Low Carbon Ukraine

Policy advice on low-carbon policies for Ukraine

Policy Briefing #1

Supported by:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

based on a decision of the German Bundestag

Balancing Renewables in Ukraine

Dr. Georg Zachmann and Dr. Frank Meissner

Berlin / Kyiv, October 2018

Low Carbon Ukraine

Executive summary

1. **We assess that the conventional power capacities, currently installed in the Ukrainian power system, can balance fluctuations of up to 15 GW of wind and solar**
2. **The aging stock of conventional power capacities as well as a potential increase of power demand will create pressure for action in the medium and long term**
3. **An integration of RES above 15 GW as part of a decarbonisation strategy will require the development of a power system that is much more flexible than the current one**

This assessment is based on on a dispatch optimisation model approach (LCO-OD-Model Version 2.1)

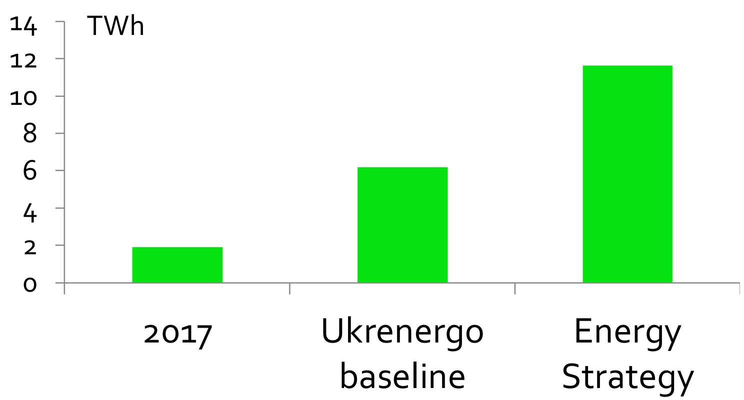
We consider the observed flexibility of the Ukrainian power plant fleet (nuclear, thermal, big hydro, pump hydro and cogeneration).

Potential constraints from grid restrictions are not considered in the current version of the model

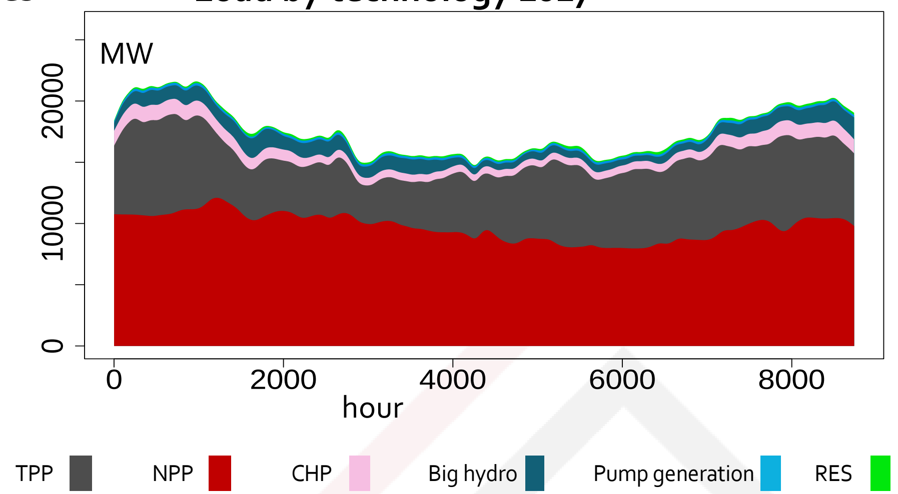
Low Carbon Ukraine

Motivation

Projected electricity consumption from renewables



Load by technology 2017



Source: Ministry of Energy, Statistical Committee, Ukrenergo, own calculations

- Increase in fluctuating renewable energy sources brings new challenges
  - Need for regulation of grid stability and power frequency by provision of **balancing power**
- Analysis of **technical and regulatory options** for balancing RES shares
  - Assessment of short-, medium-, and long-run options

Low Carbon Ukraine

Three-fold problem of RES integration

- Increasing RES power generation might lead to:

1. **Excess power in cases of low consumption and high feed-in**

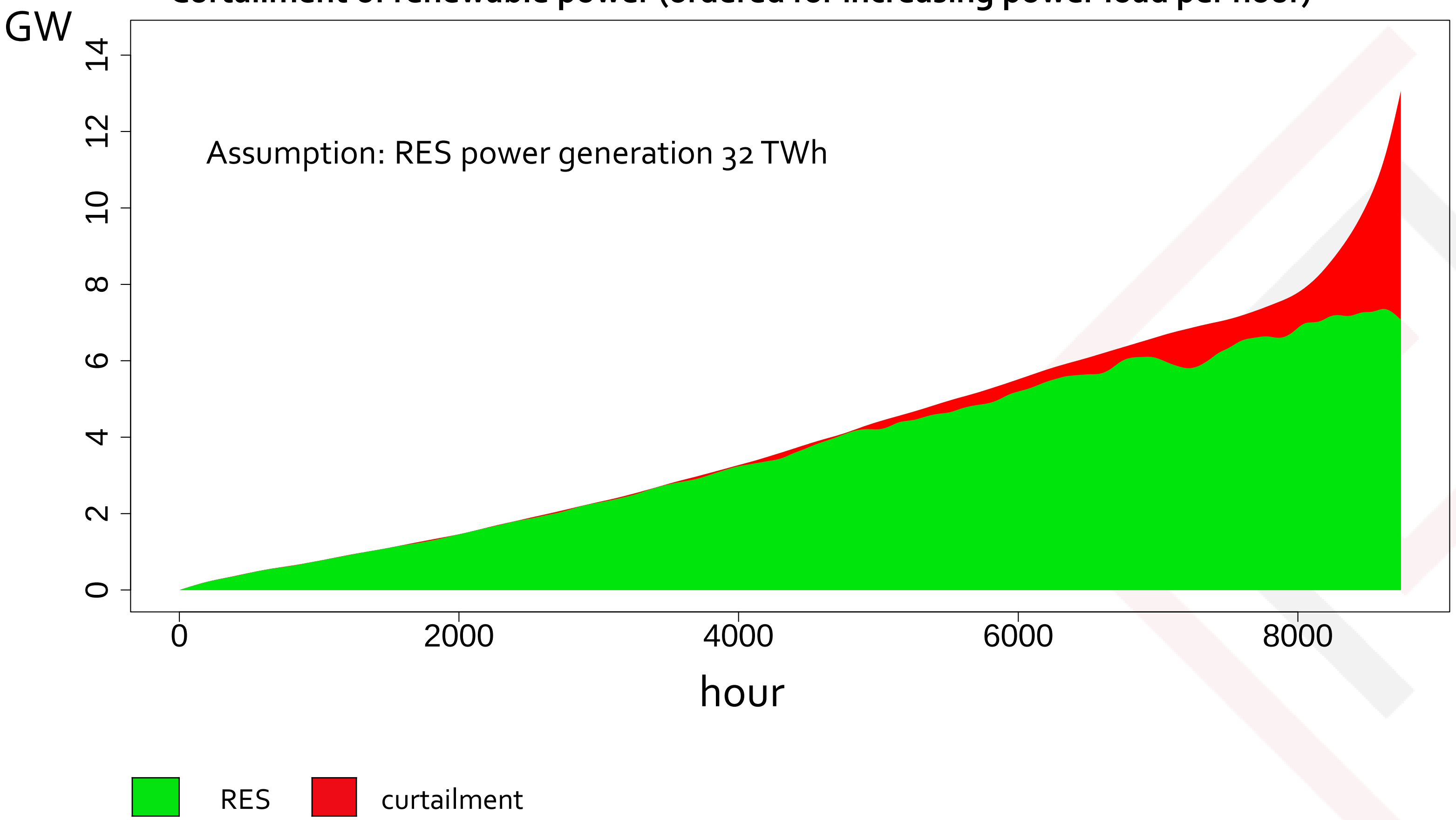
2. **Lack of power in cases of high consumption and low feed-in**

3. **Excessive fluctuations that cannot be balanced sufficiently quickly**

1. **Excess power** in cases of low consumption and high feed-in

- No need for curtailment in Energy Strategy trajectory (12 TWh)
- ~10% curtailment losses in scenario with 32 TWh of renewables

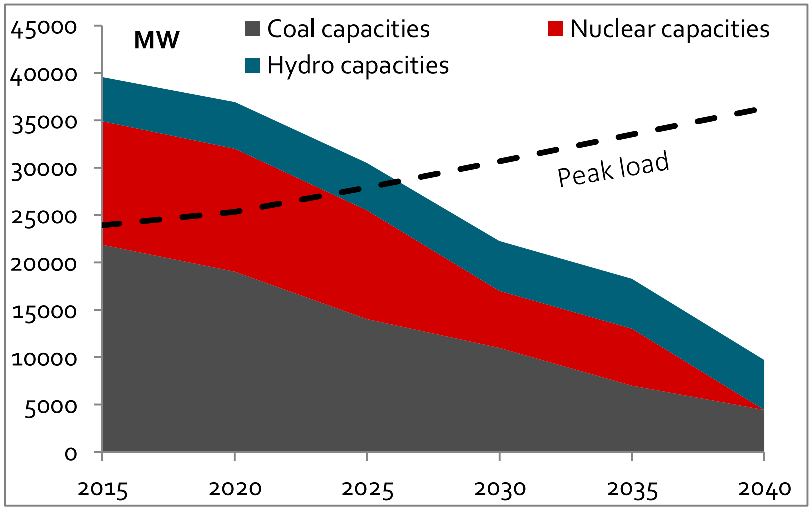
Curtailment of renewable power (ordered for increasing power load per hour)



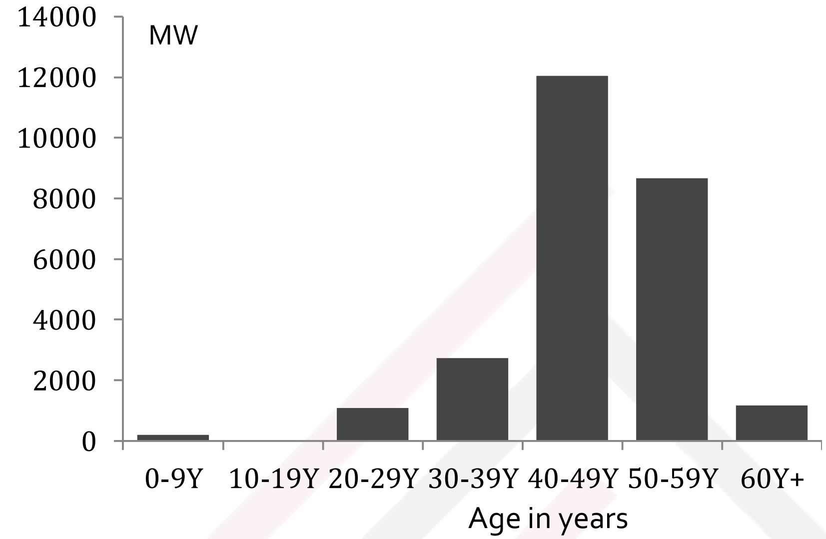
Low Carbon Ukraine

2. **Lack of power** in cases of high consumption and low feed-in

Forecasted nameplate capacity for Ukraine



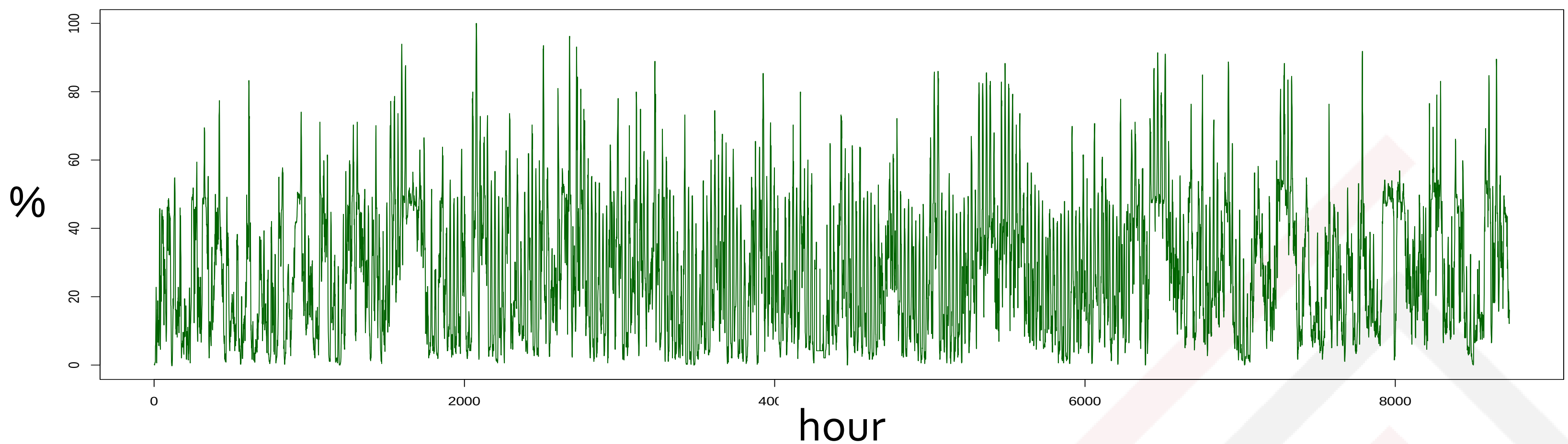
Structure of TPP's and CHP's capacity by age



- Lack of power no **short-term** issue: Excess capacities until ~2025
- Possible **medium- to long-term** issues:
  - Increase in consumption
  - Decrease in conventional power plant capacity

3. **Excessive fluctuations** that cannot be balanced sufficiently quickly

RES hour-to-hour load differences 2017, in %

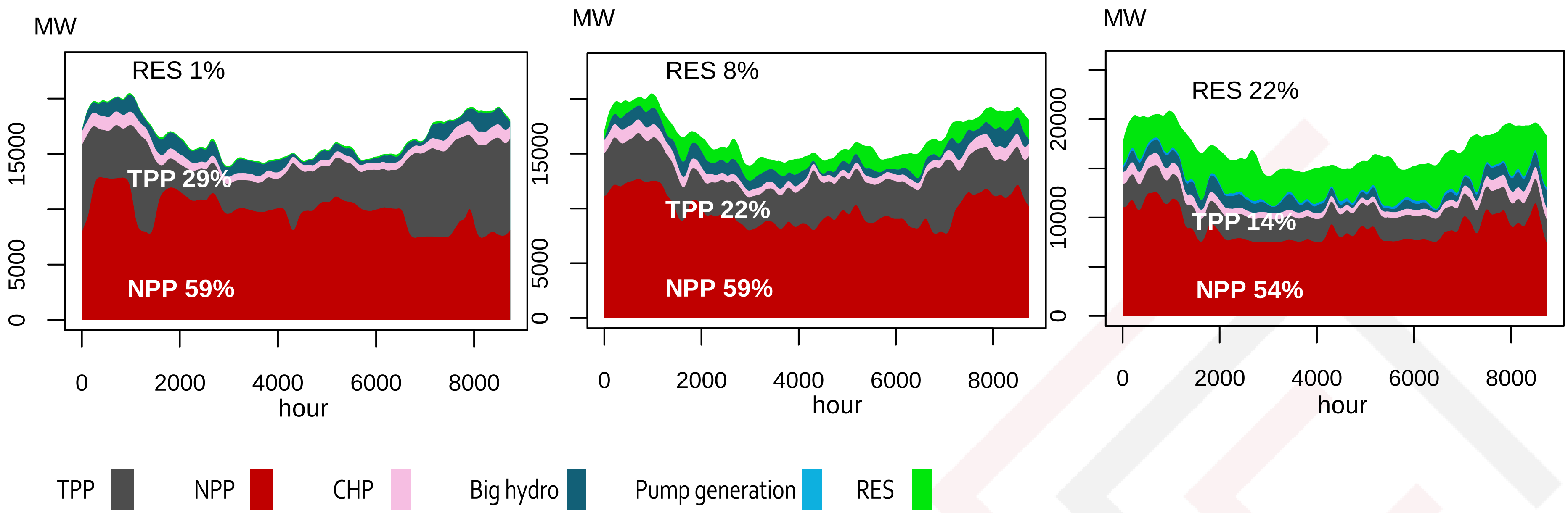


- Renewable power generation is fluctuating
- Reaction of conventional power plants on RES fluctuations is limited through technological and economic constraints:
  - NPP hour-to-hour differences (1% quantile): -130 / + 115 MW
  - TPP hour-to-hour differences (1% quantile): -960 / +760 MW

Low Carbon Ukraine

Model runs

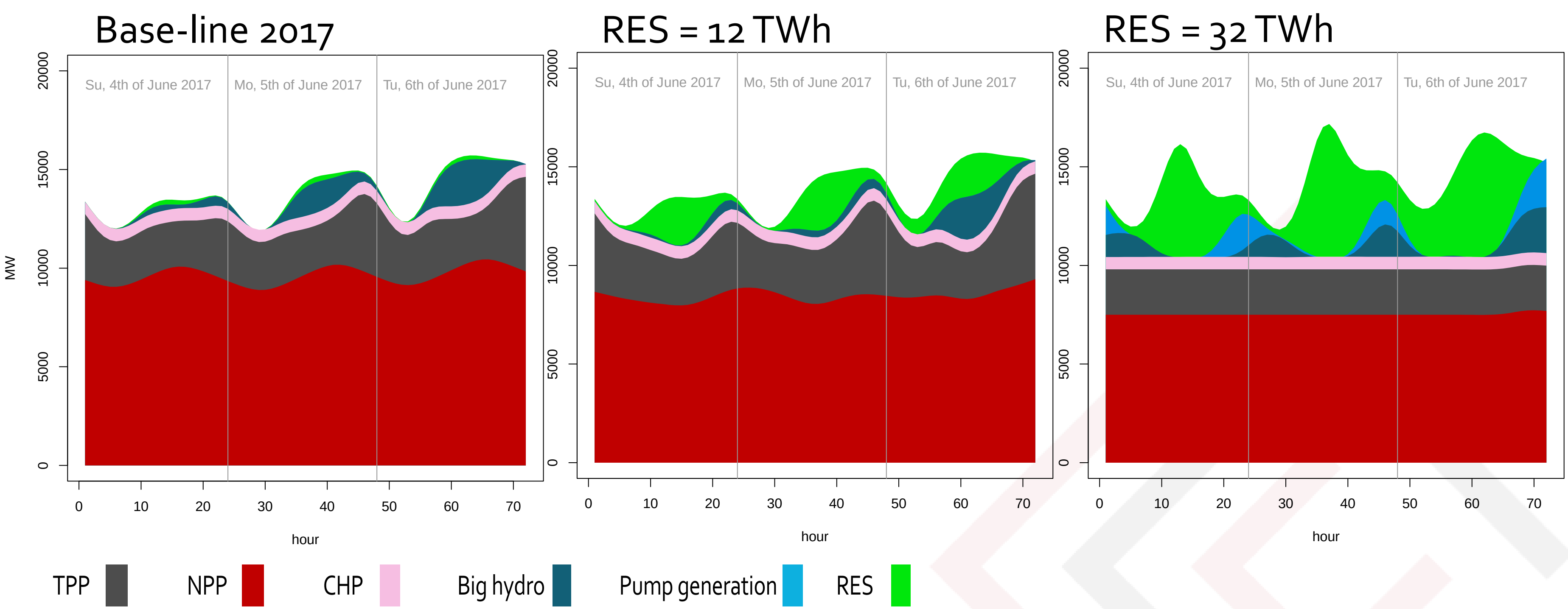
Base-line 2017 RES = 12 TWh RES = 32 TWh



- High shares of renewables can be balanced with the current power plant fleet
- Renewables replace thermal generation first
- Only at high RES shares also nuclear generation is replaced
- Significant curtailment only above RES share of 20 %

Low Carbon Ukraine

Model runs – 3 days (4-6 June 2017)



Increasing RES capacities lead to:

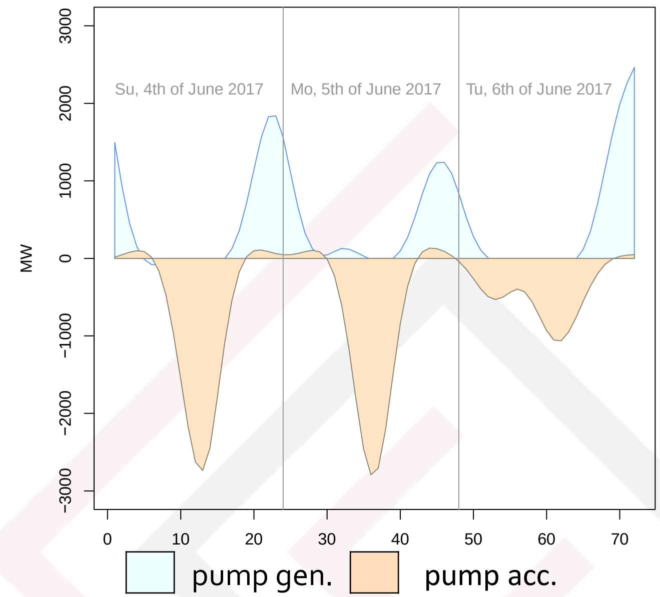
- Higher utilisation of pump storage
- Less volatile TPP and NPP generation
- Increasing volatility of RES

Model runs – pump utilisation 3 days (4-6 June 2017)

Utilisation of pump storage and pump generation in different scenarios

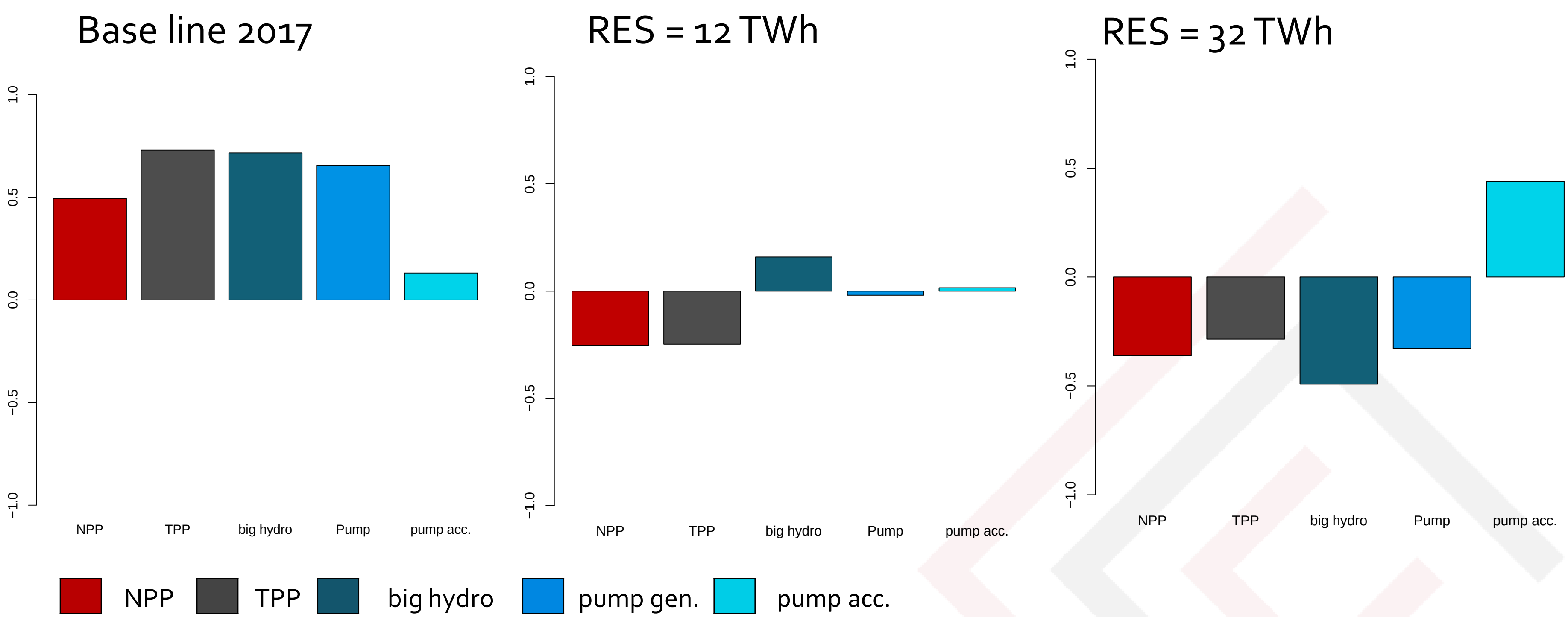
		Power load 2017	RES = 12 TWh	RES = 24 TWh	RES = 32 TWh
Power generation by RES	TWh	1.2	12	24	32
Power generation by pump	TWh	1.5	0.00	0.6	2.8

RES = 32 TWh



- Pump storage capacities in Ukraine amounted to approx. 1.3 GW (Mishra 2017), while power generation by pump reached approx. 1.5 TWh in 2017
- With an increasing penetration of renewable power sources, the utilisation of pump storage increases

Model runs – correlations various generations with RES



- Negative correlations indicate balancing of RES generation
- The original power load does not indicate such balancing
- Increase of RES shares increase the negative correlation with NPP, TPP, big hydro and pump, which indicates an economic efficient balancing

Optimisation

Objective

$$\min_{L_t^g} \sum_t \sum_g p^g L_t^g$$

- Minimisation of aggregated generation costs

L_t^g - Load of generation type g at time t

P^g - Marginal costs of generation type g

Constraint 1

$$s.t.\ C_t = \sum_g L_t^g$$

- Aggregated generation in t equals consumption

Boundary constraints for generation types

Independent variable	min load	max load	99% quantile hour-to-hour decrease	99% quantile hour-to-hour increase
NPP	7,500 MW	13,000 MW	130 MW	120 MW
TPP	2,300 MW	10,000 MW	960 MW	760 MW
Big hydro	0	380 – 1,000 GW cumulated per month depending on month 1,800 – 3,100 MW moving average of 24 hours depending on month	900 MW	860 MW
Pump generation	0	1,300 MW	-	-

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

Implemented by:

Berlin Economics

Project Leader
Dr. Georg Zachmann
zachmann@berlin-economics.com

Consultant
Dr. Frank Meissner
meissner@berlin-economics.com

Tel.: 030 2064 34 64 – 0