Low Carbon Ukraine

Policy advice on low-carbon policies for Ukraine

Supported by:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

based on a decision of the German Bundestag

Ukrenergo Adequacy Report – Evaluation of power plant park scenarios for 2032

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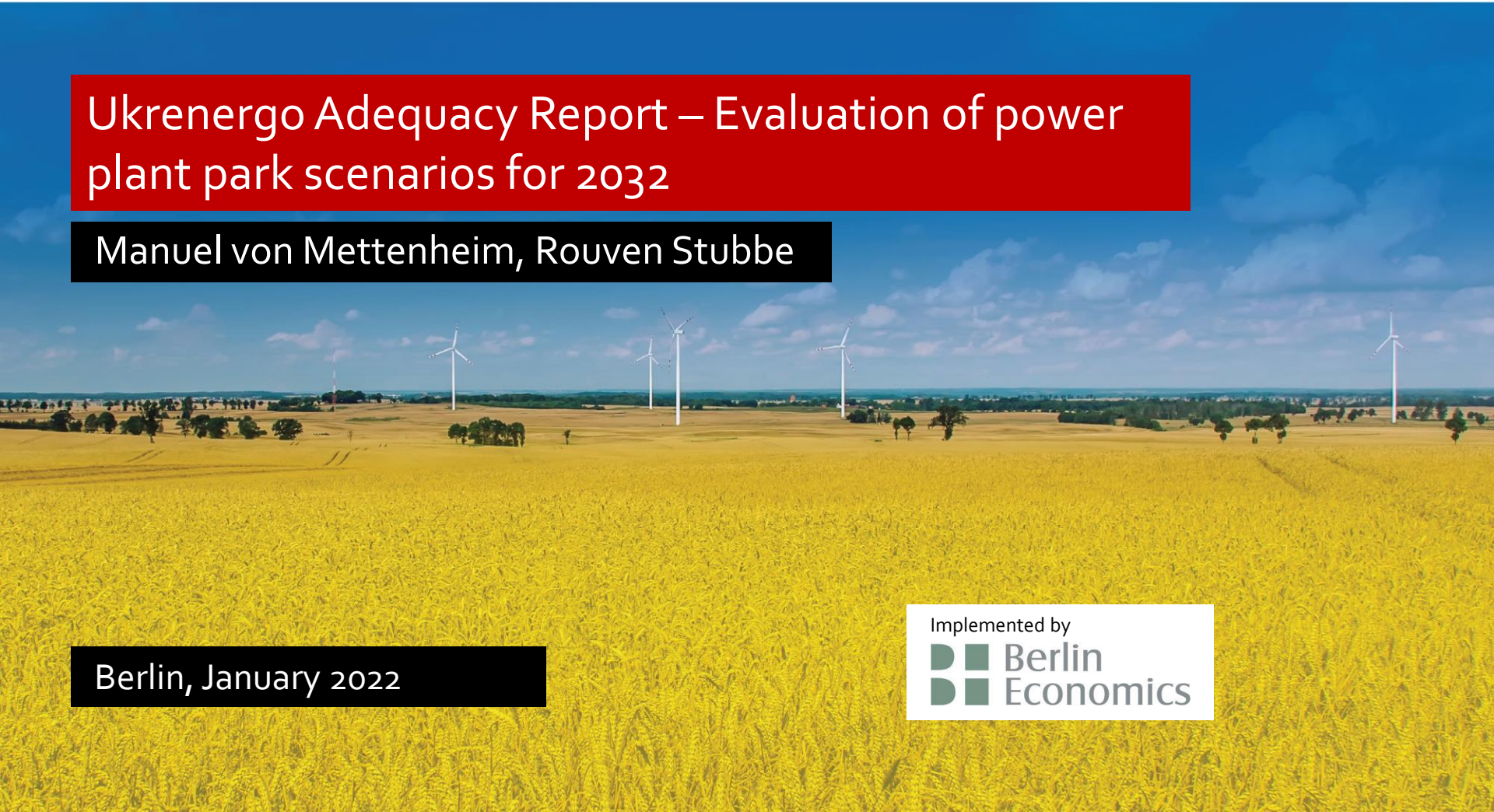

Berlin, January 2022

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Berlin Economics

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1. Background and rationale

Ukrenergo Adequacy Report

- In Dec 2021, Ukrainian TSO *Ukrenergo* published 2nd draft of Adequacy Report
- The report contains:
  - Analysis of supply and demand of electricity
  - Long-term scenarios for the Ukrainian power plant park
  - Risks for security of supply and operational security

In this report, we aim to evaluate and compare Ukrenergo results with LCU calculations with respect to …

- Scenario building
- Carbon emissions
- Expansion of renewables
- Flexibility options for electricity system

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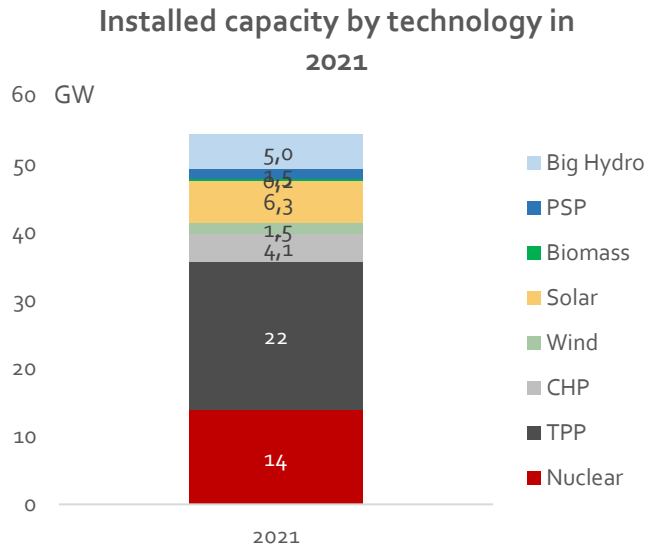
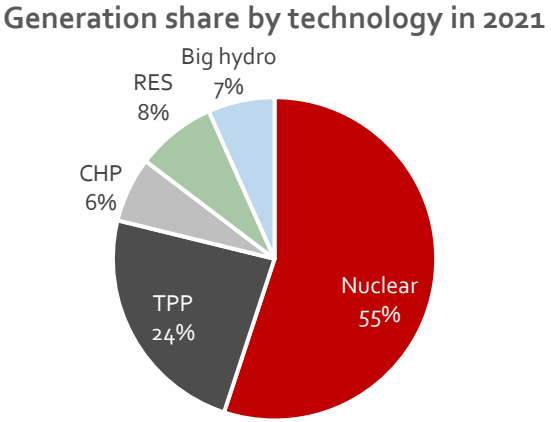
2. Current power plant park





- Installed capacity dominated by overcapacity of outdated coal-fired thermal PPs
  - Nuclear capacity at around 14 GW but plans to expand capacity in coming decades
  - Wind and solar capacity increased in recent years from 1.6 GW in 2018 to 7.8 GW
  - Pump-storage and hydropower plants provide needed balancing capacity
- Generation shares
  - Despite high maintenance requirements, nuclear generation dominates total generation
  - High coal-fired thermal PP and mostly gas-fired CHP contribute to CO_2 emissions
  - Wind and solar account for 7% in electricity mix

➢ **Major challenge in Ukrainian electricity system: Introduce more flexibility in electricity system to combine high share of nuclear baseload generation & growing share of variable RES**

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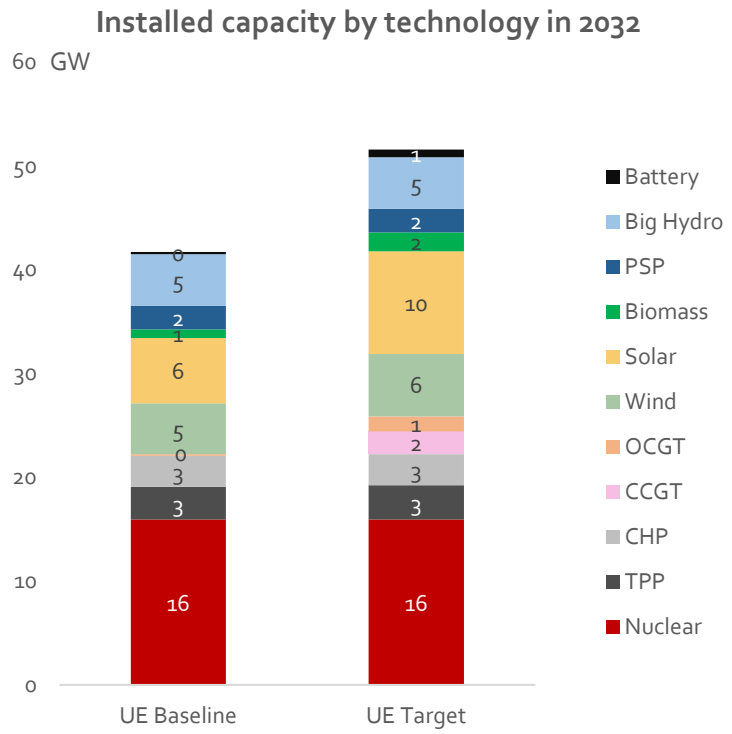
3. Ukrenergo scenarios

Ukrenergo provides two power plant park scenarios for 2032

1. Baseline	Power plant park development based on current policies and strategies of Ukraine
2. Target	Power plant park development partly based on cost optimization (Capex, Opex)



- Baseline scenario leads to underdevelopment of generation capacity
  - Not able to meet electricity demand
- Nuclear, thermal PP, CHP and hydro capacity almost unchanged between scenarios
- Target scenario envisages stronger increase of renewable and balancing capacity
  - Wind capacity slightly increase while solar and biomass capacity significantly expanded
  - More gas turbines and batteries needed to provide balancing capacity in system with more variable renewable energy capacity (wind and solar)
- Thermal PP capacity almost unchanged between scenarios

➢ **Business-as-usual leads to underdevelopment of capacity; More RES and balancing capacity needed**

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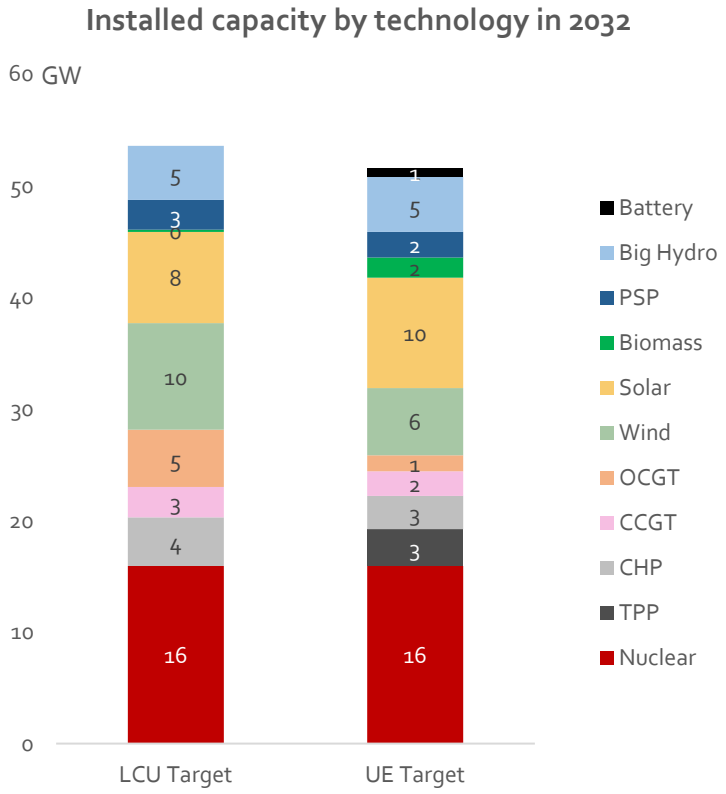
4. Comparing Ukrenergo and LCU target scenarios

Working out the differences between LCU and Ukrenergo target scenarios



Note: You can find further information about the LCU scenario in the publication "Ukraine's power plant park: Optimal configuration in 2032 and investment needs in the transition phase".

- Both power plant parks have a similar configuration
- Thermal PP capacity entirely phased-out in LCU scenario
  - Due to implementation of NDC goals (using CO_2 shadow price)
  - Ukrenergo envisages steep reduction of TPP capacity from today's 22 GW to 3 GW
- Significantly more variable renewable capacity in LCU scenario (esp. due to high wind expansion) resulting in …
  - More balancing capacity (esp. OCGT) needed
  - Higher need for total capacity due to relatively general low capacity factor of RES

➢ **LCU and Ukrenergo envisage similar development of power plant park; higher RES and gas turbines capacity in LCU scenario due to total phase-out of thermal PP**

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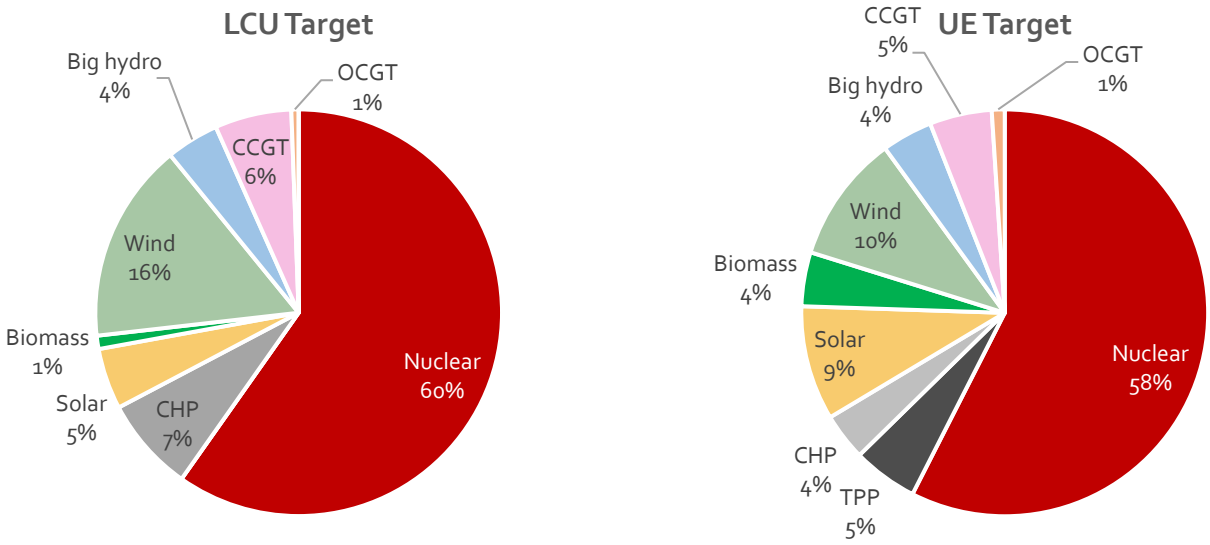
4.1 Generation shares

Generation share by technology in 2032



- Nuclear generation remains main contributor to total electricity generation in Ukraine
  - Political will to expand capacity increases share of nuclear from today 52% to 58-60% in 2032
- The share of variable renewables (wind and solar) account for 19% (UE) to 21% (LCU)
- Gas turbines generate 12 TWh in LCU scenario and 11 TWh in UE scenario
  - This equals to 1.9-2.1 bcm of additional gas demand (ca. 8% of current gas consumption)

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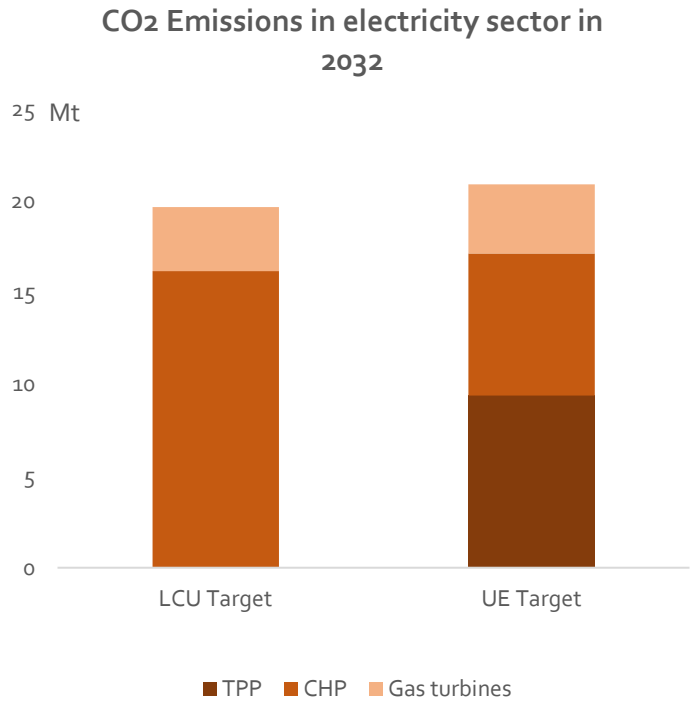
4.2 Emissions



- Slightly higher CO_2 emissions in UE Target scenario due to remaining coal-fired electricity production
- Gas turbines contribute smaller share to total CO_2 emission
- CHP contribute heavily to LCU scenario due to heat production

➢ **Decarbonisation of the heat sector is necessary but analysis goes beyond the scope of this work**

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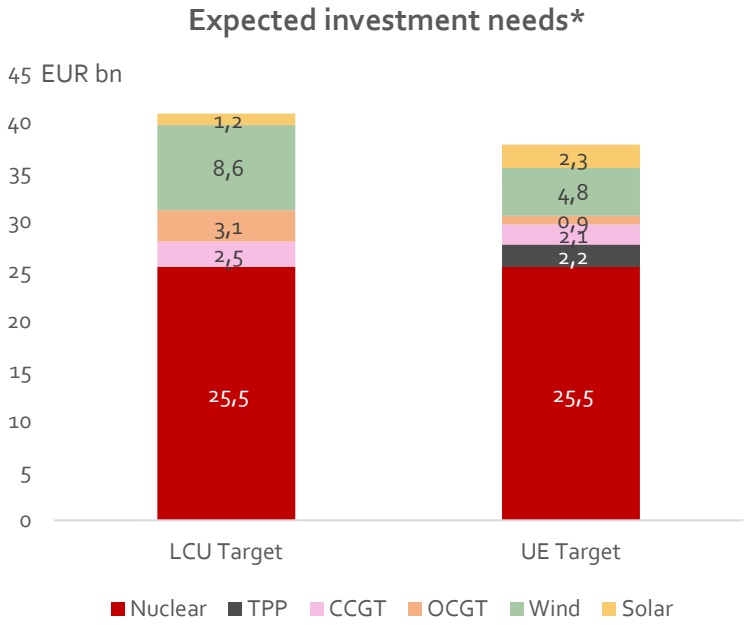
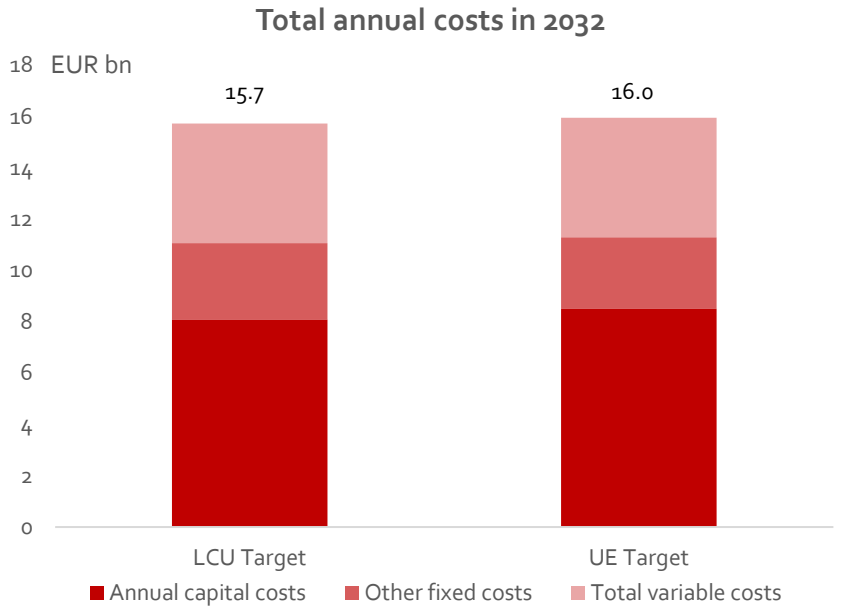
4.3 Investment needs and total system costs





**for selected technologies since investment in Hydro, CHP, and biogas do not change across scenarios*
Note: We consider greenfield, lifetime extension and filter investment.

- New construction of two nuclear units drive investment needs significantly in both scenarios
- LCU Target scenario requires more investment than UE scenario due to significantly higher expansion of wind capacity

- Higher annual costs in UE target scenario are mainly driven by investment (filter and lifetime extension) in thermal PPs as we expect relatively short amortisation period

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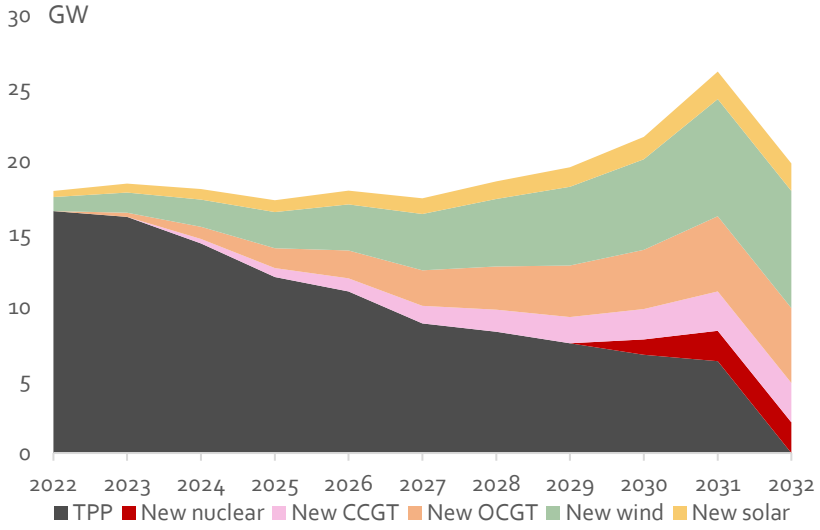
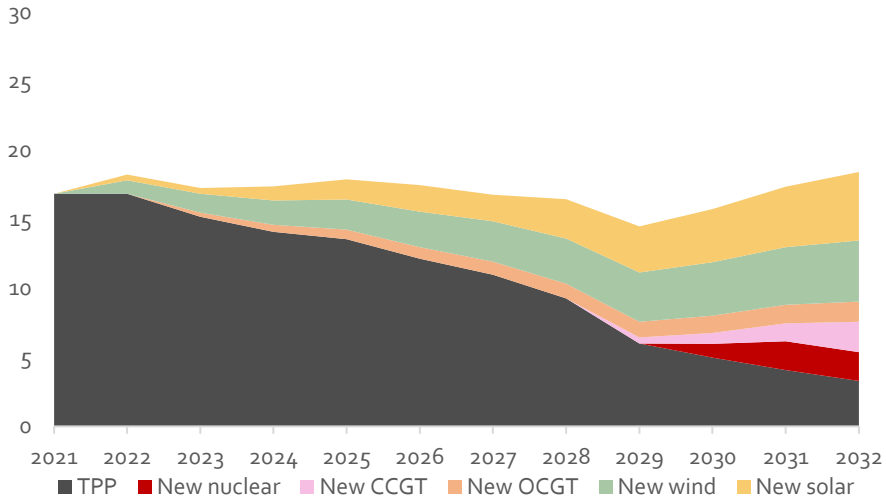
5. Outlining a feasible transition path

TPP phase-out trajectory and new generation capacities (cumulative) in LCU Target scenario



TPP reduction trajectory and new generation capacities (cumulative) in Ukrenergo Target scenario



- Timing of new investment is determined by exhaustion of TPP operating hour limits
- On average 1.1 GW of TPPs will have to stop operation every year until 2031
  - 2031: 6 GW of TPPs will close

➢ Construction of new RES & gas turbines must be tackled quickly (construction time: ~2 years)

- Slower investment in new capacity is determined by exhaustion of thermal PPs
- OCGT, wind and solar expansion is tackled first, while nuclear and CCGT capacity added later

➢ Due to slower reduction of thermal PP capacity, expansion of other generation capacity less ambitious

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6. Common ground despite slight differences

	Ukrenergo	Low Carbon Ukraine	Main message
TPP capacity	3 GW of thermal PPs still in operation in 2032	Thermal PPs will become uncompetitive in comparison to gas turbines in 2032, leading to a total phase-out by then	Both target scenarios envisage a steep reduction of coal-fired thermal PP generation
Nuclear capacity	Khmelnytskyi NPP units 5 and 6 (around 2 GW) are newly built		Nuclear capacity will be further expanded due to political decisions
Renewable capacity (excl. hydro)	Stronger focus on solar than wind expansion; additional biogas power plants	Stronger focus on wind expansion than solar; No biogas expansion due to high capital costs and unclear potential of biofuel	Wind and solar capacities will significantly increase to replace thermal PPs
Gas turbines	Expansion of gas turbines due to reduction of thermal PP capacity	Stronger expansion of gas turbines due to high renewable introduction	CCGTs and OCGTs are built to accompany RES expansion

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5. Conclusion

- LCU and Ukrenergo envisage a similar development of the electricity system in 2032
  - Nuclear share in electricity mix will increase due to political decisions to expand capacity
  - Thermal PPs will decrease significantly due to high investment needs for filters and lifetime extension
  - Replacement of thermal PPs with renewable capacity (wind, solar and biogas) accompanied with increase of balancing capacity (gas turbines and potentially batteries)
- Investment needs until 2032 are similar among both scenarios ranging from EUR 38 to 41 bn for renewable, nuclear, gas turbines and batteries
  - Just the new construction of the two nuclear blocks in Khmelnitsky will cost around EUR 26 bn (around 50% of total investment needs)
- Any investment in (existing and new) coal-fired generation has a short amortisation period
  - Most coal-fired TPPs will drop out of electricity system in coming years – LCU even projects total phase-out by 2032 due to high carbon price
- Wind and solar will be significantly expanded in the coming years to replace TPPs
  - Wind and solar will make up 19-21% of power generation by 2032

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