Low Carbon Ukraine

Policy advice on low-carbon policies for Ukraine

Policy Briefing #6

Supported by:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

based on a decision of the German Bundestag

A Scenario-based 2035 Forecast of Electricity Demand in Ukraine

Clemens Stiewe

Berlin, March 2019

Implemented by

Berlin Economics

Low Carbon Ukraine

Key Messages

1. A proper demand forecast is key to an efficiently designed future power plant park

2. Growth of total electricity demand in Ukraine is restrained by rising electricity prices and efficiency gains

3. Electricity demand is projected to increase substantially only in a scenario of strong economic growth

4. Under all scenarios of electricity demand growth, Ukraine will face overcapacities of thermal power plants by 2035

Why forecasting electricity demand is important

- Forecasting demand is crucial for the development of a country's electricity system
- **Underestimating** demand poses the risk of underdeveloping the power plant park, thus increasing the risk of not being able to cover peak loads
- **Overestimating** demand can result in expensive overcapacities and low utilisation/full load hours

How to set up the power plant park so that security of supply is guaranteed in every hour of the year?

→Make sure that **peak load** can be covered by flexible capacities

- With nuclear covering the base load in Ukraine, flexibility is provided almost entirely by thermal plants today

Low Carbon Ukraine

Even at peak demand, thermal plants are used far below capacity

- In 2018, Ukraine's total electricity consumption peaked on December 20 at 5PM with **23.7 GW** (2017: 23.2 GW)
- At the same time, thermal plants were close to their 2018 maximum hourly output of **10 GW** while having a total capacity of **25 GW** – a capacity factor at peak demand of only 42%
- The 2018 average capacity factor for thermal plants was even lower at only 25% – which is **ineffective** and **expensive**
- Moreover, less flexible capacity might be needed in the future: Measures such as **demand-side management** or increased **import** can reduce peak loads further

→ Against this background, the **development of demand** determines how much of Ukraine's thermal capacities will be really needed in the next 15 years

Low Carbon Ukraine

A model to forecast aggregated demand

- We adopt an intuitive, scenario-based method introduced by Hirschhausen & Andres (1999) to forecast aggregate electricity demand/consumption:

$$E_{2035} = \left[\left(\frac{GDP_{2035}}{GDP_{2018}}\right)^{\alpha} * \left(\frac{P_{2035}}{P_{2018}}\right)^{\beta} * (1-\gamma)^{2035-2018}\right] * E_{2018}$$

- Electricity consumption is stimulated by GDP growth but restrained by growing electricity prices and increased energy efficiency

- **α** and **β** determine the income and price elasticities of electricity consumption: To what extent is electricity demand affected by changes in GDP and electricity prices?

Low Carbon Ukraine

Executive summary of 2035 forecast results

Low growth scenario	Intermediate growth scenario	High growth scenario
Real GDP rises by 18%	Real GDP rises by 79%	Real GDP rises by 169%
Electricity prices rise by 9%	Electricity prices rise by 40%	Electricity prices rise by 79%
Energy efficiency increases by 18%	Energy efficiency increases by 18%	Energy efficiency increases by 18%
↓	↓	↓
Electricity consumption *decreases* by 10%	**Electricity consumption *increases* by 6%**	**Electricity consumption *increases* by 26%**

- How did we achieve these results?

→ For the macro model we employed, the selection of reasonable parameters and scenarios is key

Low Carbon Ukraine

GDP growth has a positive but small impact on power demand

Year	Electricity demand growth/Real GDP growth
1992	0.7
1993	0.6
1994	0.5
1995	0.4
1996	1.0
1997	1.3
1998	2.7
1999	12.9
2000	-0.3
2001	-0.1
2002	0.2
2003	0.5
2004	0.4
2005	0.7
2006	0.5
2007	0.4
2008	-0.2
2009	0.6
2010	32.3
2011	0.5
2012	-4.2
2013	.
2014	0.8
2015	0.7
2016	-0.2
2017	0.2
2018	0.7

Source: World Bank Data, IMF, Own calculations

- Income elasticity shows how electricity consumption reacts to real GDP growth
- Historically, Ukraine shows a low influence of real GDP growth on electricity demand
- Median of all **income elasticities** since 1992: **0.5**

→*„If real GDP grows by 1%, electricity demand grows by 0.5%*"

- As elasticities should always be treated with caution, we run sensitivity analyses with lower and higher values for α

Low Carbon Ukraine

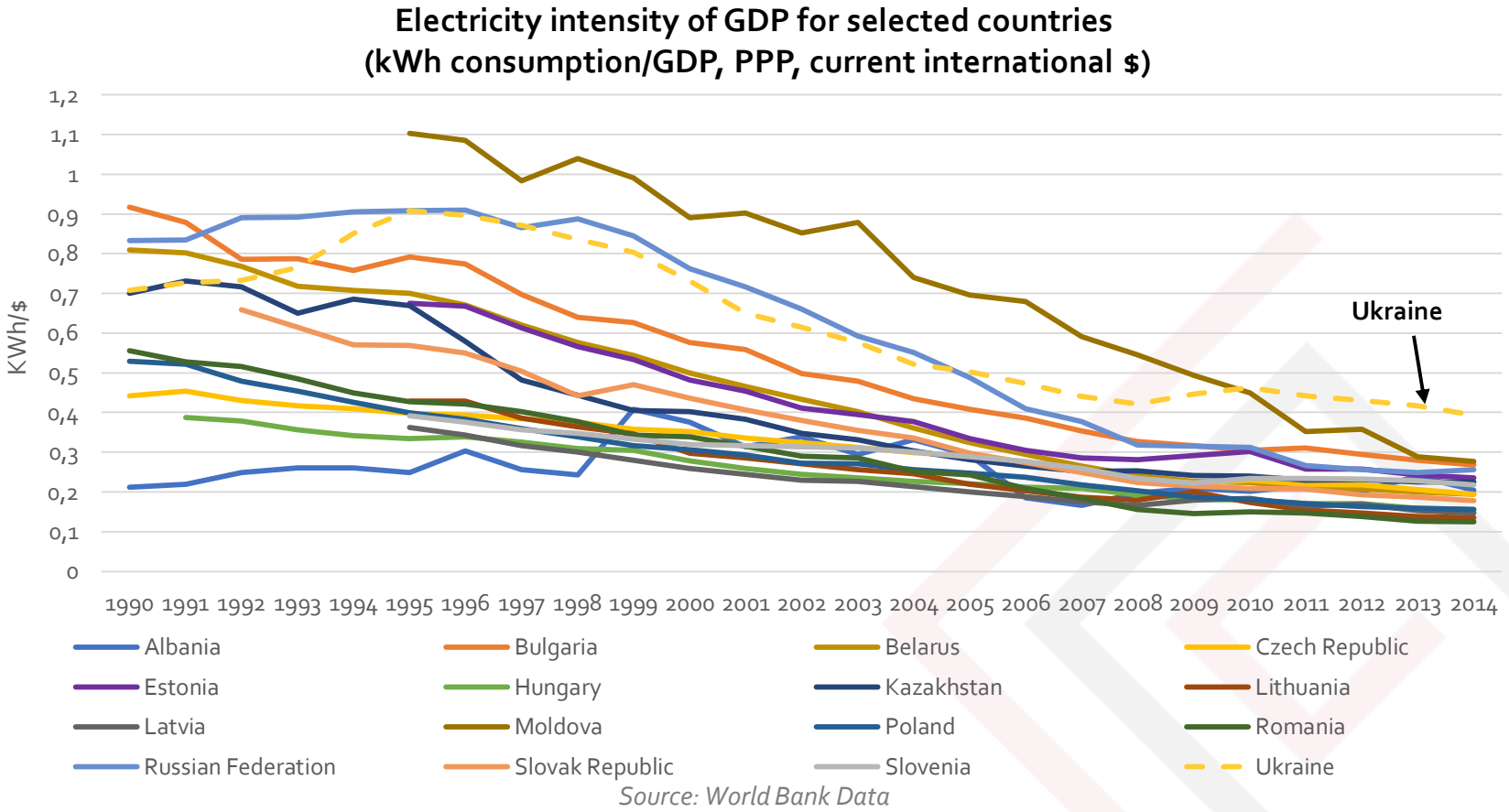
Rising prices negatively affect electricity consumption

- Price elasticity shows how electricity demand reacts to increases in real electricity prices
- Usually, this relation is **negative**: If electricity gets more expensive, people change consumption habits and consume relatively less
- Alberini et al. (2017) find short-run price elasticities for Ukrainian residential consumers of -0.2 to -0.5, with the bulk of estimates around **-0.3**
- Kozlova (2012) finds overall short-run price elasticities of around **-0.2** for Ukraine
- We opt for a price elasticity of **-0.2**, but run sensitivity analyses with lower and higher values for β

→*„If real electricity prices grow by 1%, electricity demand falls by 0.2%*"

Low Carbon Ukraine

Energy efficiency – Still a lot of room for improvement

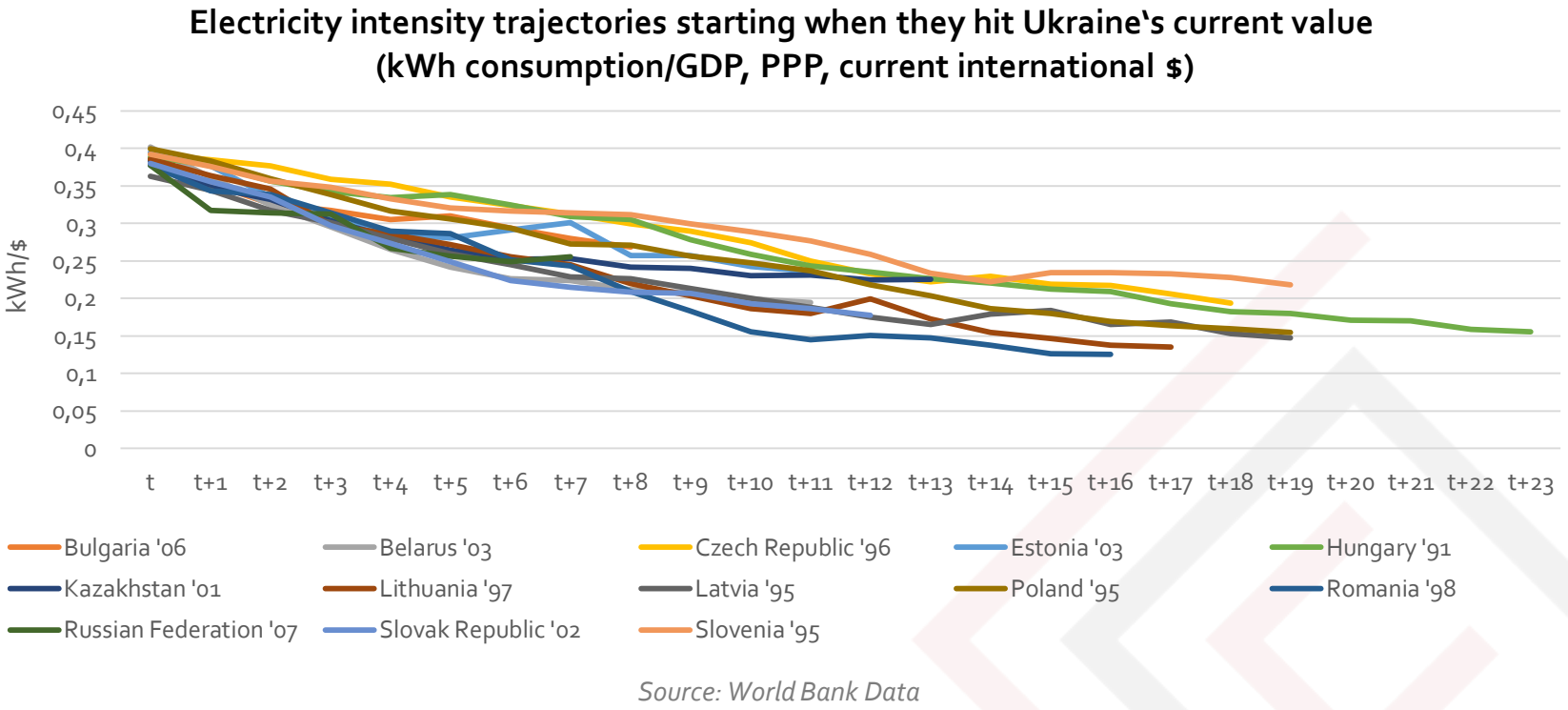


Source: World Bank Data

- Ukraine has a much higher ratio of electricity consumption to GDP than a number of selected countries

Low Carbon Ukraine

Energy efficiency – How other countries have developed

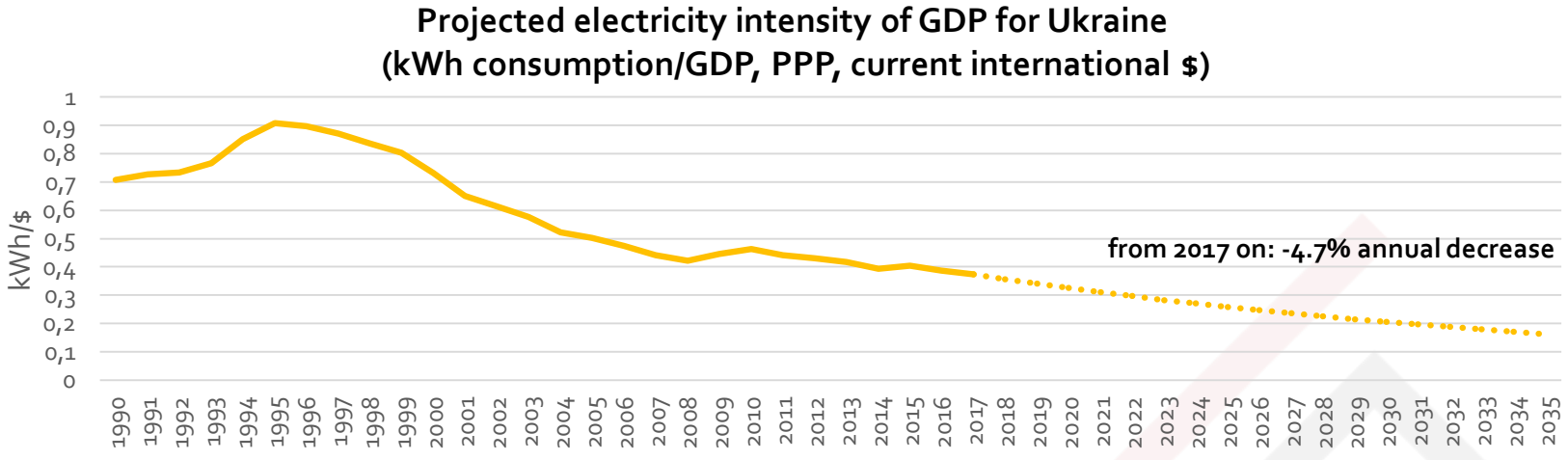


Source: World Bank Data

- Countries that once had a similar electricity intensity as Ukraine today (~0.38) have shown an average annual improvement of **4.7%**

Low Carbon Ukraine

Energy efficiency – A potential future path



Source: World Bank Data, own calculations

- With an annual improvement of 4.7%, Ukraine would be as electricity intensive by 2035 as most East European countries are today
- These improvements include price effects, structural economic shifts and technological efficiency gains, among others
- As price effects are covered separately, we choose a low value for the exogenous efficiency increase of **1%** per year for all scenarios

Low Carbon Ukraine

Scenarios for annual GDP and electricity price growth

Scenario	Real GDP	Real electricity prices
Low growth	**1%**	**0.5%**
Intermediate growth	**3.5%**	**2%**
High growth	**6%**	**3.5%**

- Prices linked to GDP growth: The higher economic growth, the easier to implement price increases and vice versa
- Intermediate/ reference scenario for **GDP** based on IMF forecast until 2023 (see Backup)
- **Electricity prices** need to increase in order to reach cost-recovering levels – the higher economic growth, the more prices move towards European levels

Low Carbon Ukraine

Detailed results and parameters of the aggregate model

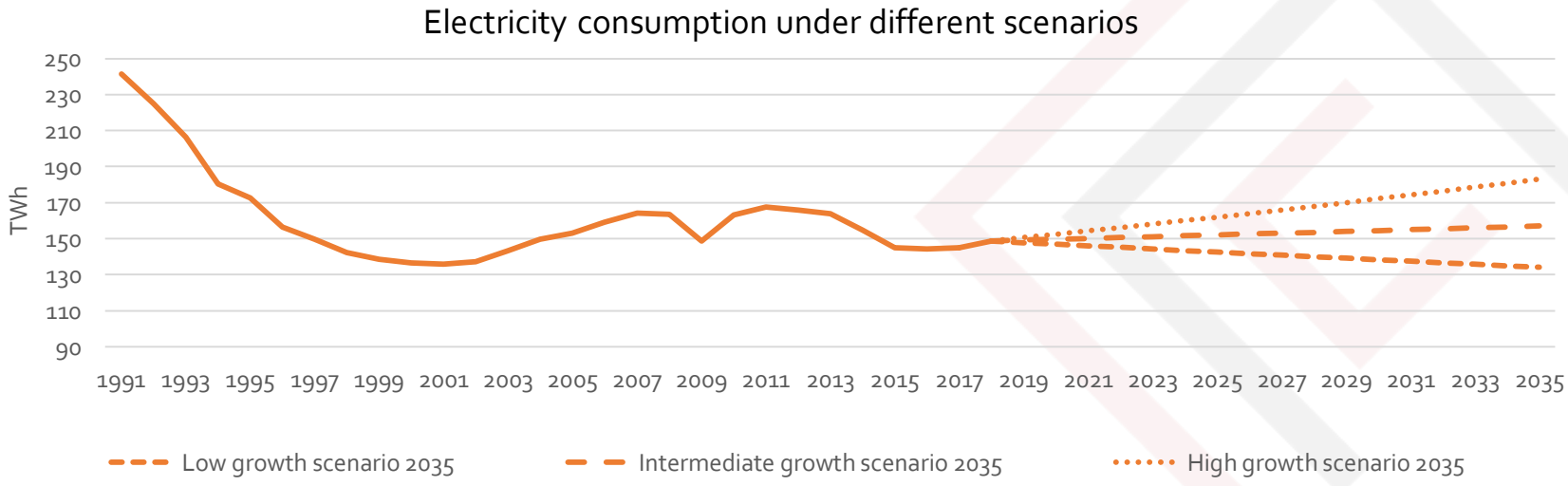
Categories	Unit	Low growth scenario 2035	Intermediate growth scenario 2035	High growth scenario 2035
Total electricity consumption (2018=100)	Total % change	**-10%**	**+6%**	**+23%**
	TWh	134	157	183
GDP (2018=100)	Total % change	**+18%**	**+79%**	**+169%**
	% growth p.a.	1.0%	3.5%	6.0%
Real electricity prices (2018=100)	Total % change	**+9%**	**+40%**	**+79%**
	% growth p.a.	0.5%	2.0%	3.5%
Energy efficiency increase	% growth p.a.	1%	1%	1%
Income elasticity		0.5	0.5	0.5
Price elasticity		-0.2	-0.2	-0.2

Source: Own calculations

Low Carbon Ukraine

Demand is unlikely to exceed 2011 levels in the next 10 years

- With real GDP growth of **3.5% p.a.** and electricity prices up **40% in total**, Ukraine's electricity consumption would only grow marginally until 2035
- Total electricity demand is projected to increase significantly only in the high growth scenario
- Results depend on assumption of prices rising slower than GDP: If price growth overtakes GDP growth, resulting electricity demand growth is significantly smaller or even negative



Source: Own calculations

Low Carbon Ukraine

Conclusion and outlook

- Only under a scenario of **high GDP and price growth**, total electricity demand would be significantly higher in 2035 (up ~23% in total)
- Even in this case, peak loads would not exceed 30 GW – in the intermediate scenario, peak loads of not more than **25 GW** are realistic
- Assuming that nuclear plants will continue to cover the base load, not more than **12 GW** of flexible plants will be necessary to cover peak loads – less than half of today's installed capacity
- This number could be further reduced if old coal plants are replaced with more flexible, gas-fired plants

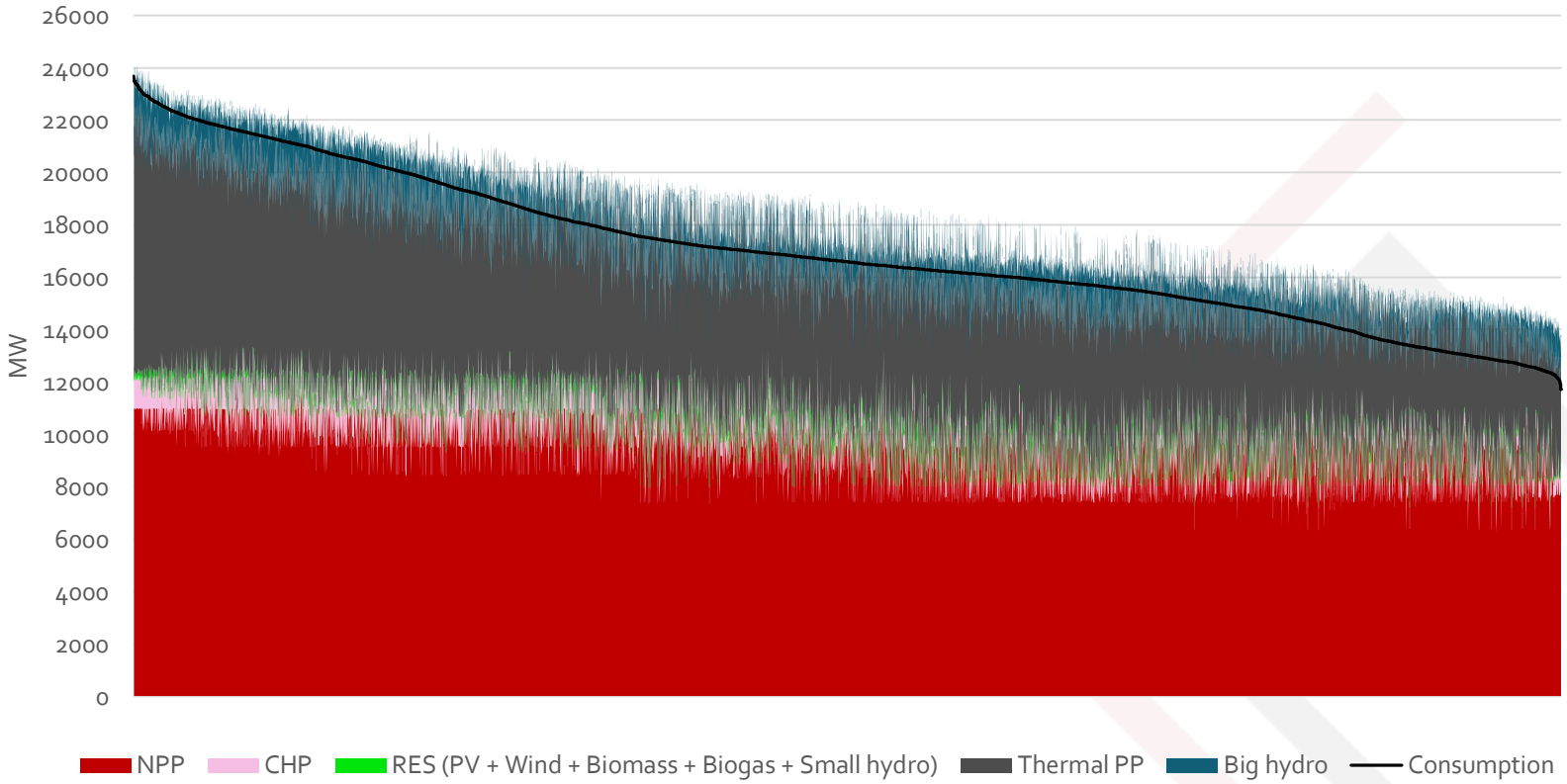
Low Carbon Ukraine

Backup

Low Carbon Ukraine

Backup – TPPs are constantly operating far below capacity

2018 hourly loads and generation ordered according to descending consumption, MW



Source: Ukrenergo

Low Carbon Ukraine

Backup – IMF forecast for real GDP growth in Ukraine

Year	2019	2020	2021	2022	2023
Real GDP growth (Annual percent change)	2.7	3	3.2	3.3	3.4

Source: IMF

Low Carbon Ukraine

Backup – Sensitivity Analysis I: Elasticities

Price elasticity	Income elasticity		
	0.3	**0.5**	**0.7**
-0.1	92	104	117
-0.2	88	100	113
-0.4	82	93	105

- Within the intermediate scenario, different **income** and **price elasticities** have a large effect on final electricity demand in 2035

Low Carbon Ukraine

Backup – Sensitivity Analysis II: Energy efficiency improvement

Low growth scenario	Intermediate growth scenario	High growth scenario
Real GDP rises by 18%	Real GDP rises by 79%	Real GDP rises by 169%
Electricity prices rise by 9%	Electricity prices rise by 40%	Electricity prices rise by 79%
Energy efficiency increases by **40%**	Energy efficiency increases by **40%**	Energy efficiency increases by **40%**
↓	↓	↓
Electricity consumption *decreases* by 24%	**Electricity consumption *decreases* by 11%**	**Electricity consumption *increases* by 4%**

- With an annual improvement in energy efficiency of **2%** instead of **1%**, electricity consumption only increases marginally in the high growth scenario