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Long-term Planning of UA IPS with Higher Shares of Variable Renewable Energy

South East Europe workshop on grid integration of variable renewable energy sources
7 November 2018, Vienna

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General Energy Planning Framework

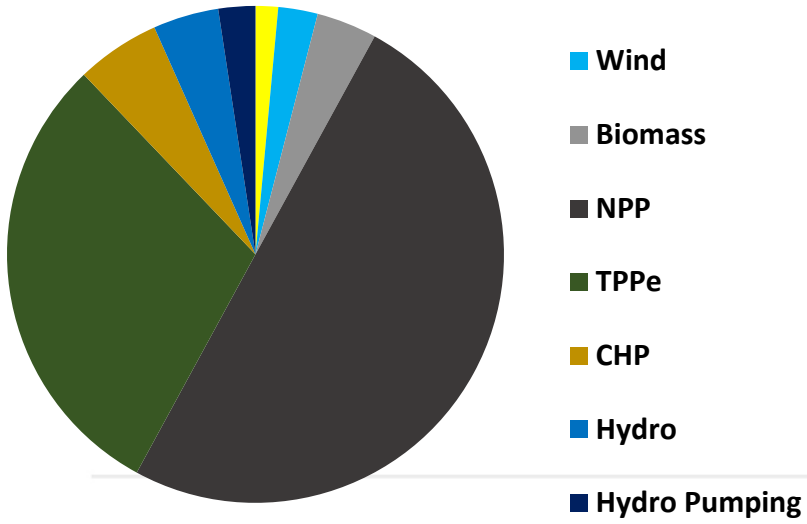
- The Law of Ukraine “On Electricity Market” (adopted on April 13, 2017) is aimed at implementing the Energy Community legislation (2009/72/EC and 2005/89/EC);

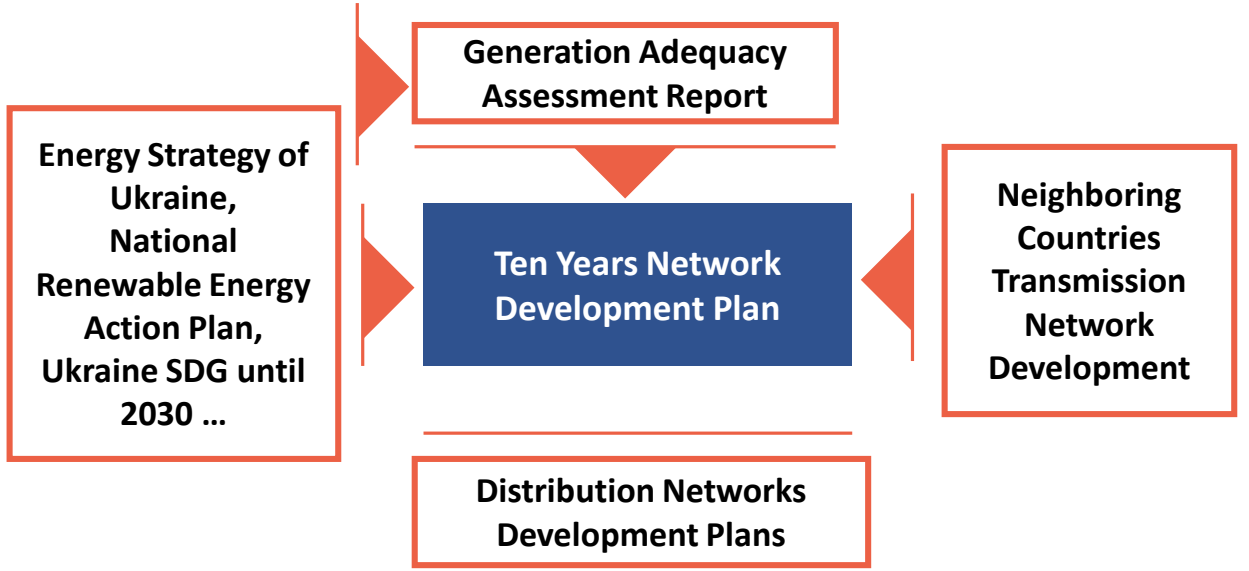
- Transmission Network Code (NEURC Resolution No309 of March 14, 2018) : describes the procedures of Generation Adequacy Assessment Report and TYNDP development;

- “Energy Strategy of Ukraine until 2035: Safety, Energy Efficiency, Competitiveness” (approved by the Cabinet of Ministers on 18 August, 2017):
2035 electricity production 195 TWh of which: nuclear power – 94 (48%), Wind&PV – 25 (13%), hydropower – 13 (7%) and the rest 63 (32%) by thermal power plants;

- National Renewable Energy Action Plan through 2020 (State Agency for Energy Efficiency and Energy Saving of Ukraine)

Electricity Production 2027, TWh (Generation Adequacy Assessment – 2017 (Project)





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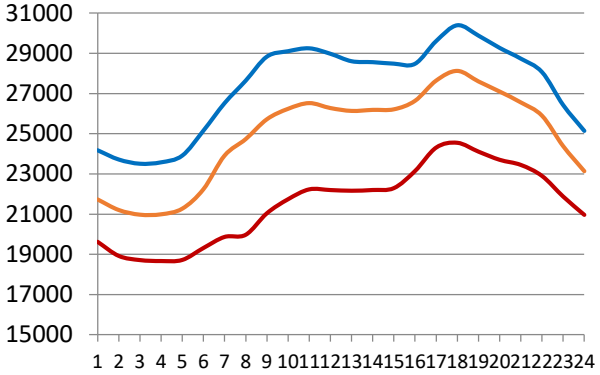
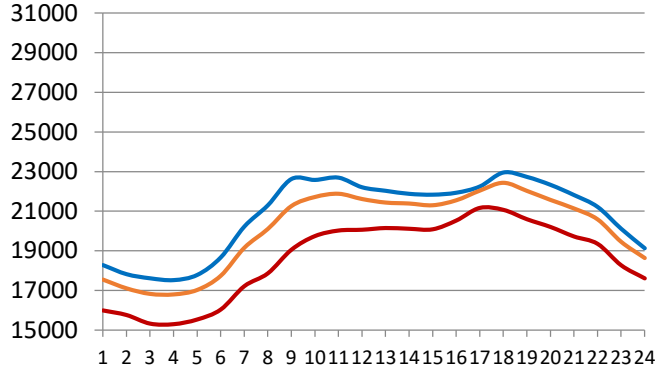
Power Sector Planning

Power Demand Forecast:

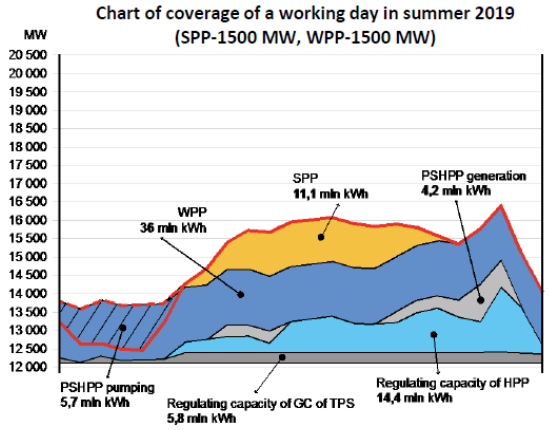
1) Electricity consumption by sectors
2) Typical sectoral load profiles
3) Minimum, Maximum and Typical loads for each month (season)
4) Load Forecast

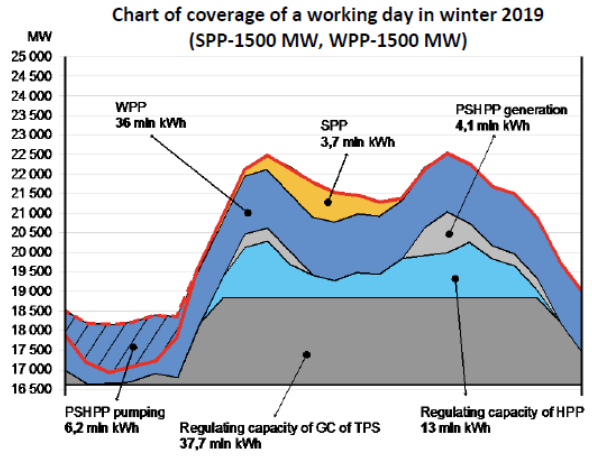


January, 2010



January, 2017





Consumption, GWh	2017	2022	2023	2024	2025	2026	2027
Industry and construction	51350	53152	53873	54739	55798	57016	58434
Agriculture	3650	4020	4165	4328	4503	4692	4894
Transport	7100	7497	7647	7800	7956	8115	8277
Municipal (district heating, services)	15400	16528	16842	17179	17540	17926	18338
Other non-industrial consumption	6100	6255	6333	6422	6522	6632	6755
Households	36200	38163	38831	39588	40439	41390	42445
Net Consumption	**119800**	**125615**	**127691**	**130056**	**132758**	**135771**	**139143**
Export	6200	7000	7000	7000	7000	7000	7000
Hydro Pumped Storage	2250	4717	5161	5606	6111	6111	6111
Transmission losses	4000	4330	4400	4410	4420	4430	4450
Distribution losses	13500	14499	14771	14797	14970	15119	15305
Power plants own needs	11700	12625	12751.25	12878.763	13007.55	13137.626	13269.002
Total consumption	**157450**	**168786**	**171774**	**174747**	**178266**	**181568**	**185278**

Generation Capacity Investment Scenarios:

- **National Emission Reduction Plan from Large Combustion Plants**
- **Hydro Power Development**
- **NPP life extension**
- **CHP modernization**

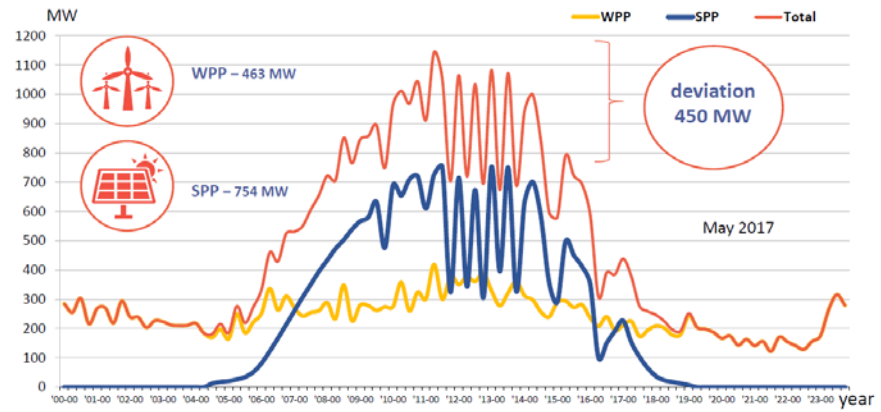
Future Generation Dispatch Scenarios:

- **Basic approach is assessment of generation adequacy for typical days: Winter maximum, Summer minimum, Flooding season**
- **N-1 criterion is defined by most powerful NPP unit – 1 GW**
- **Most important specific factors: low level of loads, high share of NPP, narrow range of capacity changes at TPP**

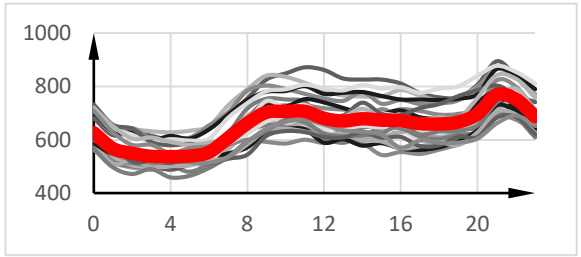
Representation of Renewables in Generation Capacity Expansion Planning Tools

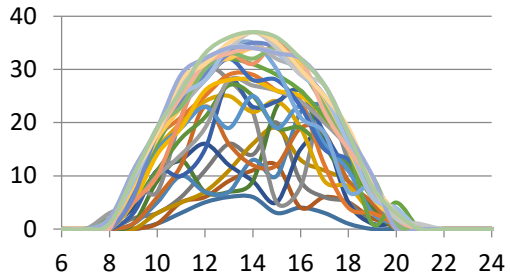
Renewable Energy capacities development are represented as exogenous variables according to **“Energy Strategy of Ukraine until 2035: Safety, Energy Efficiency, Competitiveness”** and **“National Renewable Energy Action Plan through 2020”**

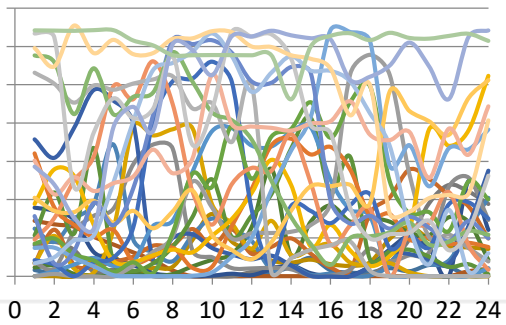
Challenge 1 – poor prediction of Wind and PV generation



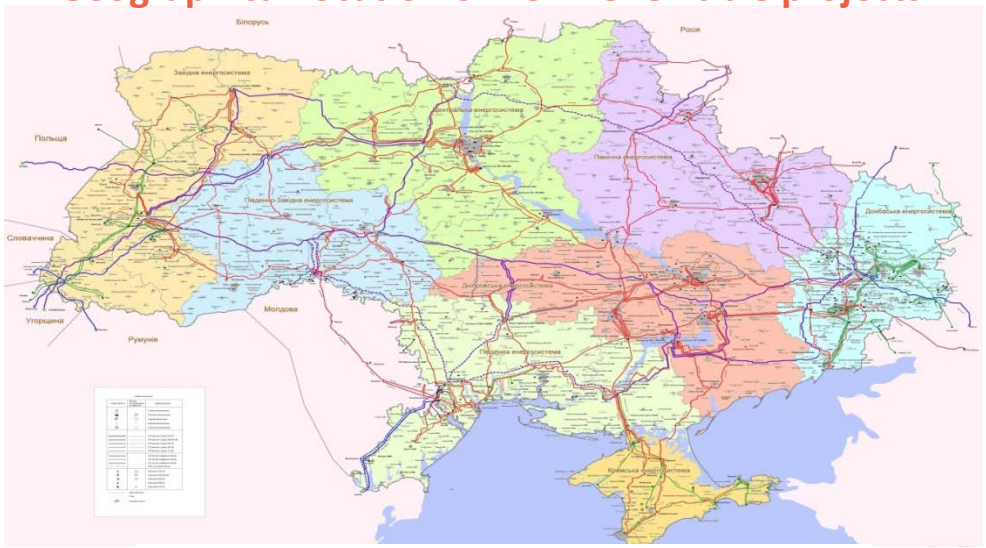
The normative amount of reserves in the IPS of Ukraine must be equal to 650 MW. The target fluctuations of RES generation in the amount of up to 450 MW must be taken into account when drafting a daily chart.







Challenge 2 – Geographical location of new renewable projects

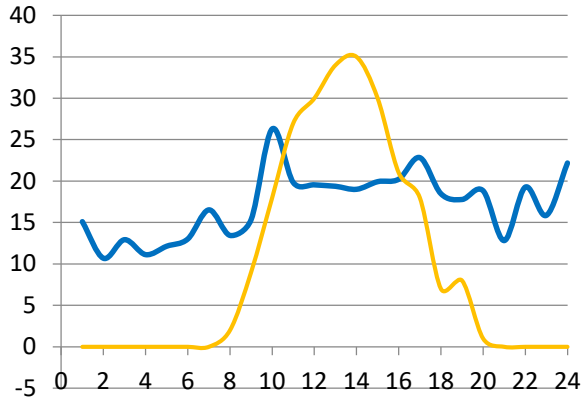


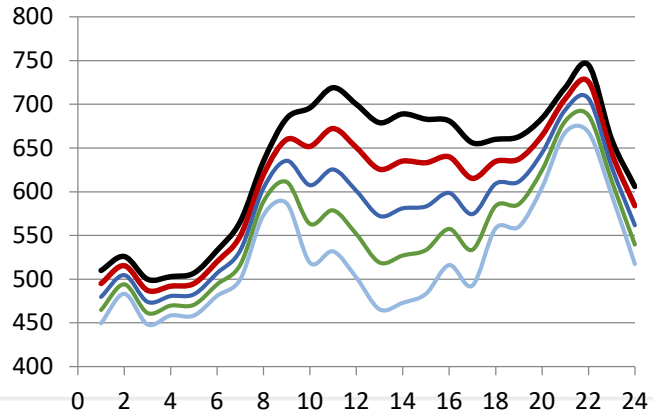
Generation scheduling with high share of variable renewable energy (Burshtyn TPP Island Case)

Burshtyn TPP Island – "Isolated" sub-power system within IPS of Ukraine: population – **3 million**, square – **27000 square km**, maximum export capacity <= **650 MW**, daily consumption - Winter Max **– 1050 - 1150 MW;** Summer Min **– 450 – 500 MW**

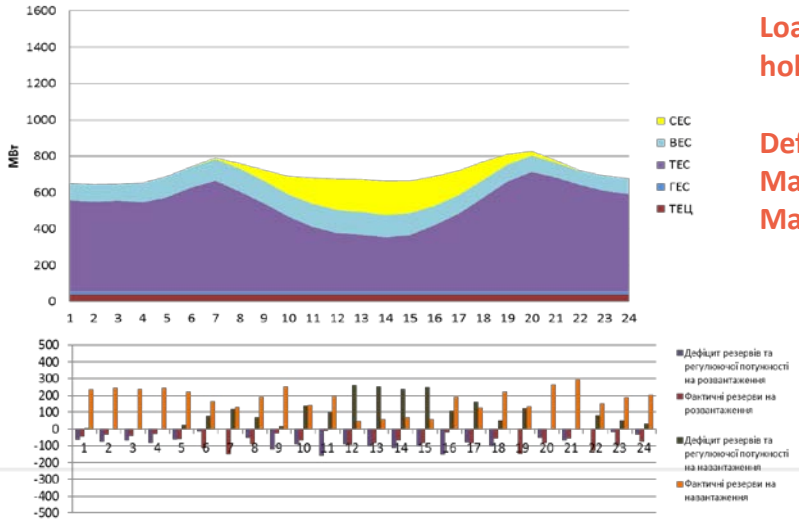
Load profile transformation for Burshtyn TPP Island (actual data for 30 April, 2018)

Hours	10	11	12	13	14	15	16	17
Consumption, MW	696	719	700	679	689	683	681	656
Wind (33.9MW)	26	20	20	19	19	20	20	23
PV (39.8MW)	18	27	30	34	35	30	21	18
Consumption-Wind-PV Wind (33.9), PV(39.8)	**652**	**672**	**650**	**626**	**635**	**633**	**640**	**615**
Consumption-Wind-PV Wind (67.8), PV(79.6)	**607**	**625**	**601**	**572**	**581**	**583**	**599**	**574**
Consumption-Wind-PV Wind (101.7), PV(119.4)	**563**	**579**	**551**	**519**	**527**	**533**	**557**	**534**
Consumption-Wind-PV Wind (135.6), PV(159.2)	**519**	**532**	**502**	**466**	**473**	**483**	**516**	**493**





	2018 April		2022 (forecast)	
Generating capacity	**MW**	**%**	**MW**	**%**
Burshtynska TPP	2351	87.17	2351	73.49
Kalush TPP	200	7.42	200	6.25
Tereble-rykska HPP	27	1	27	0.84
Drogobych CHP	17	0.63	17	0.53
Renewables, including:	102.05	3.78	604.04	18.88
- PV	50.76	1.88	236.07	7.38
- Wind	34.50	1.28	275.80	8.62
- Small Hydro	13.62	0.5	82.00	2.56
- Biomass	3.17	0.12	10.17	0.32



Load for 2022, Summer holiday, no export

Deficit of reserves:
Max ramp-up – 260 MW
Max ramp-down – 150 MW

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Tools Used and Network analysis

- **Power flow analysis – Graph Scanner (Ukrainian), Digsilent PowerFactory**

Power Flow Analysis Tools were intensively used for Chernobyl PV Project with Installed capacity – 1200 MW

- Generation Adequacy Assessments (deterministic modelling) - various simulation modelling (MS-Excel), multi-stage dynamic optimization modelling (GLPK solver), one-day optimization (MS-Excel+OpenSolver), multi-day optimization (MS-Excel+VBA+OpenSolver) is tested

- Generation Adequacy Assessments (stochastic modelling under development, tasting phase) - one-day optimization (MS-Excel+VBA+OpenSolver), seasonal multi-day optimization (MS-Excel+VBA+OpenSolver)

Ukrainian Legislation regarding Renewables regulation is still under development:

- 2019 – expected adoption of “Renewable Auctions” low

- Regulation for new generating capacities implementation is under consideration

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THANK YOU!

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