Hybrid energy power system based on NPP with hydrogen production and the use of storage batteries

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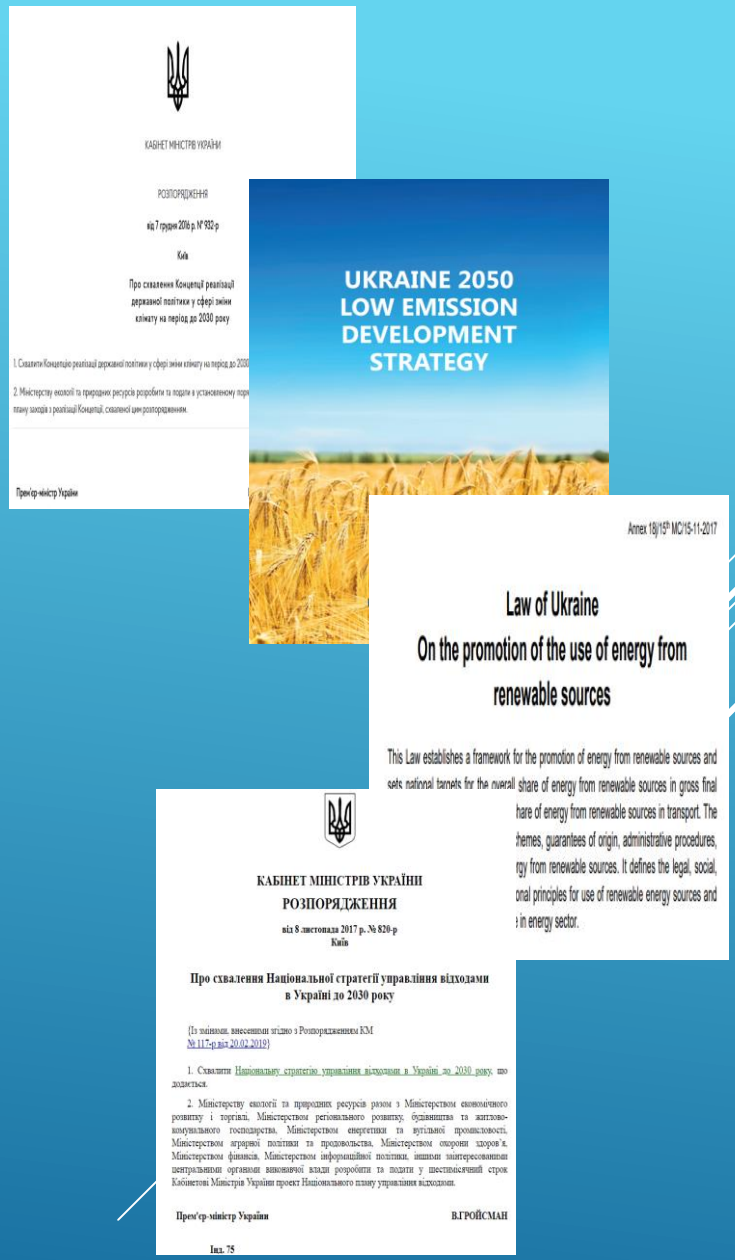
III МІЖНАРОДНИЙ КРУГЛИЙ СТІЛ
ПЕРСПЕКТИВИ ВПРОВАДЖЕННЯ ІННОВАЦІЙ У АТОМНУ ЕНЕРГЕТИКУ

UKRAINE RESPONSIBILITY ON PARIS AGREEMENTS 2015

- UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (1992) – Law 435|96-BP of 29.10.1996
- National Cadastre of Anthropogenic Emission 1990 – 2015
- Kyoto Protocol 2008 – 2012, Law 1430-15 of 04/02/2004. In 1990 – 2012 the total CO2 emission decreased on 60%
- Strategy Assessment Protocol of Convention on Environmental Impact in Transboundary Context – Law 562-VIII 01.07.2015. The environmental impact assessment take to account as part of strategic plans, government directions and National Law forming
- 22.04.2016 - **Paris Climate Agreement 2015.** Ratification – Law 13.07.2017 0105
- 07.12.2016 - Conception of national policy of Climate Change Mitigation is approved by Cabinet of Ministry of Ukraine
- 12 January 2015, the President approved the Strategy for Sustainable Development "Ukraine 2020". The main goal is to achieve European standards and help Ukraine earn its rightful place in the world.



UKRAINE'S ENERGY SECTOR UNTIL 2035

- Ukraine was one of the first countries to join the Paris Agreement. The National Emissions Reduction Plan endorsed by the Government of Ukraine in November 2017, became an important practical measure pursuant to the Paris Agreement, and a step forward in adopting European environmental standards, as it gradually and significantly reduces CO2 emissions from power plants.
- For Ukraine the reducing energy use in 2006-2016 is -36% rate. However, this has occurred because of dramatic drop in GDP rather than increased energy efficiency measures.
- The share of low carbon energy in Ukraine is 53% vs 38.6% globally

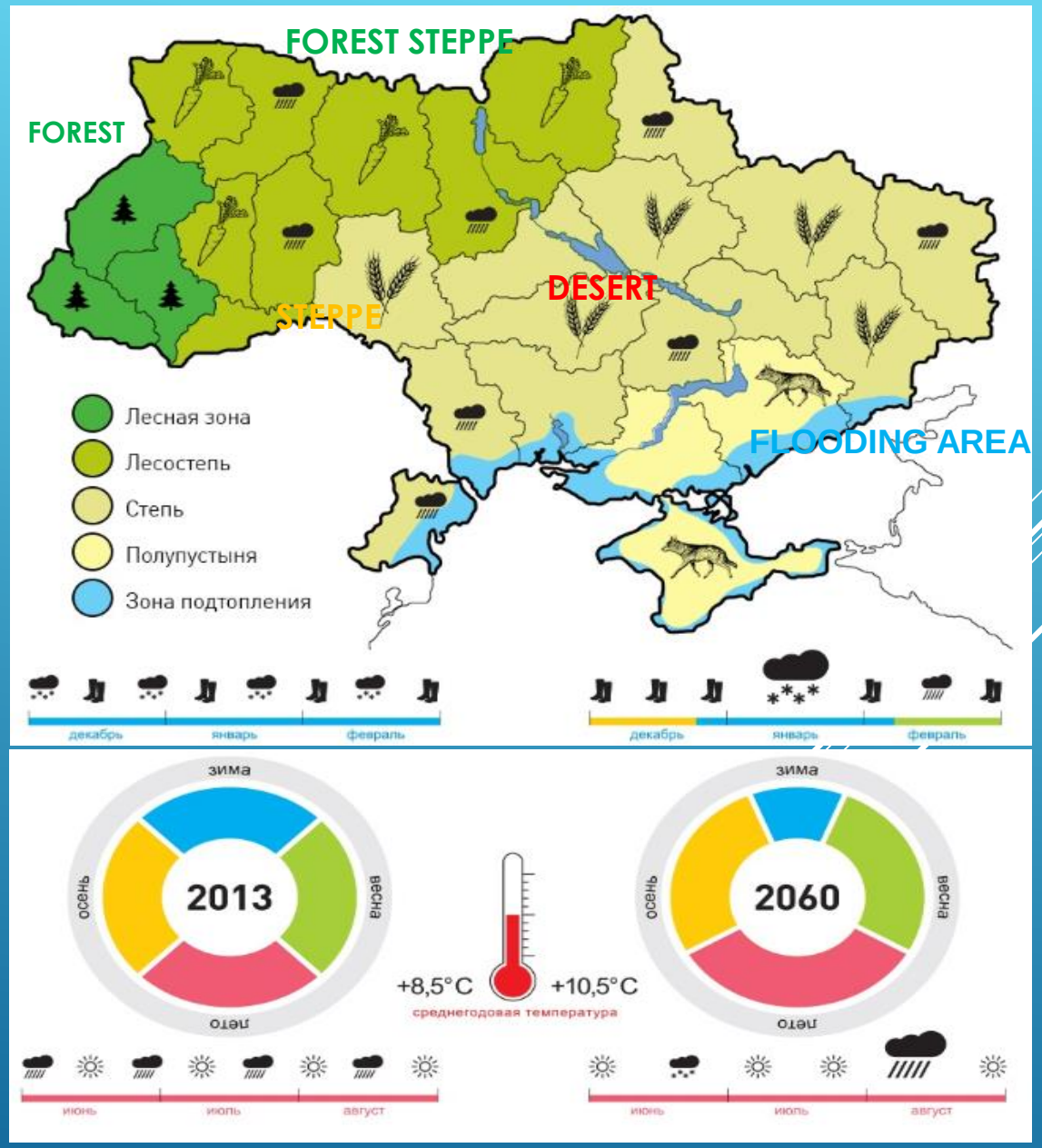
Energy Strategy of Ukraine until 2035 (ESU-2035) represents such a systemic document.
Key objectives of the government's energy policy until 2035 include:

- developing conscious and energy efficient society;
- ensuring Ukraine's energy independence with reliable and stable functioning of its fuel and energy complex;
- developing energy markets;
- creating favourable conditions for investment;
- integrating Ukraine's power grids and energy markets in the EU;
- updating management system in line with the present day challenges and global energy trends.

Globally Ukraine has a plan for decreasing of CO2 emission up to 60% to 2030 vs 1990

DECARBONISATION OF ENERGY SYSTEM

- In Ukraine, the effects of climate change can be felt in the growing number of heavy rainfalls and in increasing quantity, range and duration of seasonal temperature anomalies, which have already caused decline in the productivity of farmlands and forests. According to the Ukrainian Hydrometeorological Institute forecasts for the period of 2011-2030, the highest rate of warming in summer should be expected in north-eastern Ukraine. Over the next 20 years, the maximum summer warming will occur in southern regions.
- According to prognosis the annual average temperature groves 8,5 to 10,5 to 2060.



http://techno.bigmir.net/discovery/1541187-Kak-izmenitsja-klimat-v-Ukraine-cherez-50-let--INFOGRAFIKA

PROVISIONS OF ENERGY STRATEGY TO 2035

RENEWABLE ENERGY

Ukraine's renewable energy sector is set to play a decisive role in implementing the ESU-2035. Above all, this concerns decarbonisation of the energy sector and reduction of the country's dependence on fuel imports

Despite the enormous potential of renewable sources estimated at 68 mtoe, Ukraine currently uses it at 5%. According to the Energy Strategy (and in line with the Energy Community Treaty, and the National Renewable Energy Action Plan until 2020), the share of renewables in final energy consumption should reach 11%.

It is clear, however, that this task was politically motivated with no prior assessment of realistic investment opportunities. In other words, Ukraine is unlikely to reach this target

The main disadvantages of solar technologies are:

- They do not generate power at night or in cloudy weather.
- Solar panels lose up to 1.5% of their initial capacity each year due to the ageing of silicon.
- the wide web of electricity grids is required

The main disadvantages of small hydro are:

- Small hydropower will be only of local significance with little effect on the demand for commercial capacities in general
- Additional installed capacity in 2030 is 180 MW (for Ukraine)
- Impact on environment

CONTRIBUTION OF UKRAINIAN NPPs TO MITIGATION OF CLIMATE CHANGES

For the time of operation of Ukrainian NPPs, the total volume of **prevented CO_2 emissions** has made up **3,25 billion metric tons**. If Ukraine had not operated NPPs at all, the annual volume of CO_2 emissions released into the environment would have increased by 117 million metric tons.

Since 1990 Ukraine has generally halved CO_2 emissions.

Energoatom is actively involved in communications with the public regarding the impact of Ukrainian NPPs to the climate and holds consultations with the environmental experts and representatives of the environmental organizations.

DECARBONISATION OF ENERGY SYSTEM

- Intention to create a decarbonized energy system considers extensive RES deployment in order to reduce CO2 emissions. It means there will be a rearrangement of electricity generation sources (first of all for those based on fossil fuel) considering strict requirements to the environmental impact minimization.
- In the long term nuclear can meet the increasing demand in electricity since it has some significant benefits:
  - Huge source of electricity production;
  - Small territory required for NPP site;
  - Available infrastructure involvement;
  - Load follow operation to back up RES
- ***It means further development of energy system should be considered through tight connection nuclear and RES deployment***.
- The importance of nuclear power in the context of climate changes and achievement of climatic goals under the Paris Climate Agreement are also mentioned in the Strategy of low-carbon development of Ukraine for the period until 2050 that refers to further development of nuclear energy along with RES.

ENERGOATOM CASE STUDY

Simulation of future Ukraine's energy system using MESSAGE code

- Main objectives

- **Comparison of long term nuclear deployment scenarios**

- The following scenarios were considered:
  - The construction cost of LWR – 4700 USD/kW and 5900 USD/kW
  - Carbon prices – 0; 5 and 50 USD/t
  - Externalities
- Calculations were made at 10% discount rate that is usually applied for developing countries

ENERGOATOM CASE STUDY

Simulation of future Ukraine's energy system using MESSAGE code

	WPP	Solar	Coal	Nuclear
Capacity, MW	10	1	300	1200
Overnight cost, USD/kW	900	1500	2300	4700 – 5900
Thermal efficiency			35	33
Fixed cost, USD/kW	39,7	23,4	50,9	100.28
Variable cost, USD/kWh	-	-	5,00	2.3
Plant factor	0,25	0,15	0,85	0,92
Lifetime, years	25	15	40	60
Construction period, years	1	1	4	50

1. Capital cost estimates for utility Scale Electricity Generating Plants. EIA. November 2016
2. Projected cost of Electricity. OECD. 2015
3. INPRO Assessment of the Planned Nuclear Energy System of Belarus. IAEA-TECDOC-1716. IAEA, 2013
4. Nuclear New Build: Insights into Financing and Project Management. OECD. NEA No. 7195. 2015

CO2 emission [Projected cost of electricity. 2005. P.39]
0.9 t/ MWh coal
0.33 t/ MWh gas

ENERGOATOM CASE STUDY

Simulation of future Ukraine's energy system using MESSAGE code

Externality values for various electricity generation sources (cents/kWh)

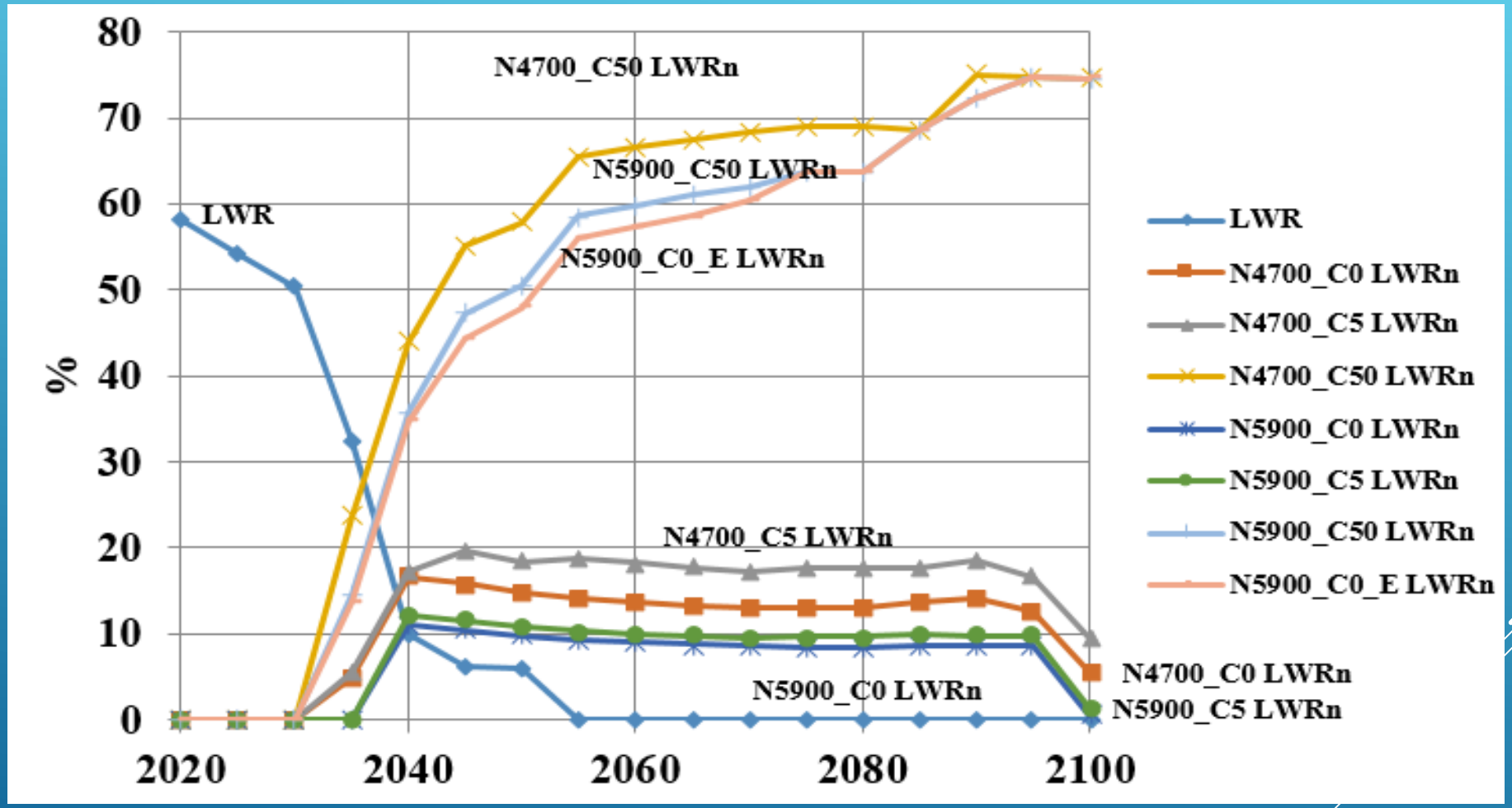
Value	Coal	Oil	Gas	NPP	Hydro	Wind	Solar	Biomass
Min	3,0	4	0,49	0,2	0,03	0,001	0,25	0,08
Max	9,5	9	3	1,5	1	0,25	0,6	3,5
Applied in calculations	5,4	5,9	1,7	0,6	0,4	0,1	0,5	1,3

source: environmental externalities from electric power generation. the case of rcreee member states. 2013 – 9 p. rcreee

Externalities include indirect costs of electricity production that impact climate, environment, human health, agriculture and so on. In other words externalities comprise total side effect from electricity generation by various technologies no matter what technical parameters they have.

ENERGOATOM CASE STUDY

Simulation of future Ukraine's energy system using MESSAGE code



Calculation Results

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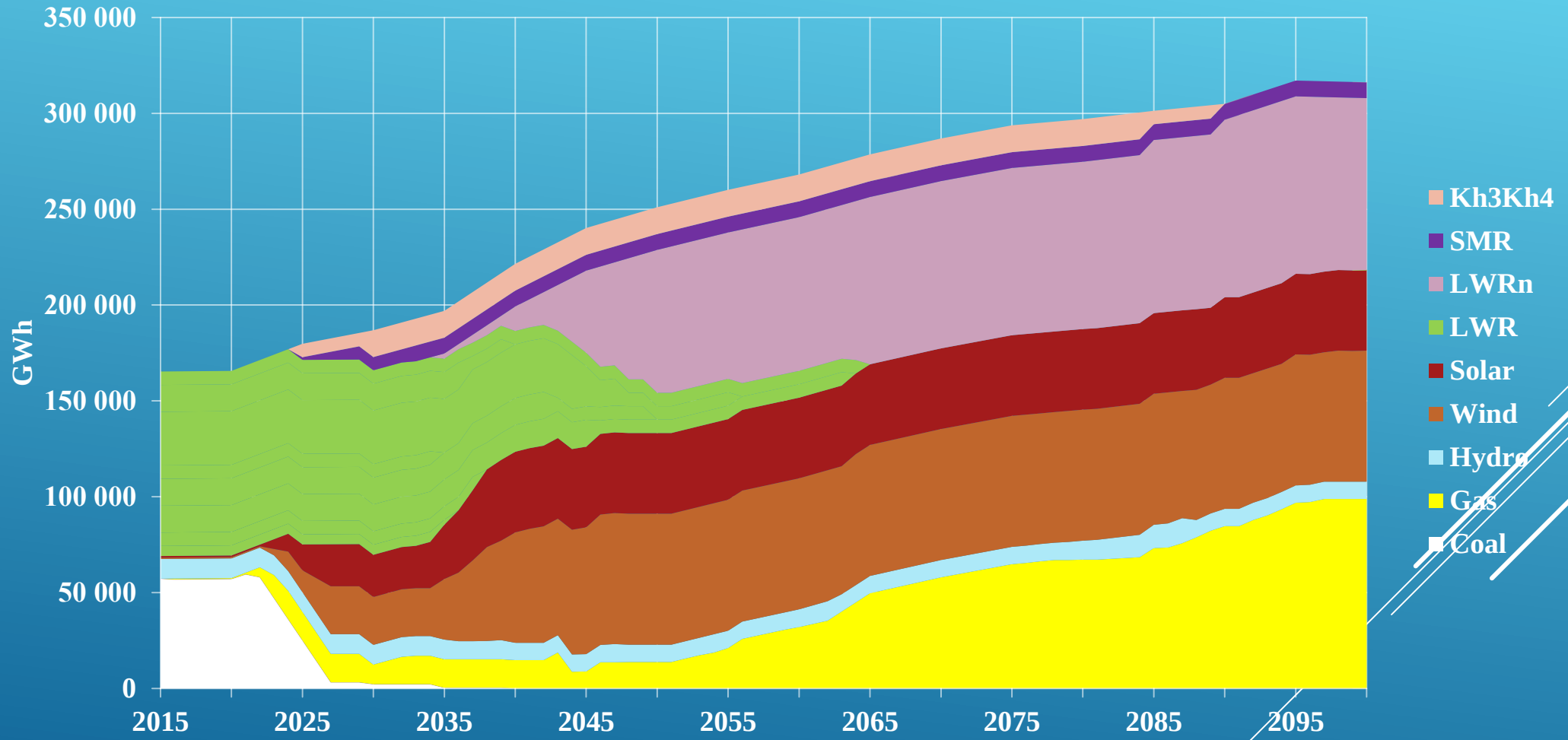
Scenarios for optimal power mix criteria of CO2 reduction



NPP – 5500 kW, Gas – 300 $/1000m3, CO2 – 50 $/t

ENERGOATOM CASE STUDY

CONCLUSIONS

- The low CO2 taxes not influence on energy mix in Ukraine. The additional economical factors need to consider for preferable deployment of nuclear (same for previous scenario with Externalities)

- For perspective deployment of nuclear the high capital cost of conventional gas generation is needed and the increasing of gas price up to 300 $/1000m3. This scenario is possible at middle term based on increasing of gas consumption in the world

- The 5500 $/kW can be considered as optimal overnight cost for nuclear in Ukraine

ENERGOATOM CASE STUDY

CONCLUSIONS

- The main predictive research algorithm is using of modeling energy system tools for making informed decisions. The approaches adopted in practice for the comparative assessment of various types of generation only by comparison of the LCOE often do not allow substantiating the promising role of nuclear power plants in the production of electricity
- It is necessary to formalize the approach of realizing of predictive comparative assessment of various types of generation in order to take into account the following factors:
  - a. The concomitant impact of generation on the environment, humans (Externality)
  - b. Reservation of capacities of Solar and Wind
  - c. Battery decommissioning
  - d. Seasonal and daily efficiencies of Solar and Wind, decrease in efficiency of SES depending on the operating life (at least 1% / year)
  - e. Land exception for Solar and Wind


Thank a lot for attention!