Carbon Avoided Costs: Approach & Examples

Andrey Khorshev

The Energy Research Institute of the Russian Academy of Sciences

Virtual Regional Training Course on Energy Technology Assessments for Energy & Climate Strategies

IAEA, 15 – 26 March 2021

LCOE or CAC

Type of economy	Main question asked by decision makers	Possible preliminary metric
Conventional industrial economy	**What are the cheapest ways to supply needed demand for electricity?**	LCOE
Modern decarbonizing economy	**What are the cheapest ways to cut CO_2 emissions supplying needed demand for electricity?**	**Carbon avoided costs**

Methodology

Carbon avoided costs calculations are used to:

-rank low or non-carbon technologies by per ton cost of avoided CO_2

-estimate needed level of carbon price/tax to support low or non-carbon technologies

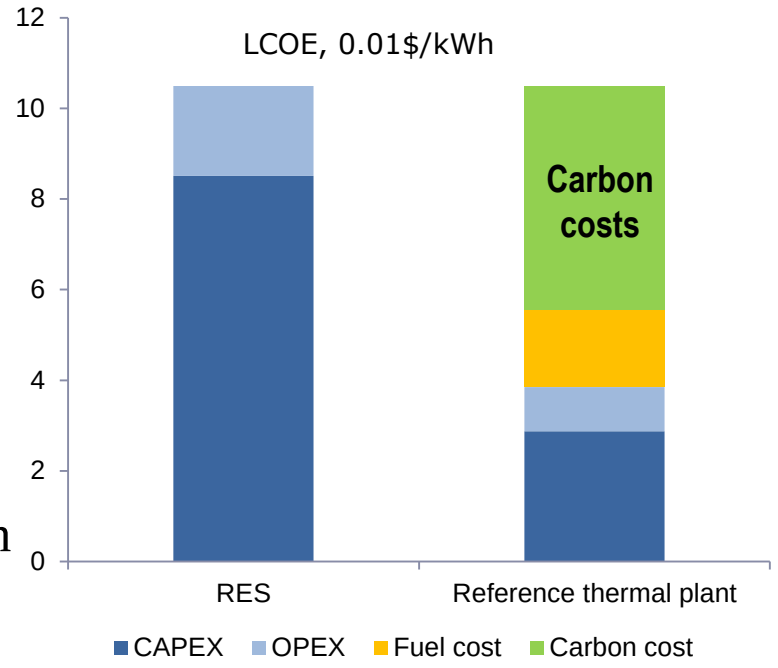
Carbon Avoided Costs calculation is based on LCOE approach

$$CAC_{alt} = \frac{LCOE_{alt} - LCOE_{ref}}{E_{ref}^{CO_2} - E_{alt}^{CO_2}}$$

$LCOE_{ref}, LCOE_{alt}$ - levelized cost of electricity of reference and alternative technologies, $/MWh

$E_{ref}^{CO_2}, E_{alt}^{CO_2}$ - per MWh CO_2 emissions of reference and alternative technologies, t CO_2/MWh

CAC – the needed carbon tax/price to level the efficiencies of non-carbon technology with reference thermal power plant



Pros and Cons

Pros and cons of CAC are arising from LCOE approach

Pros:

-easy to calculate

-very illustrative and easy to understand

-can help to preliminary identify a variety of cost-effective technologies for decarbonization and needed support level

-allows to include regional and technology-specific details

Cons:

-it's just a first step in assessing the decarbonization pathways

-it cannot help to find appropriate scales of technologies' expansion (i.e., share in capacity and energy mix)

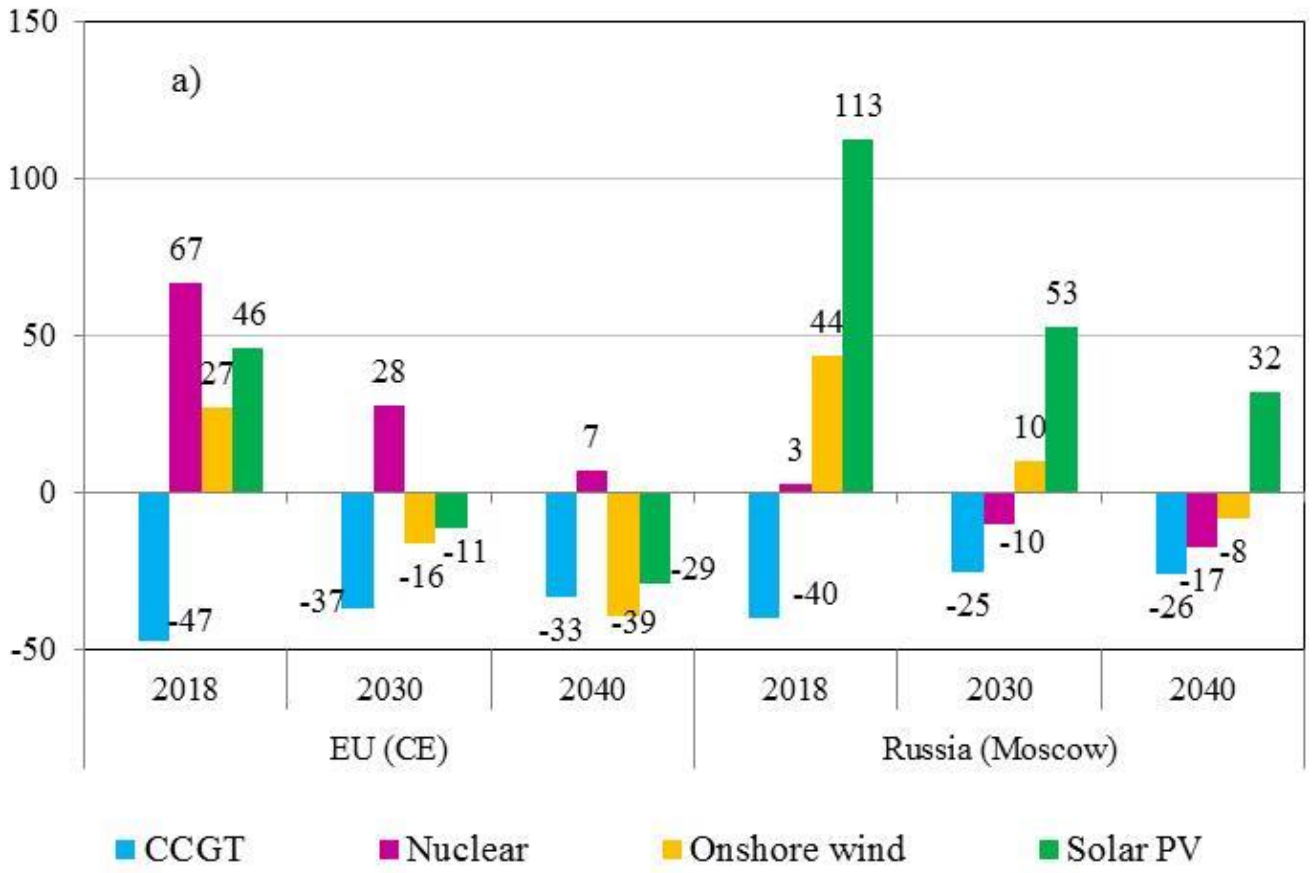
-it does not take into account system effects arising from the development of low-carbon technologies

Main Assumptions

Main assumptions you need to make:

- Choice of a **REFERENCE** fossil fuel technology
- Assumption used in **LCOE** calculation:
  - Discount rate
  - Capital and O&M costs
  - Efficiency
  - Fuel Prices
  - Annual capacity factor
- When assessing CAC, calculations **usually** do **NOT** take into account:
  - carbon prices/taxes;
  - tax, investment and other support measures for RES;

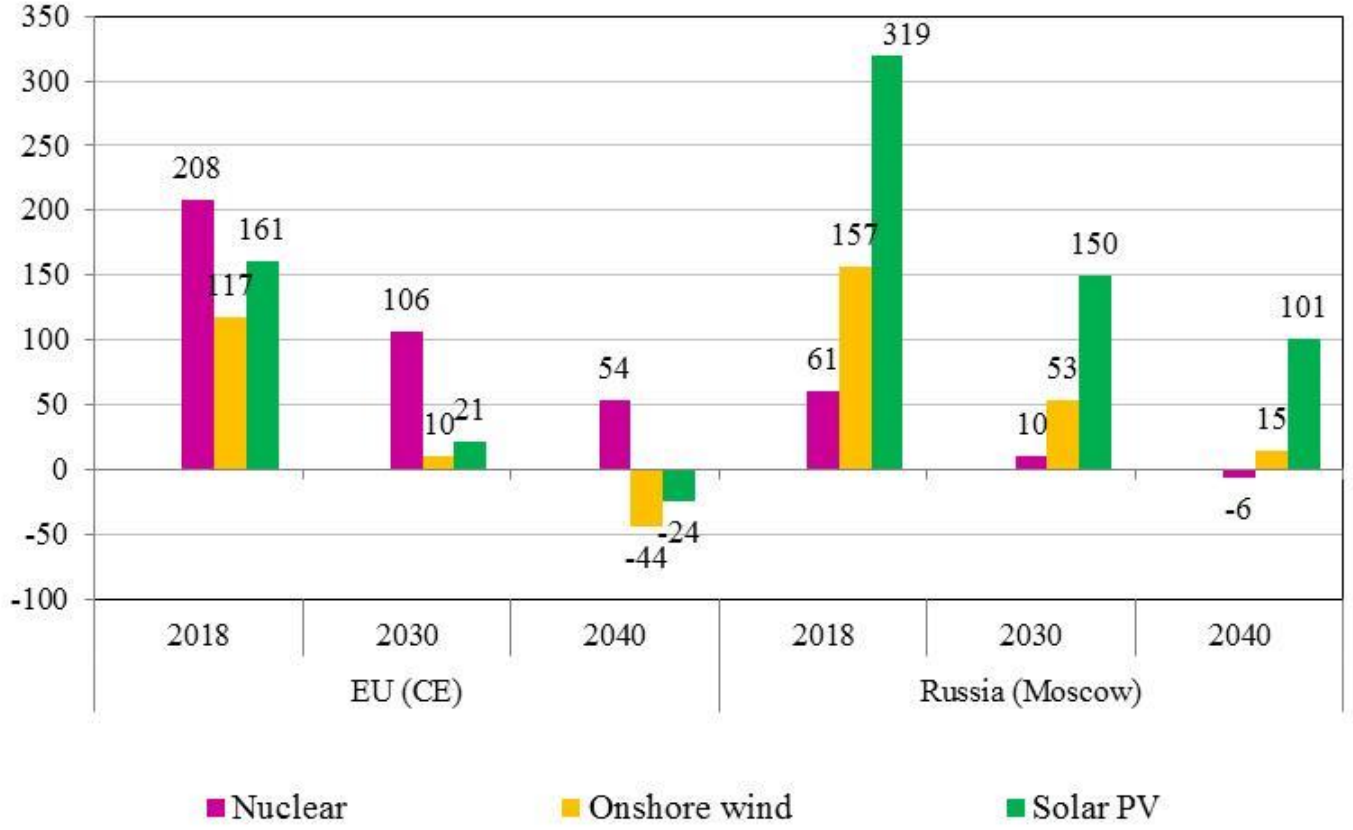
Example: Carbon Avoided Costs in Russia and the EU, USD2018/t CO_2. Reference technology – COAL



Assumptions: Reference technology – coal PP, 10% discount rate, faster technological learning for RES, high fuel prices

- In Russia as well as in the EU most efficient way of cutting carbon emissions is to substitute coal plants with CCGTs.
- But unlike the EU nuclear generation could be a way to go for Russia, especially after 2030.
- It appears that after 2030 RES development in the EU could be viable w/o carbon taxation, In Russia carbon price of about 30-50$/t CO_2 should be in place to ensure solar PV development

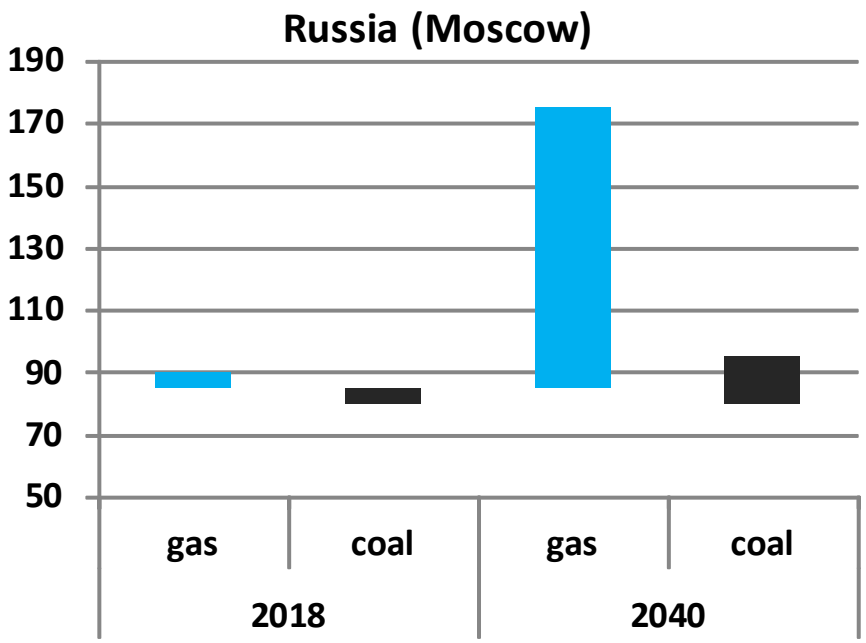
Example: Carbon Avoided Costs in Russia and the EU, USD2018/t CO_2. Reference technology – CCGT

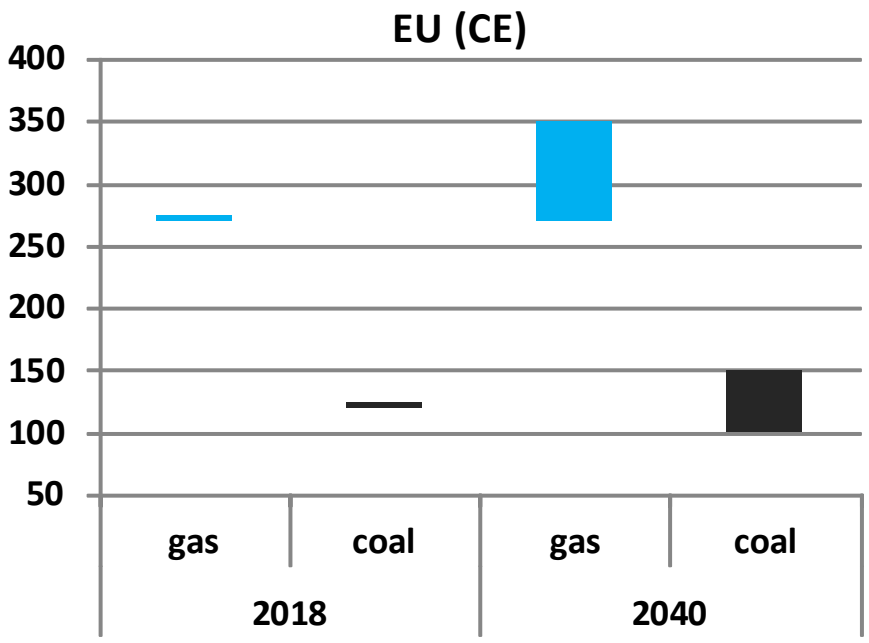


Assumptions:
Reference technology – CCGT,
10% discount rate,
faster technological learning for RES, high fuel prices

- To further decline GHG emissions by substituting gas with non-carbon sources carbon prices/taxes should be in place at least up to 2030 in the EU and up to 2040 in Russia

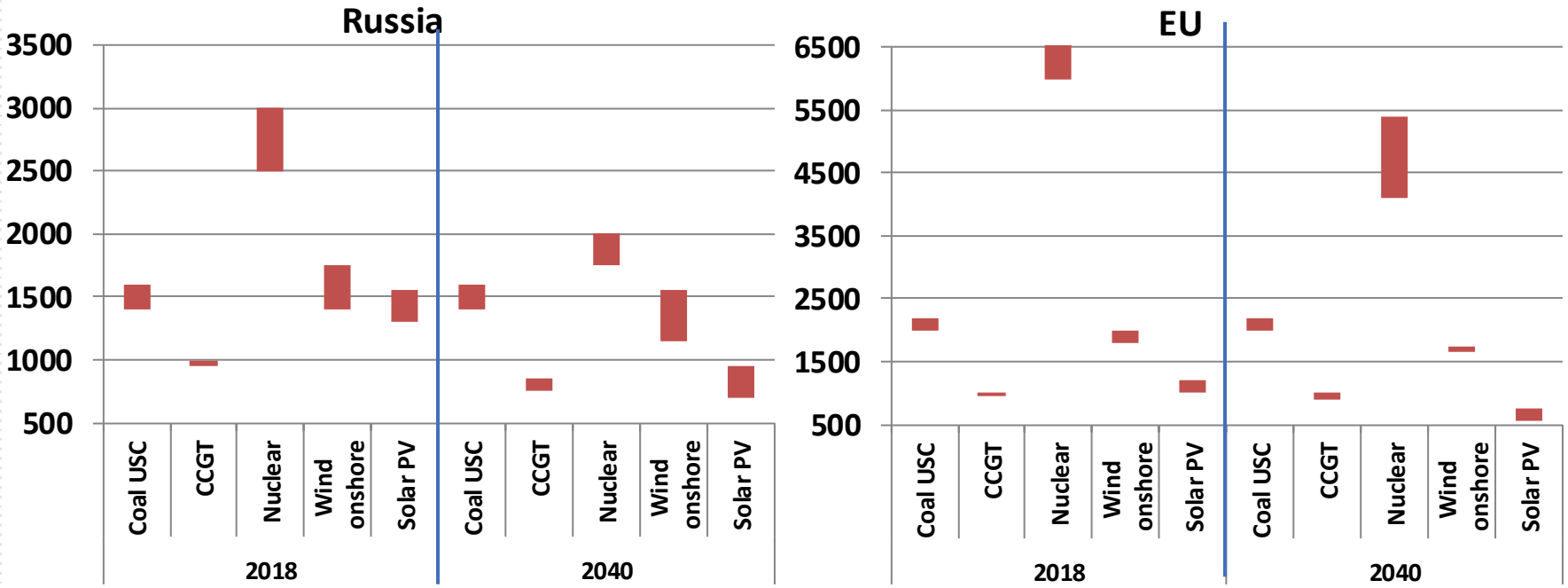
CAC Drivers: Fuel Prices in Russia and the EU, USD2018/toe





- Currently, Russia maintains regulation of domestic gas prices and their level is about 2.5 times lower than in the EU
- It seems realistic that Russian policy of keeping the growth of gas prices around inflation rate will continue up to 2030. It will keep the 3-4 times gap between gas prices in Russia and the EU
- But even in case of moving to “net-back” pricing mechanism gas price still will be 2 times lower than in the EU
- Despite the fact that coal prices in Russia are formed using market mechanisms, they still will be lower than in the EU by 20-30%

CAC Drivers: Capital Costs of Power Generation in Russia and the EU, USD2018/kW



- Capital costs of thermal generation in Russia and the EU are almost equal.
- A sharp drop in the ruble exchange rate and imposed sanctions made imported RES equipment too expensive or difficult to acquire. This led to the launch of a government localization program.
- Its implementation is already bringing results. At the 2018-2019 auction for RES PPA capital costs of wind decreased 2 times, solar PV – almost 3 times (comparing with 2014-16 auctions)
- There is a big difference in the cost of nuclear power plants in Russia and the EU. Lower labor and construction material costs as well as serial construction will keep their cost as low as 2300-2500 $/kW. It's assumed that introduction of new VVER-TOI units after 2025 will reduce the cost by another 10-15% making nuclear very cost competitive in Russia

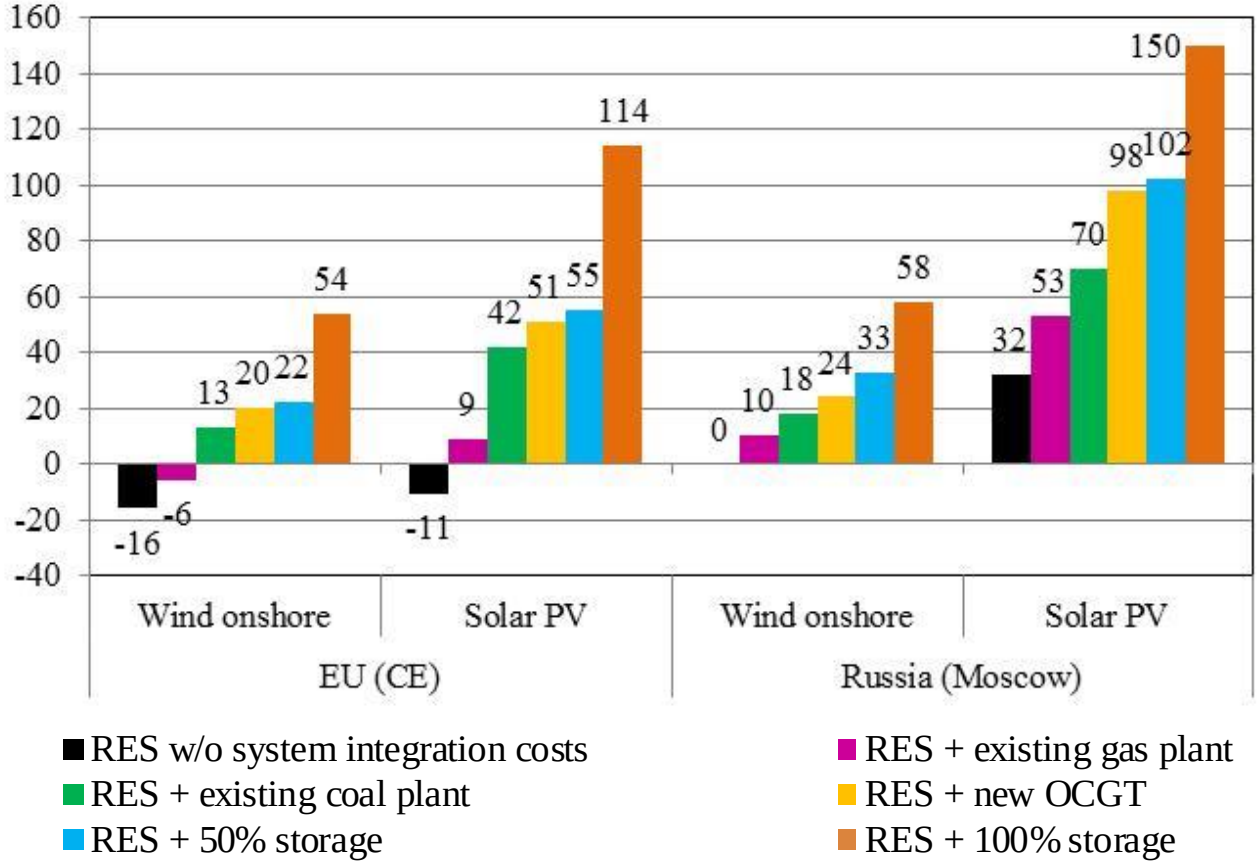
Source: for Russia – ERI RAS forecast, for EU – based on IEA World Energy Outlook 2019, Columbia University (2018). The Role of Natural Gas in Europe's Electricity Sector Through 2030, etc.

Assumptions – Going beyond plant level

Like with LCOE approach, you can try to go BEYOND plant level

- **For example, what if we assume that all wind and solar capacity must be RESERVED by:**
  - **existing thermal generation (+O&M costs to maintain the availability of existing gas/coal fired plants are included in LCOE) or;**
  - **new open cycle gas turbines (1-to-1) (+ capital costs of OCGT + O&M costs of OCGT) or;**
  - **new storage capacity (from 50% to 100%) (+ capital costs of storage + O&M costs of storage + additional storage losses).**

Carbon Avoided Costs – Going Beyond Plant Level. Reserving RES generation.



Assumptions: 2030, 10% discount rate, faster technological learning for RES, high fuel prices

- Including system integration costs into CAC calculation will substantially increase CAC values.
- Reserving with existing power plants is the cheapest way to harmonize RES plants and power system operation modes, but it could increase CAC by 10-20% for wind and 30-50% for solar
- The most expensive option is the combining RES plants with energy storage. For example, the carbon price of at least 55 USD/t CO_2 is required to make development of solar PV with 50% storage effective in the EU, more than 100 USD/t CO_2 – in Russia

Takeaways

- Carbon avoided costs are illustrative and easy to calculate
- Carbon avoided can be used as preliminary metric to draw possible decarbonization pathways for power sector
- Carbon avoided costs can depict regional and technology-specific details quite well
- Like LCOE, carbon avoided costs can’t assess effective scale of expansion of generating technologies
- Like in case of LCOE, in carbon avoided costs calculations we need to look “beyond plant level” to catch (at least partially) some of the system effects

The Energy Research Institute of the Russian Academy of Sciences

www.eriras.ru

Andrey Khorshev,
PhD, Head of the Center for Energy Modeling
epos@eriras.ru

Thank You for Attention