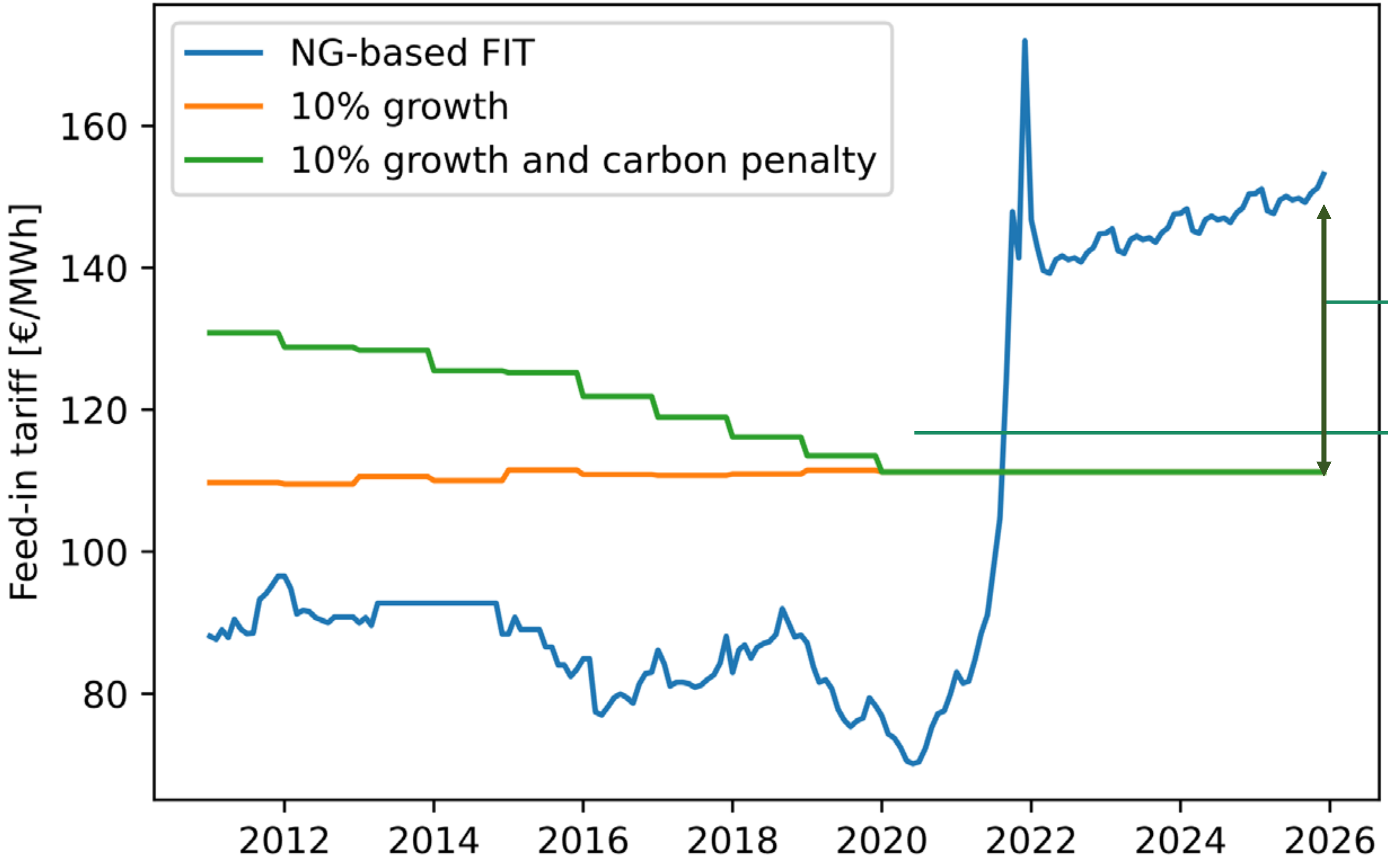


Savings in gas decarbonization costs: LCOB (final month) is **27.4% lower** than under a gas-based mechanism

Carbon penalty generates higher costs due to gas-fired generation contribution

Effect of natural gas price variation on stored electricity cost

Results: variation in projected feed-in tariff

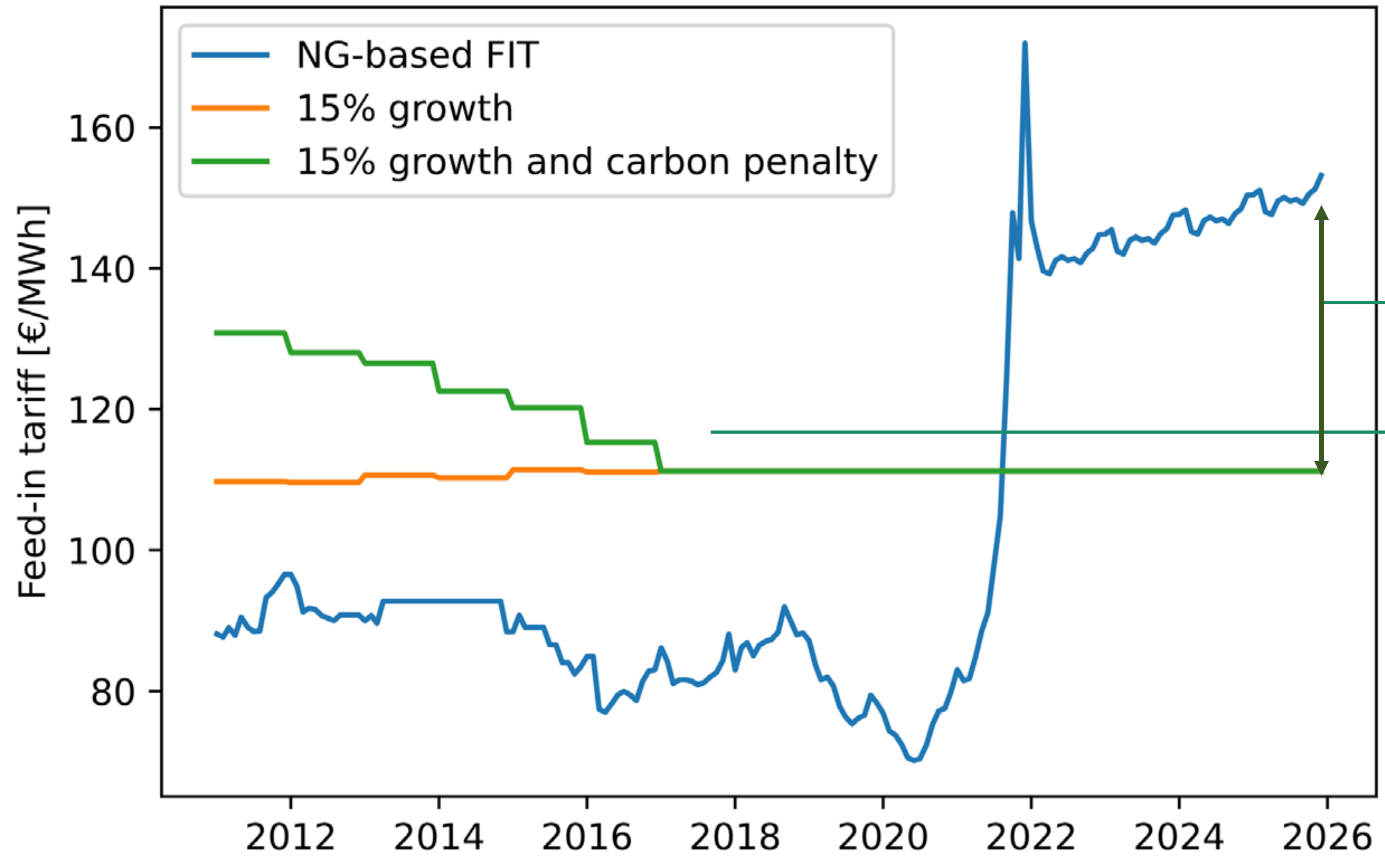


Savings in gas decarbonization costs: LCOB (final month) is **27.2% lower** than under a gas-based mechanism

Faster gas decarbonization cost reduction at higher renewables growth rate

Effect of natural gas price variation on stored electricity cost

Results: variation in projected feed-in tariff



Savings in gas decarbonization costs: LCOB (final month) is **27.2% lower** than under a gas-based mechanism

Faster gas decarbonization cost reduction at higher renewables growth rate

Conclusions

1. **Contemplating variability in the underlying reference commodity price** of natural gas is **essential in the evaluation of project feasibility** in biomass-Power-to-Gas projects supported by subsidy schemes that operate based on natural gas prices.

2. Application of a simple forecast technique enabled estimating a sign difference in NPV and ROI indicating as **profitable projects that otherwise emerge as unprofitable**.

3. An alternative feed-in tariff defined as a function of **electricity cost** show **faster gas decarbonization costs reductions** at growing renewables growth rates and overall **cost reductions in the region of 27%** in the final month of the time series considered.

4. The simple assessment presented points to **a need to build systematic economic assessment** methodologies in which the **price variation of fundamental underlying energy commodities** is contemplated.

Freie Universität Bozen
Libera Università di Bolzano
Free University of Bolzano

Bioenergy & Biofuels LAB

Thank you

Come & visit us!
bnb.groups.unibz.it

Lorenzo Menin*, Stefano Piazzi,

Daniele Antolini, Marco Baratieri

*lorenzo.menin@unibz.it