Attracting Private investments into clean electricity

Assessment of the fund's potential payout

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Background

- Our paper “Attracting private investments into clean electricity” proposes the establishment of an investment fund for renewable energy projects in Ukraine.
- The proposed fund aims to strengthen the bankability of private clean energy projects in Ukraine by guaranteeing a minimum payout (price) for electricity provided.
- This will help to provide planning certainty for investors and lenders, with details to be determined in cooperation with investors and stakeholders.
- Payouts of the fund are a function of the difference between a pre-determined strike price and the market price of electricity.
- **The long-term financial sustainability of the fund will depend on its financial resources and the expected payouts. The possible level of such payments is examined here.**

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The fund's annual payout, and therefore its financial needs, depend on three main factors:

1. **Eligible investments:** The amount of new power generation capacity covered
2. **Electricity prices:** In the Ukrainian wholesale market they are determined in each hour by the most expensive bid that is needed to meet demand

   The expected electricity generation costs and therefore the prices are essentially determined by three factors*:

   - **Structure of power plant park:** incl. nuclear, renewable and thermal capacities
   - **Electricity demand:** Incl. their hourly patterns
   - **Fuel and CO_2-prices**: These variables are particularly important as they define the production cost of marginal price-setting thermal plants.
3. **Payout function**: The specific formula determining the payouts to investors given a certain electricity price.

* There are also other considered factors, including weather/climate; hourly import/export opportunities; …

We determine the electricity prices using our electricity system model

- An electricity system model is used to determine the minimum cost of electricity generation at an hourly resolution, allowing electricity prices to be calculated.
- Two different scenarios are defined to represent a range of possible futures. They differ in terms of demand and installed capacities in Ukraine.
  - **Scenario 1**: "NECP WEM 2030" follows demand and supply assumptions according to the WEM* ('With Existing Measures') scenario of the 'National Energy and Climate Plan' (2024) for 2030.
  - **Scenario 2**: "Present-course projection 2030" follows demand and supply assumptions based on an expert assessment provided by IMEPOWER.
- We use a PyPSA model implementation, developed by the GDU project (see Appendix 1).

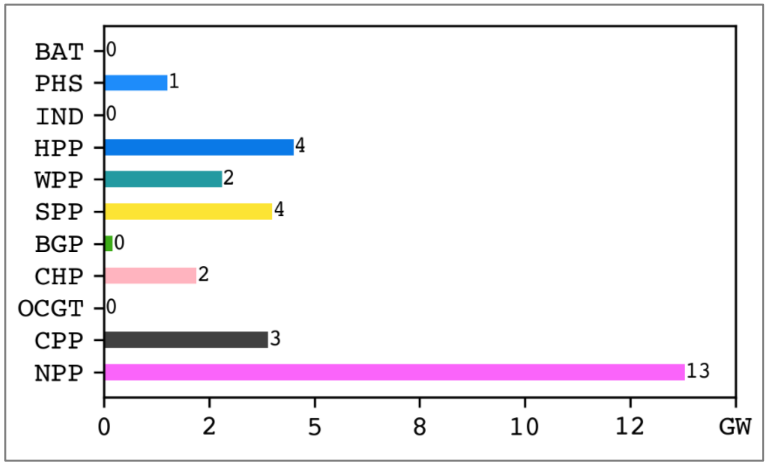
** WEM is a conservative scenario in terms of emission reductions with a significant share of nuclear generation and a relatively low demand.*

Common assumptions across both scenarios

- **Installed capacities** and aggregated electricity **demand** in all ENTSO-E countries except Ukraine based on assumptions from the 'Ten Year Network Development Plan (TNYDP) NT+" scenario for 2030.
- **Fuel prices** for all countries including Ukraine following TYNDP for 2030.
- **CO_2-price** for all countries but Ukraine following TYNDP for 2030.
- **CO_2-price** in Ukraine according to WEM scenario from the NECP for 2030
- All **net transfer capacities** between countries are parameterised based on assumptions from the 'Ten Year Network Development Plan' (TNYDP) "NT+" scenario for 2030.

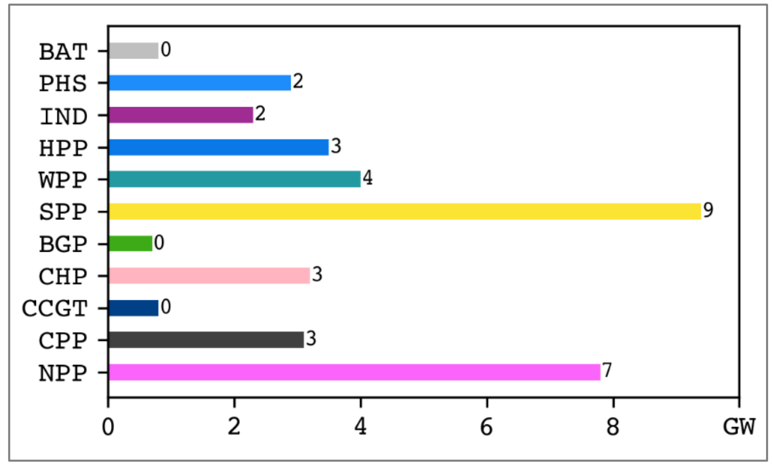
Installed capacities Ukraine (GW) 2030

NECP WEM scenario 2030



Source: Veda Online – UA TIMES results

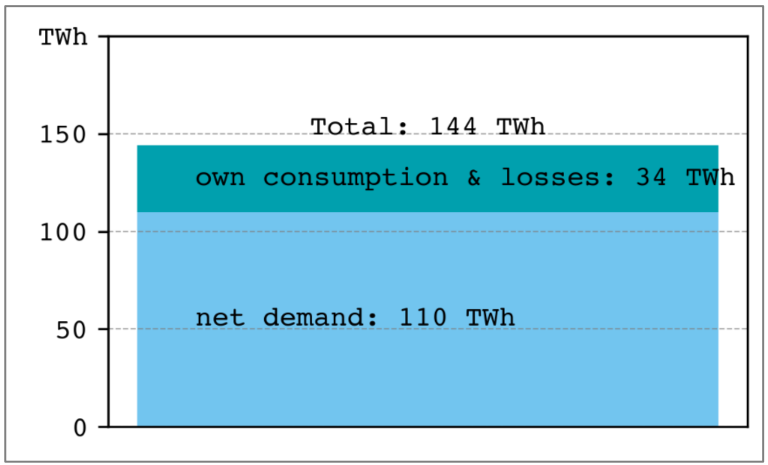
Present-course scenario 2030



Source: expert assessment provided by IMEPOWER

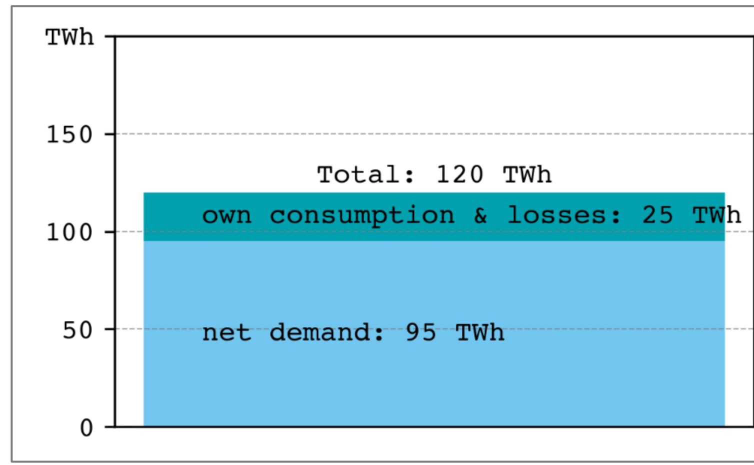
Demand Ukraine (TWh) 2030

NECP WEM scenario 2030



Source: Veda Online – UA TIMES results

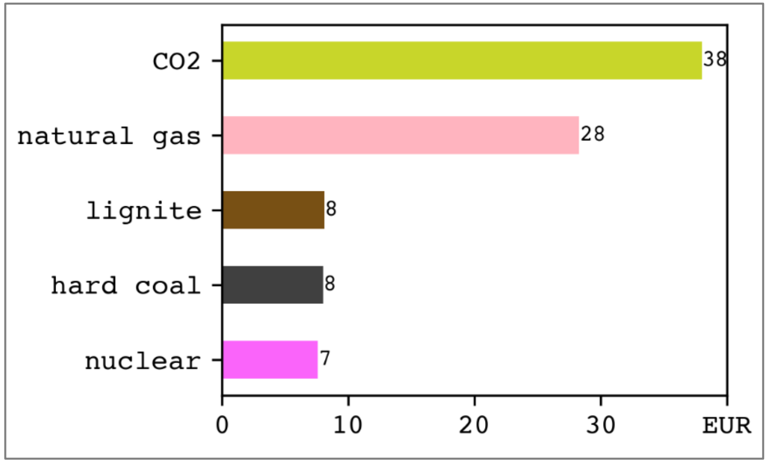
Present-course scenario 2030



Source: expert assessment provided by IMEPOWER

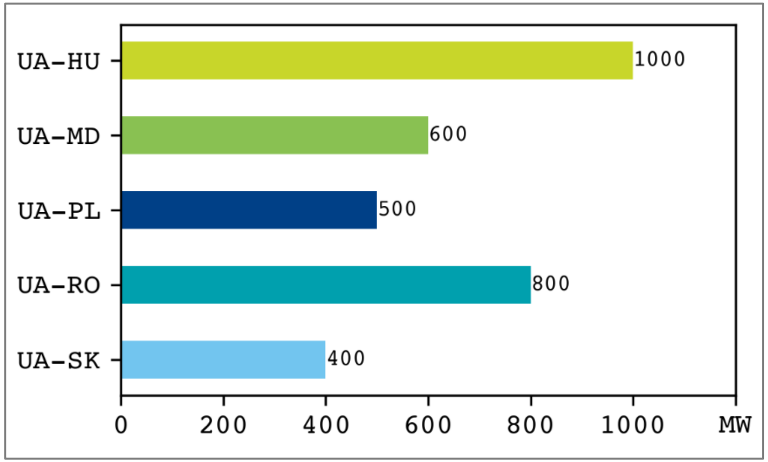
Assumptions for both scenarios

Fuel price EUR/MWh and CO_2-prices EUR/t 2030



Source: TYNDP

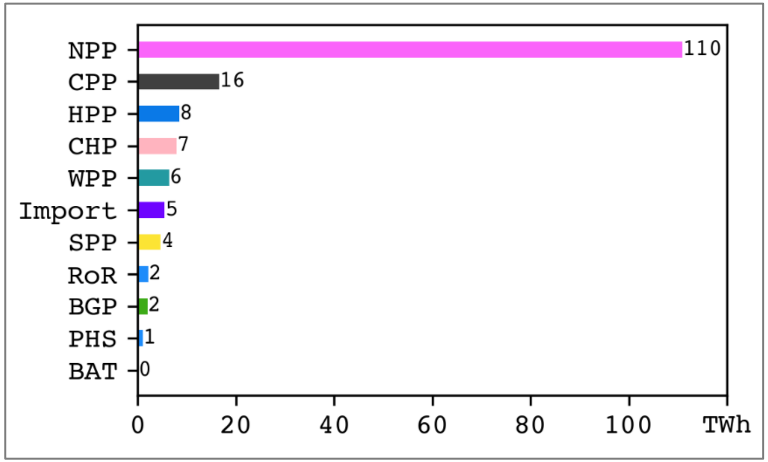
NTCs, UA and neighbouring countries (MW) 2030



Source: TYNDP

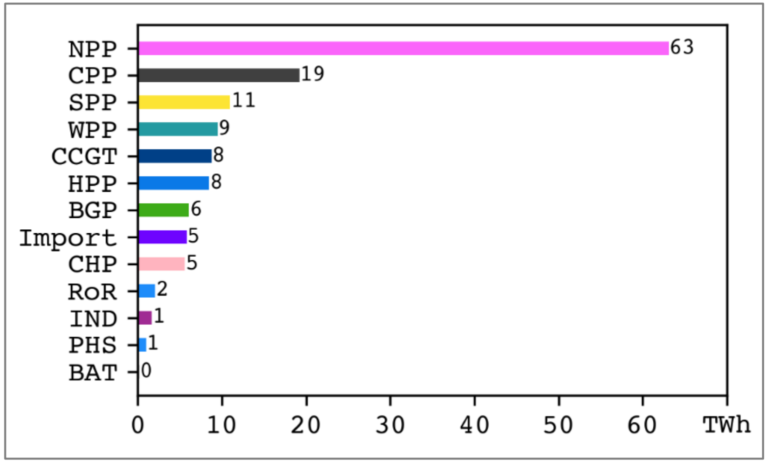
Generation mix Ukraine (TWh) 2030

NECP WEM scenario 2030



Source: Own calculation using the GDU PyPSA-UA model

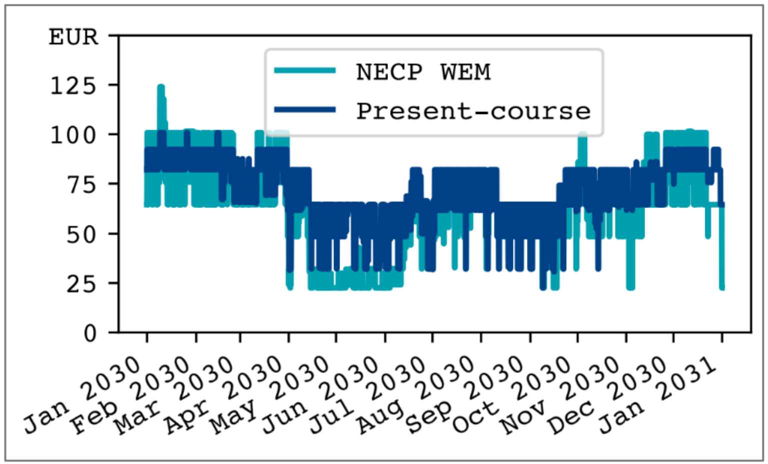
Present-course scenario 2030



Source: Own calculation using the GDU PyPSA-UA model

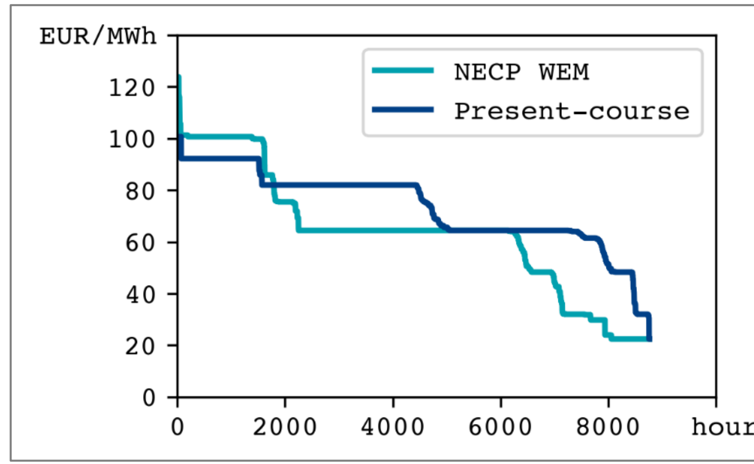
Prices and price duration curves (EUR / MWh) 2030

Price trajectories



Source: Own calculation using the GDU PyPSA-UA model

Price duration curves



Source: Own calculation using the GDU PyPSA-UA model

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Determination of the aggregated annual fund payout

The fund's payout depends on:

- *The **hourly electricity prices:***
  - *We derive hourly prices from the 'NECP WEM' and 'Present-course' scenario outputs.*
- *The **strike price*** is an electricity price threshold below which investors are compensated:
  - We analyse the effects of three strike prices: 50, 65 and 80 EUR/MWh.
- *The **payout function***, which determines the exact compensation an investor obtains when the electricity prices is below the strike price:
  - Four payout functions that differ between the consideration of hourly vs. average prices and individual plants vs. reference plants (see Appendix 2).
- To illustrate the impact of these three determinants we assess the annual payouts of the fund for 1 MW of installed wind power, 1 MW of PV and a mix of both.

How to interpret the results on the next slide

***Input**: two price scenarios*

***Input**: four payout functions*

***Input**: three renewable capacity types*

***Output**: average market price*

***Input**: three strike prices*

***Output**: fund payout in 1,000 EUR/a*

***Output**: market revenue of a 1 MW plant in 1,000 EUR/a*

		NECP WEM			Present-course		
	average market price:	ø 64 EUR / MWh			75 EUR / MWh		
		market revenue individual plant: 139			market revenue individual plant: 159		
	strike price:	50 EUR/MWh	65 EUR/MWh	80 EUR/MWh	50 EUR/MWh	65 EUR/MWh	80 EUR/MWh
1 MW WIND onshore 2100 MWh / a	hourly prices & hourly generation, individual plant	9	17	41	1	5	18
	hourly prices & average generation, individual plant	10	19	43	1	5	20
	hourly prices & hourly generation, reference plant	10	19	45	1	5	21
	average price & annual generation, individual plant	0	3	35	0	0	14
		market revenue individual plant: 61			market revenue individual plant: 68		
	strike price:	50 EUR/MWh	65 EUR/MWh	80 EUR/MWh	50 EUR/MWh	65 EUR/MWh	80 EUR/MWh
1 MW PV solar utility scale 1100 MWh / a	hourly prices & hourly generation, individual plant	7	15	29	1	5	18
	hourly prices & average generation, individual plant	5	10	22	1	3	10
	hourly prices & hourly generation, reference plant	8	16	31	3	10	23
	average price & annual generation, individual plant	0	1	18	0	0	7
		market revenue individual plant: 101			market revenue individual plant: 114		
	strike price:	50 EUR/MWh	65 EUR/MWh	80 EUR/MWh	50 EUR/MWh	65 EUR/MWh	80 EUR/MWh
RES MIX 1600 MWh / a	hourly prices & hourly generation, individual plant	0	16	35	0	5	18
	hourly prices & average generation, individual plant	0	14	33	0	4	15
	hourly prices & hourly generation, reference plant	0	18	38	0	7	22
	average price & annual generation, individual plant	0	2	26	0	0	11

Fund payout in 1,000 EUR / MW 2030

		NECP WEM			Present-course		
	average market price:	ø 64 EUR / MWh			75 EUR / MWh		
		market revenue individual plant: 139			market revenue individual plant: 159		
	strike price:	50 EUR/MWh	65 EUR/MWh	80 EUR/MWh	50 EUR/MWh	65 EUR/MWh	80 EUR/MWh
1 MW WIND onshore **2100 MWh / a**	hourly prices & hourly generation, individual plant	9	17	41	1	5	18
	hourly prices & average generation, individual plant	10	19	43	1	5	20
	hourly prices & hourly generation, reference plant	10	19	45	1	5	21
	average price & annual generation, individual plant	0	3	35	0	0	14

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Key findings

- The fund payout in the 'NECP WEM' scenario is about 100% higher than in the 'Present-course scenario' in all cases (renewable type, payout function and strike price).
- A significantly higher NPP generation in the 'NECP WEM' scenario leads to lower prices, so that a so higher fund payout is required.
- As expected, and intended, there is an inverse relationship between fund pay-out and renewable energy operators' own revenues from electricity generation.
- Revenues per MW of wind capacities are two times higher than that of PV, as expected. This should be considered in the determination of strike prices.
- In our example (but this does not necessarily have to be the case) the F III payout function which is based on a reference plant rather than a specific plant, results in higher payouts than the other functions.

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Uncertainties and further analyses

- Many of the assumptions are based either on Ukrainian NECP and the ENTSO-E TYNDP scenario or expert assessments provided by IMEPOWER. As with all forecasts and plans, there are substantial uncertainties associated.
- In our view, the main issues - apart from uncertainty around the further development of the Russian aggression - are as follows (the +/- sign indicates whether an increase leads to an increase in the payout):
  - Demand development in Ukraine (-) and its neighbouring countries (-),
  - The issue of continued/increased operation of nuclear power plants in Ukraine (+),
  - The introduction of a CO_2-price in Ukraine (-) of at least 38 EUR/ton until 2030.
  - The fuel price development in Europe (-).
- The results show the fund payout per 1 MW of installed capacities for one year only. Further analysis is needed to show how changing fundamental parameters in Ukraine and in Europe will affect the fund payout in the long term.

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PyPSA

PyPSA* can be used for a variety of problem types (e.g. electricity market modelling, long-term investment planning, transmission network expansion planning), and is designed to scale well with large networks and long time series**. There are four main functions:**

- **Static Power Flow Analysis:** various parameters and metrics that describe the operating state of an electrical power network under steady-state conditions
- **Linear Optimal Power Flow (LOPF):** least-cost optimisation of power plant and storage dispatch within network constraints, using the linear network equations, over several snapshots
- **Security-Constrained Linear Optimal Power Flow (SCLOPF)**
- **Total Electricity/Energy System Least-Cost Investment Optimization:** using linear network equations, over several snapshots simultaneously for optimisation of generation and storage dispatch and investment in the capacities of generation, storage, transmission and other infrastructure

* ‘Python for Power System Analysis‘: https://pypsa.org

Payout functions

- With payout function FI, a payment is made in every hour in which the current price is below the strike price. The amount paid out results from the difference in these two prices and the RES generation of the respective plant in the respective hour.
- The FII function differs in that the output level is not determined by the actual hourly generation but by the average.
- F III behaves like FI with the difference that not the actual production of an installation but that of a reference installation is used.
- Payout function F IV is also based on F1. Here, however, the price difference is not determined in relation to the hourly price but between the strike price and the average electricity price for the year. The payment is again made for the generation of a specific plant.

F I : 'hourly prices (p_t) & hourly generation ($g_t^{..}$), individual plant': $F_I^{wind} = \sum_{t=1}^{8760}\big(max\big((\pi - p_t), 0\big) \cdot g_t^{wind}\big)$

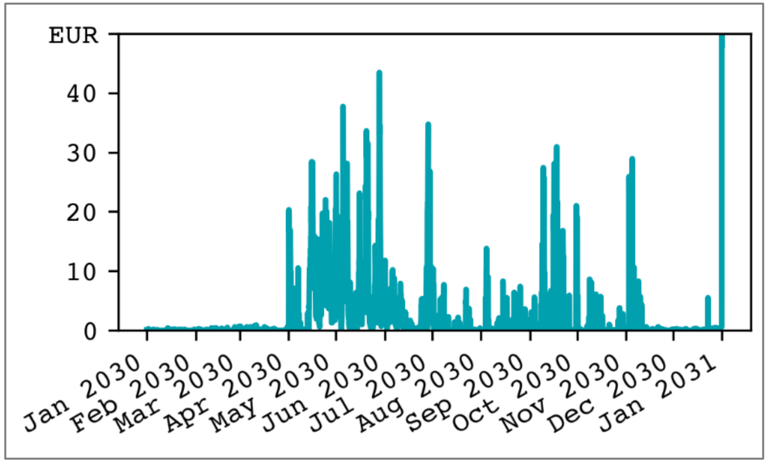
F II: 'hourly prices (p_t) & average generation ($\tilde{g}$), individual plant': $F_{II}^{wind} = \sum_{t=1}^{8760}\left(max\big((\pi - p_t), 0\big) \cdot \frac{\sum_{t=1}^{8760} g_t^{wind}}{8760}\right)$

F III: 'hourly prices (p_t) & hourly generation ($g_t^{..}$), reference plant': $F_{III}^{\widehat{wind}} = \sum_{t=1}^{8760}\left(max\big((\pi - p_t), 0\big) \cdot g_t^{\widehat{wind}}\right)$

F IV: 'average price ($\tilde{p}$) & hourly generation ($g_t^{..}$), individual plant': $F_{IV}^{wind} = \sum_{t=1}^{8760}\big(max\big((\pi - \tilde{p}), 0\big) \cdot g_t^{wind}\big)$

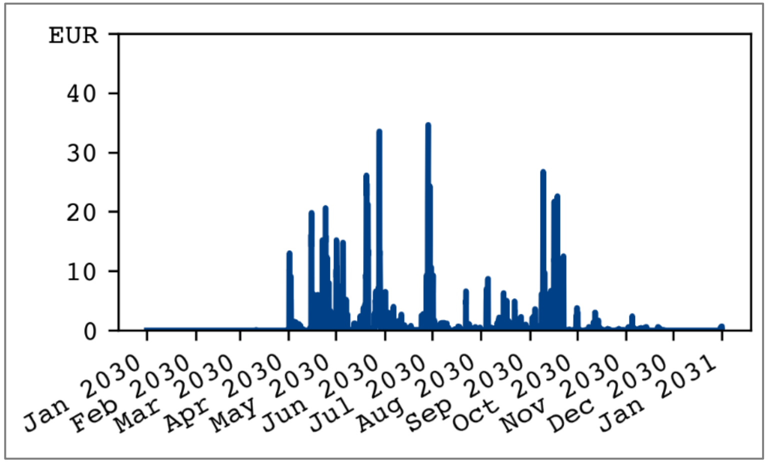
Hourly payout, for 1 MW wind capacity, payout function FI strike price 65 Euro / MWh

NECP WEM scenario 2030



Source: Own calculation using the GDU PyPSA-UA model

Present-course scenario 2030



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