Confidential

In-depth analysis of the dynamics of demand for coal in the Republic of Tajikistan until 2050

18th session of the Group of Experts on Coal Mine Methane and Just Transition

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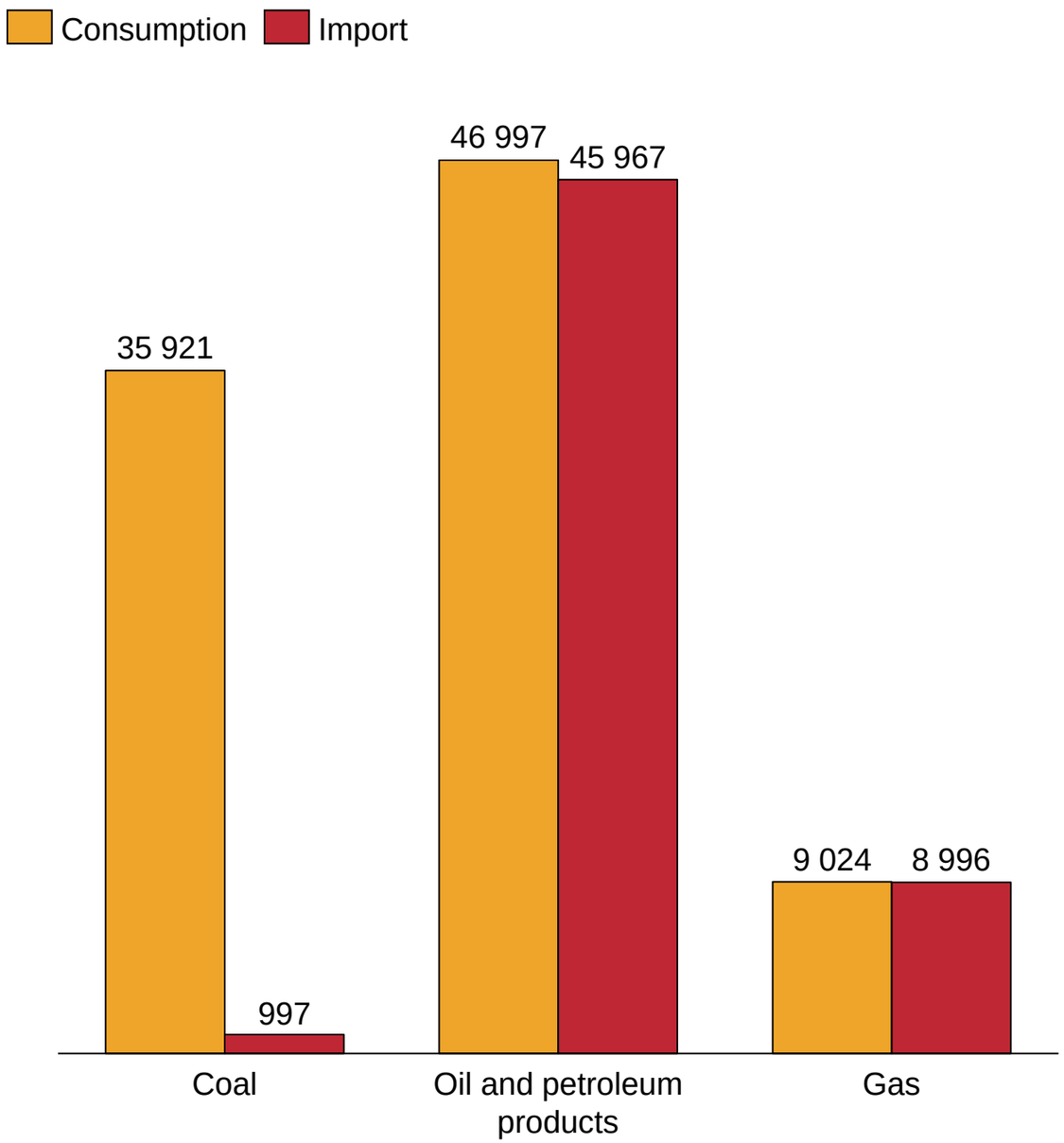
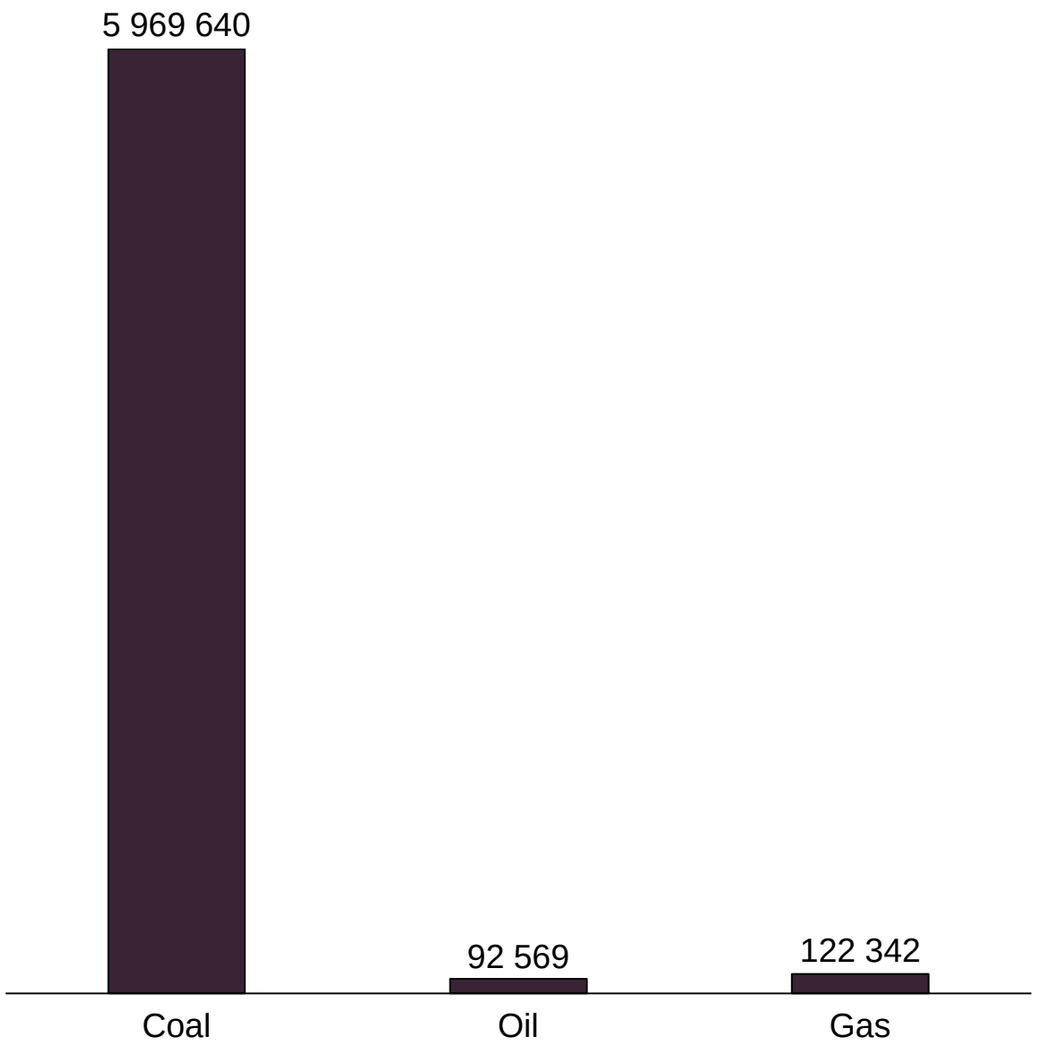
Outlook for demand for coal mined in the Republic of Tajikistan: general characteristics

Coal is the only fossil fuel whose consumption in Tajikistan is covered by domestic production, and its explored reserves in the country are 27 times superior to those of oil and gas combined

Energy consumption and imports
Tajikistan, 2020, TJ



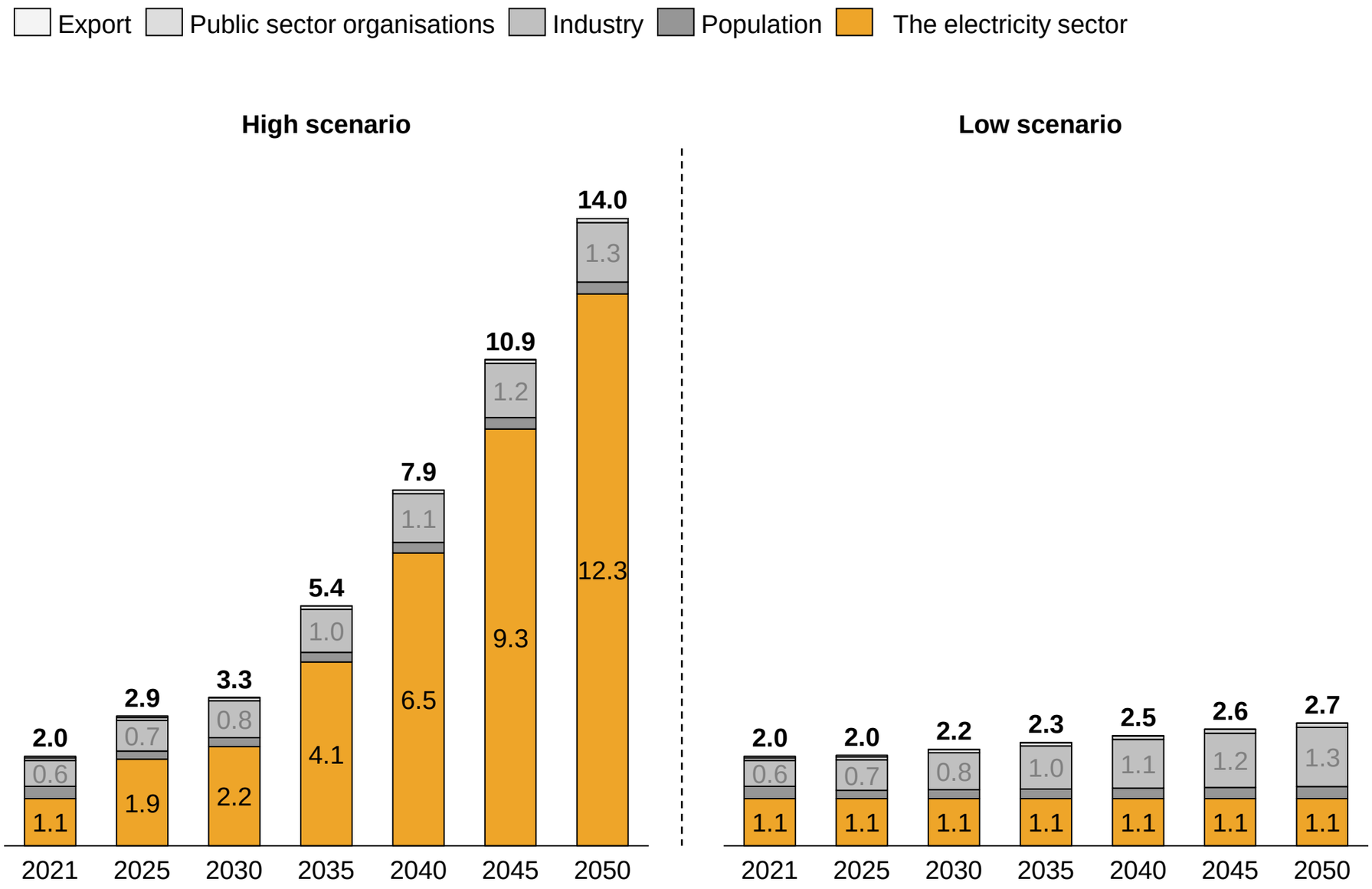
Explored mineral reserves
Tajikistan, 2020, TJ



Source: MINT, IEA, Petromarket RG

Tajikistan's coal demand in 2050 will be in the range of 2.7 to 14.0 million tonnes, which is 1.4-7.0 times higher than in 2021.

Forecast of demand for Tajik coal from domestic and foreign consumers
Tajikistan, fact 2021, forecast 2022-2050, mln tonnes



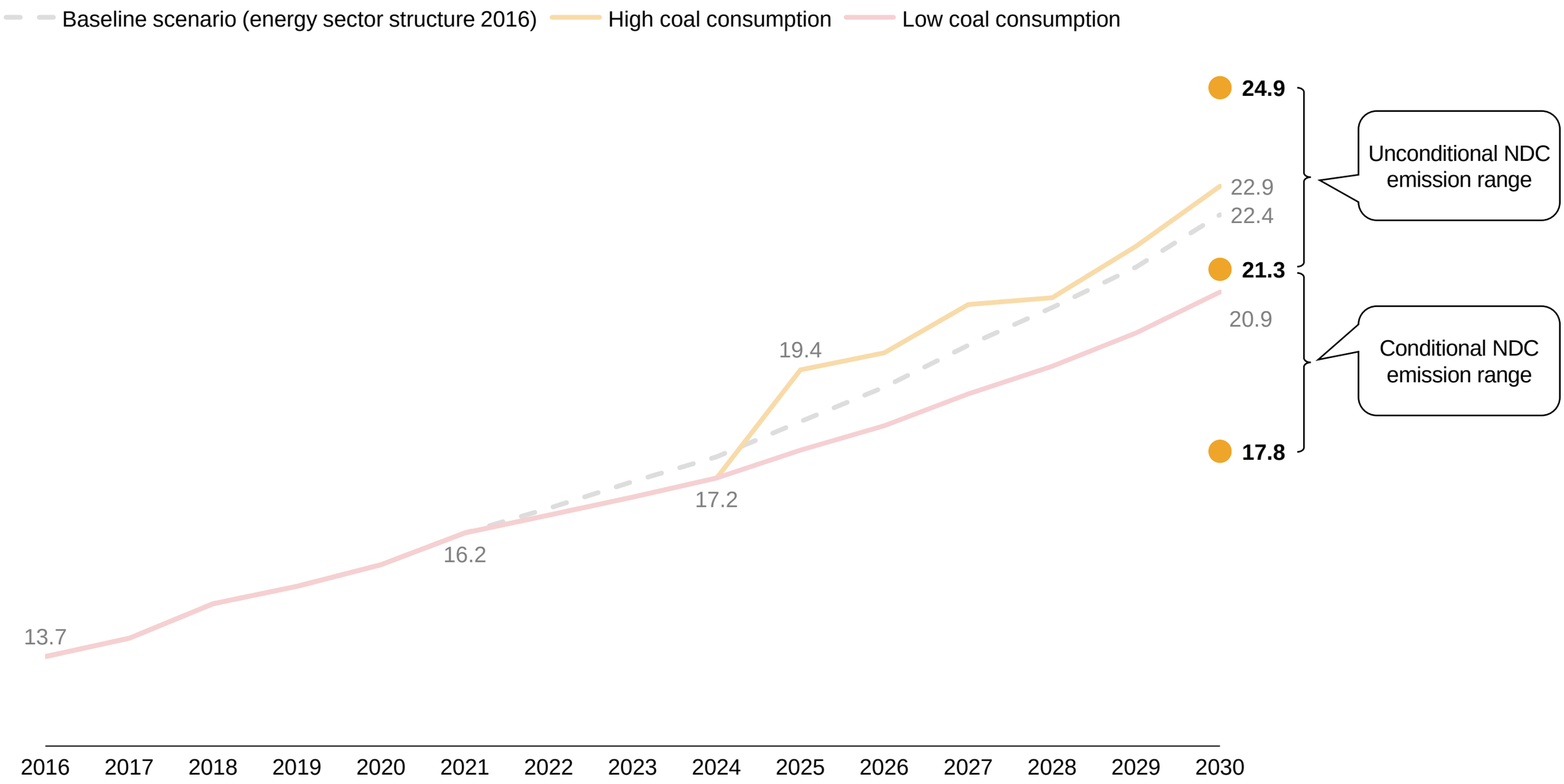
- The **main source of uncertainty** for future coal demand is the structure of **electricity generation by source**:
  - the demand for coal would **increase by a factor of 7** if current and future electricity shortages were met by building coal-fired power plants
  - the demand for coal would **increase by a factor of 1.4** if current and future shortages were met through construction of hydropower plants (HPP)/wind power plants (WPP)/solar power plants (SPP)

Source: Petromarket RG

Even if Tajikistan undertakes no additional measures to reduce greenhouse gas emissions, in the high scenario of coal demand they would be within the unconditional NDC target, in the low scenario within the conditional target

Forecast of greenhouse gas emission

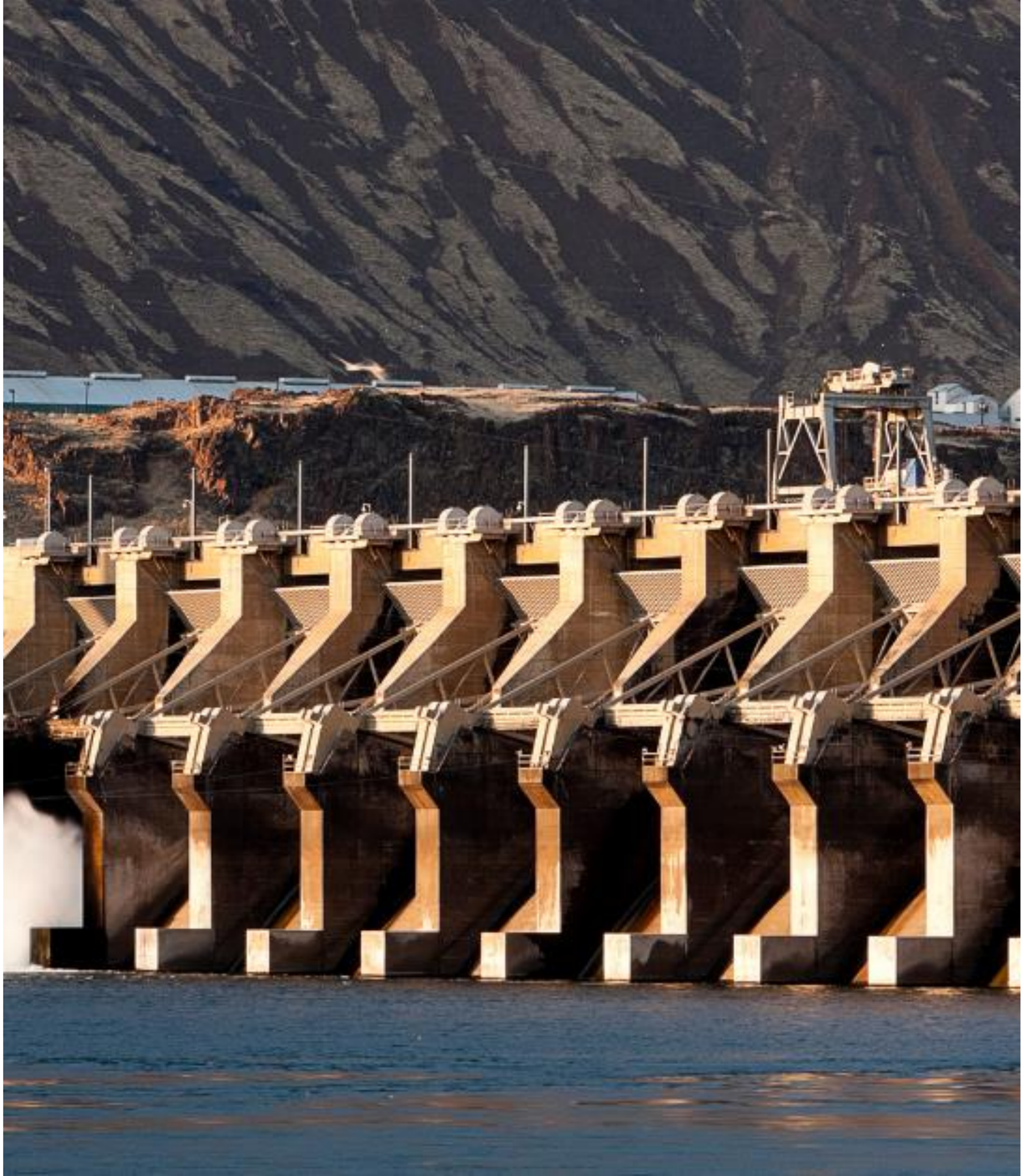
Tajikistan, actual 2016, estimate 2017-2021, forecast 2022-2030, mln tonnes CO_2eqv



Source: Updated NDC of the Republic of Tajikistan, Petromarket RG

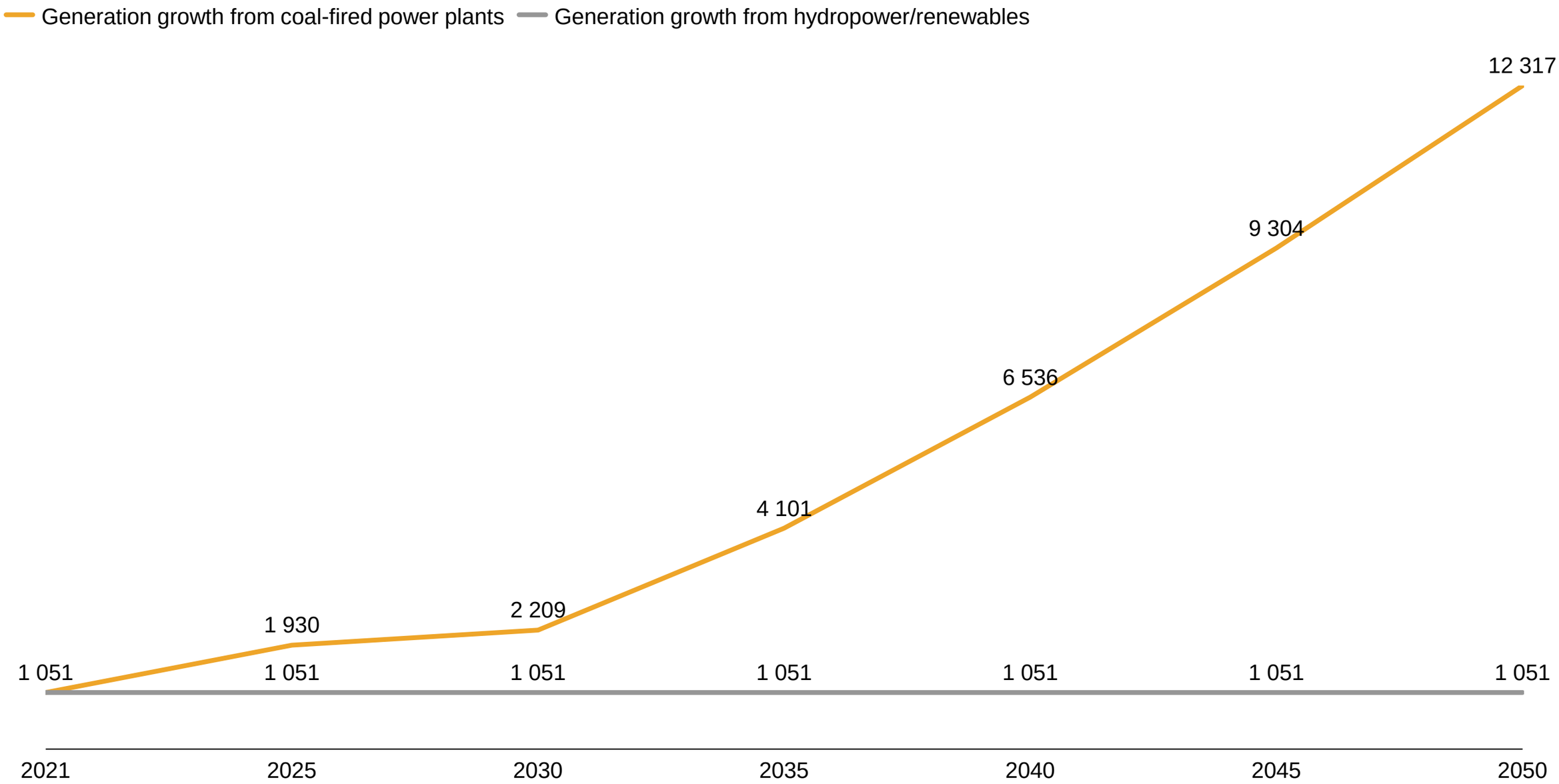
B

Energy generation demand forecast



If the growing electricity demand in the country is met by the construction of coal-fired power plants, coal consumption on the generation side will increase by a factor of 12 by 2050 compared to 2021, while if it is met by the construction of HPP/WPP/SPP, coal consumption will remain at 2021 levels

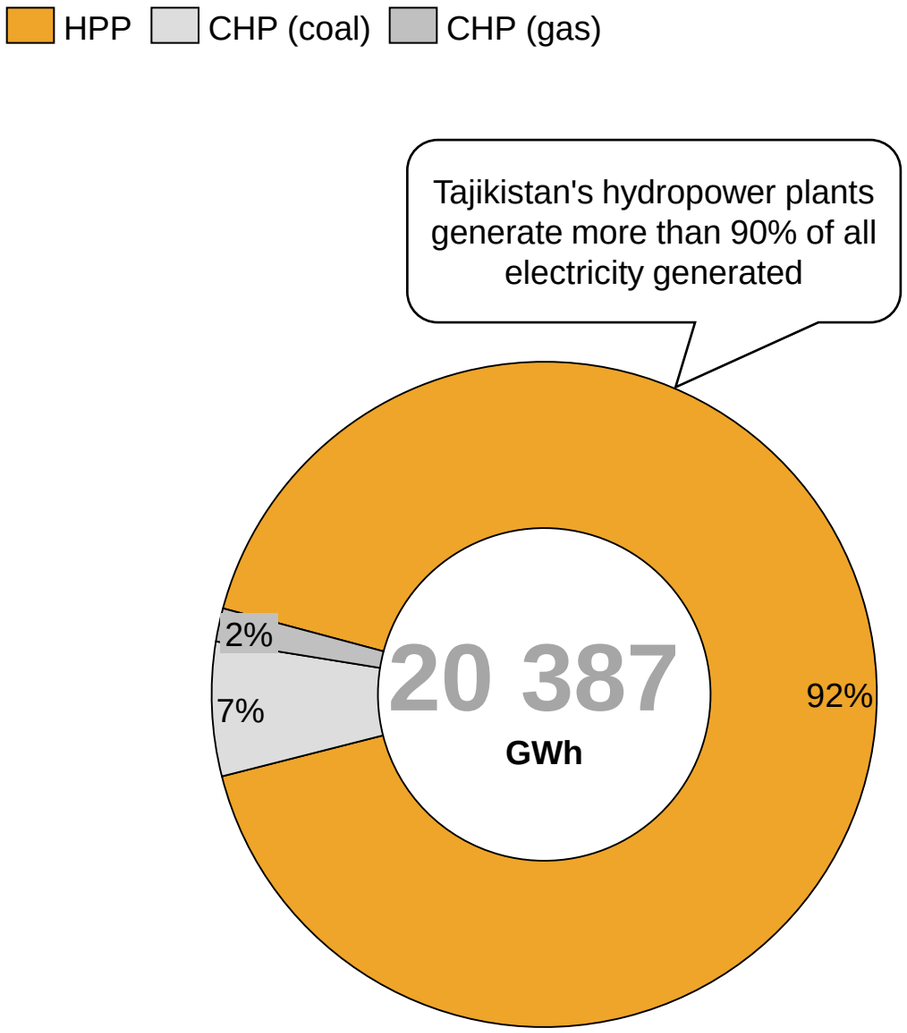
Forecast of coal demand on the power generation side
Tajikistan, actual 2021, forecast 2022-2050, thousand tonnes



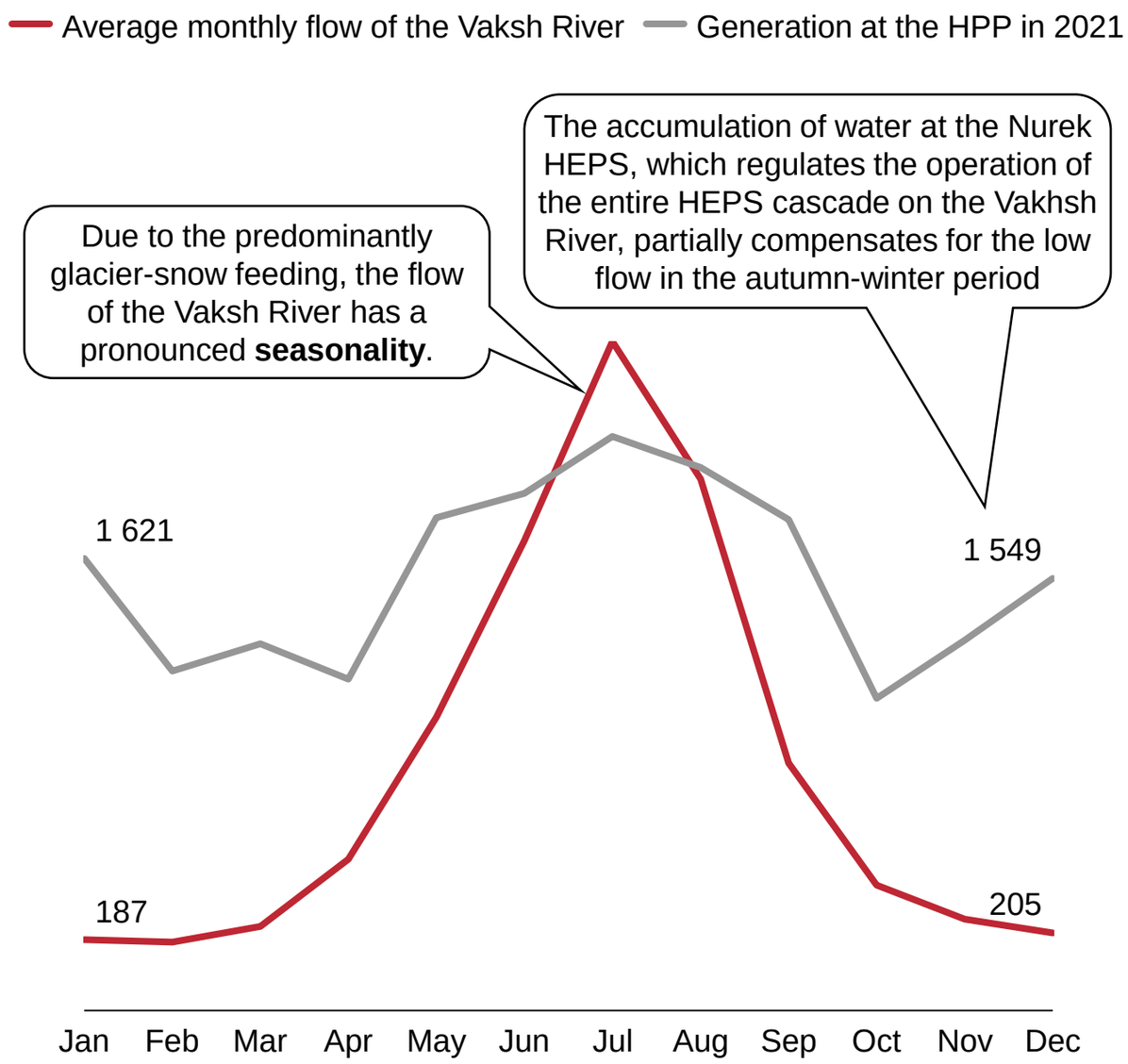
Sources: Petromarket RG

More than 90% of Tajikistan's electricity generation comes from hydropower plants, which have a distinctly seasonal character

Electricity generation by source
Tajikistan, 2021, GWh



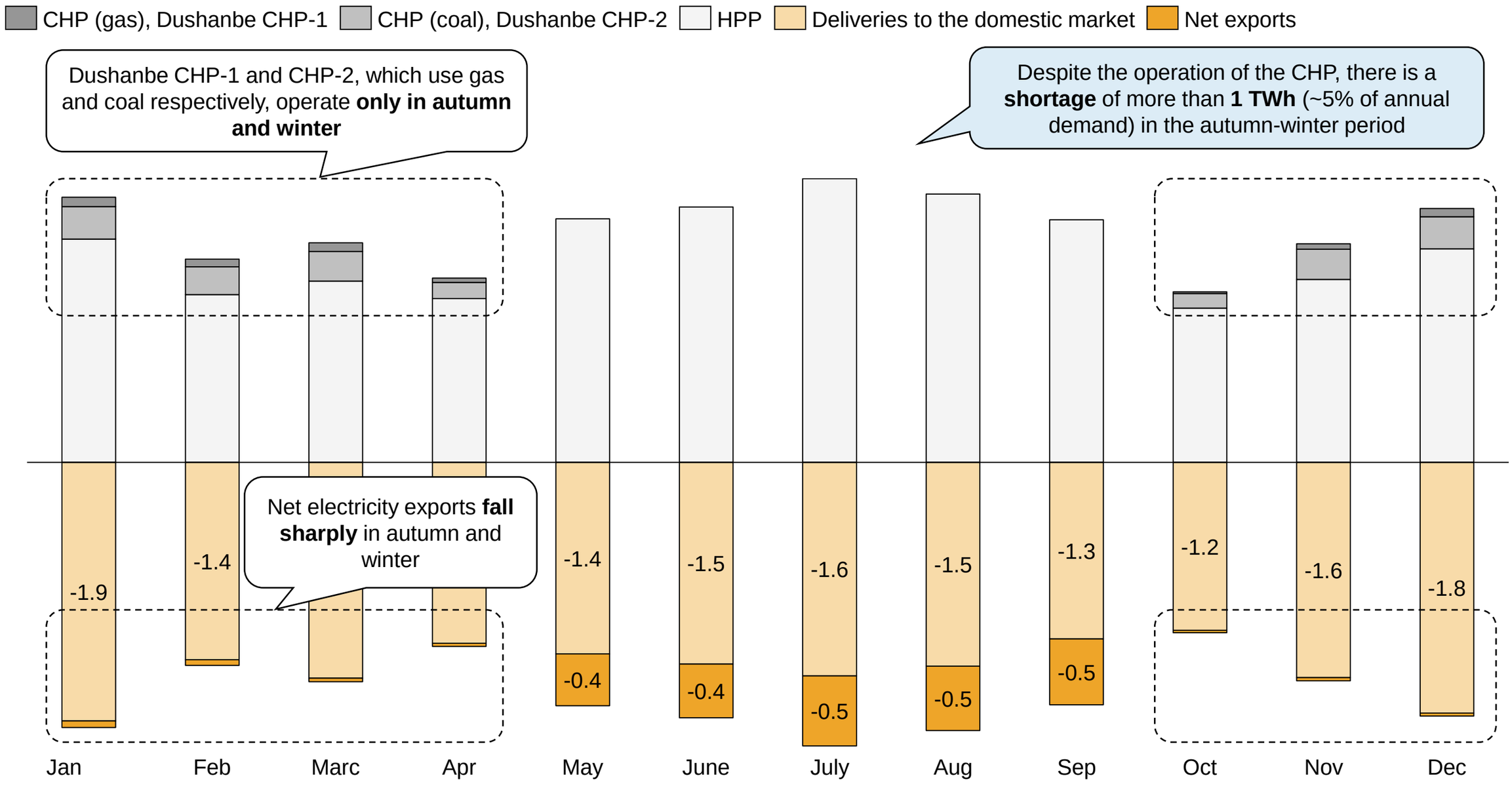
Seasonality of hydropower generation (new of own needs) and average monthly flow of the Vaksh River
Tajikistan, hydropower generation in 2021, GWh; flow rates: averages for 1932-2010, m^3/sec



Source: State Hydrometeorological Service of Tajikistan, Barki Tojik, Petromarket RG

CHP plants in the country start up in the autumn-winter period, when the electricity generated by hydropower plants is insufficient to meet domestic market demand

Electricity generation by type of power plant, net export and domestic supply of electricity
Tajikistan, 2021, TWh



Source: Barki Tojik, Tajstat, Petromarket RG

In Tajikistan, several projects are being implemented to reduce electricity shortages during the autumn-winter period

Existing electricity generation facilities and modernisation projects
Tajikistan, conditions of 2022

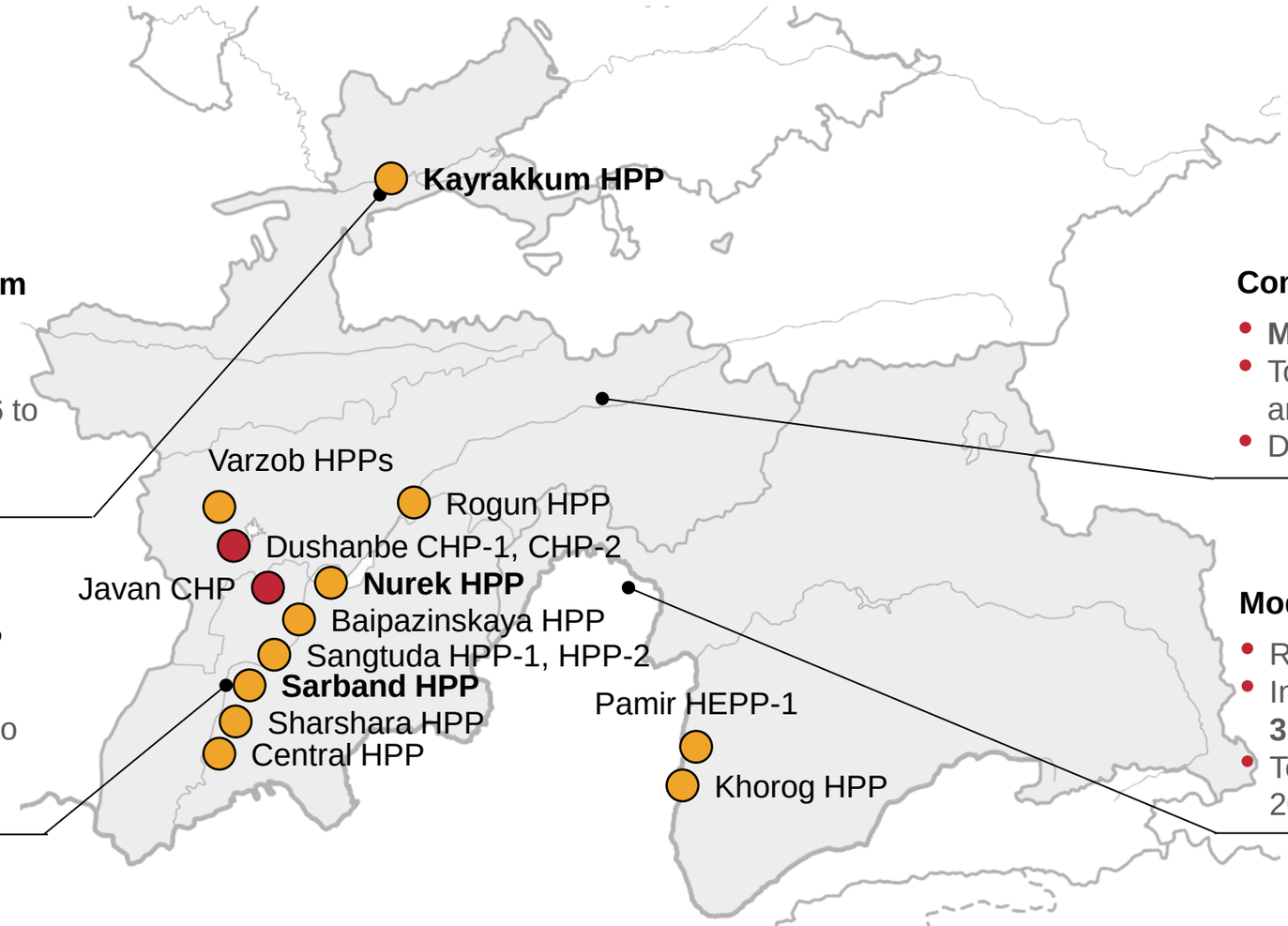
The National Development Strategy of the Republic of Tajikistan for the period until 2030 sets a **target** of reducing electricity losses **to 10%** by 2030.

HPP CHP

Available capacity[1]
4 763
MW
in 2020

Electricity generation
9.7
TWh
in 2021

Network losses
20%
generation
in 2021



Modernisation of the Kayrakkum hydropower plant
- Replacement of all **6 units**
- Increase of capacity from **126** to **174** MW
- Term – **2023**

Modernisation of Sarband HPP
- Replacement of all **5 units**
- Increase in capacity from **240** to **270** MW
- Term – **2023**

Construction of SPP and WPP
- **Multiple projects**
- Total capacity: **330** MW (SPP) and **130** MW (WPP)
- Deadline – **2026**

Modernisation of the Nurek HPP
- Replacement of all **9 units**
- Increase of capacity from **3,000** to **3,300** MW
- Term – first stage (3 units) – 2023, second stage – 2029

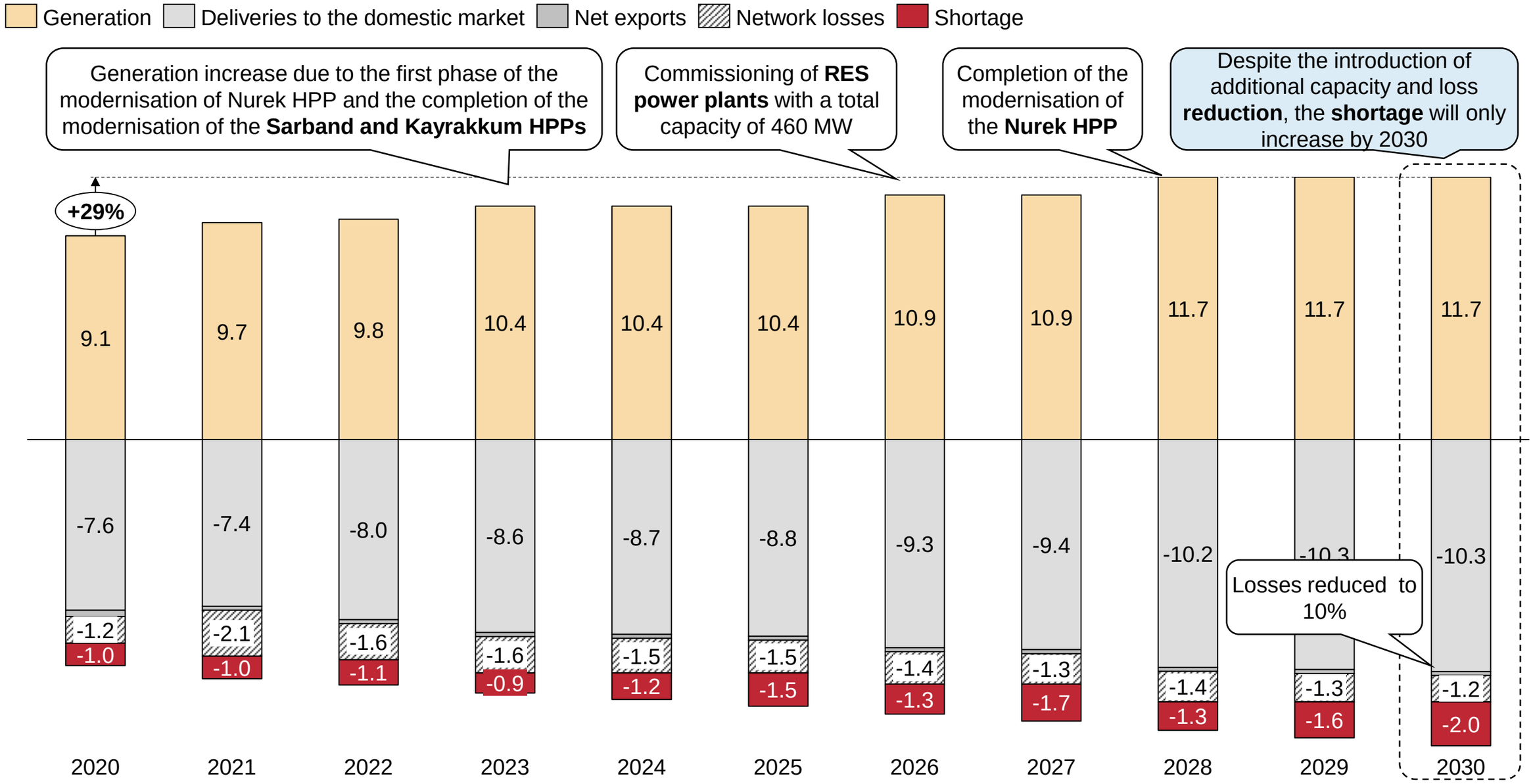
Notes:
1. Available capacity is indicated, including: Nurek HPP – 2400 MW, Sangtuda HPP-1 – 670 MW, Baipazin HPP – 450 MW, Rogun HPP – 240 MW, Sangtuda HPP-2 – 220 MW, Vakhsh HPP Cascade (Sarband HPP, Sharshara HPP, Central HPP) – 214 MW, Kayrakkum HPP (Kayrak-Kum HPP) – 120 MW, Varzob HPPs – 7 MW, Dushanbe CHP-2 – 400 MW, Dushanbe CHP-1 – 42 MW

Source: IEA, Petromarket RG

The planned increase in generation capacity and reduction of grid losses will not be enough to eliminate electricity shortages in the country in the autumn-winter period

Generation, net exports, distribution losses, domestic supply, demand and shortage of electricity in autumn-winter (October-March)

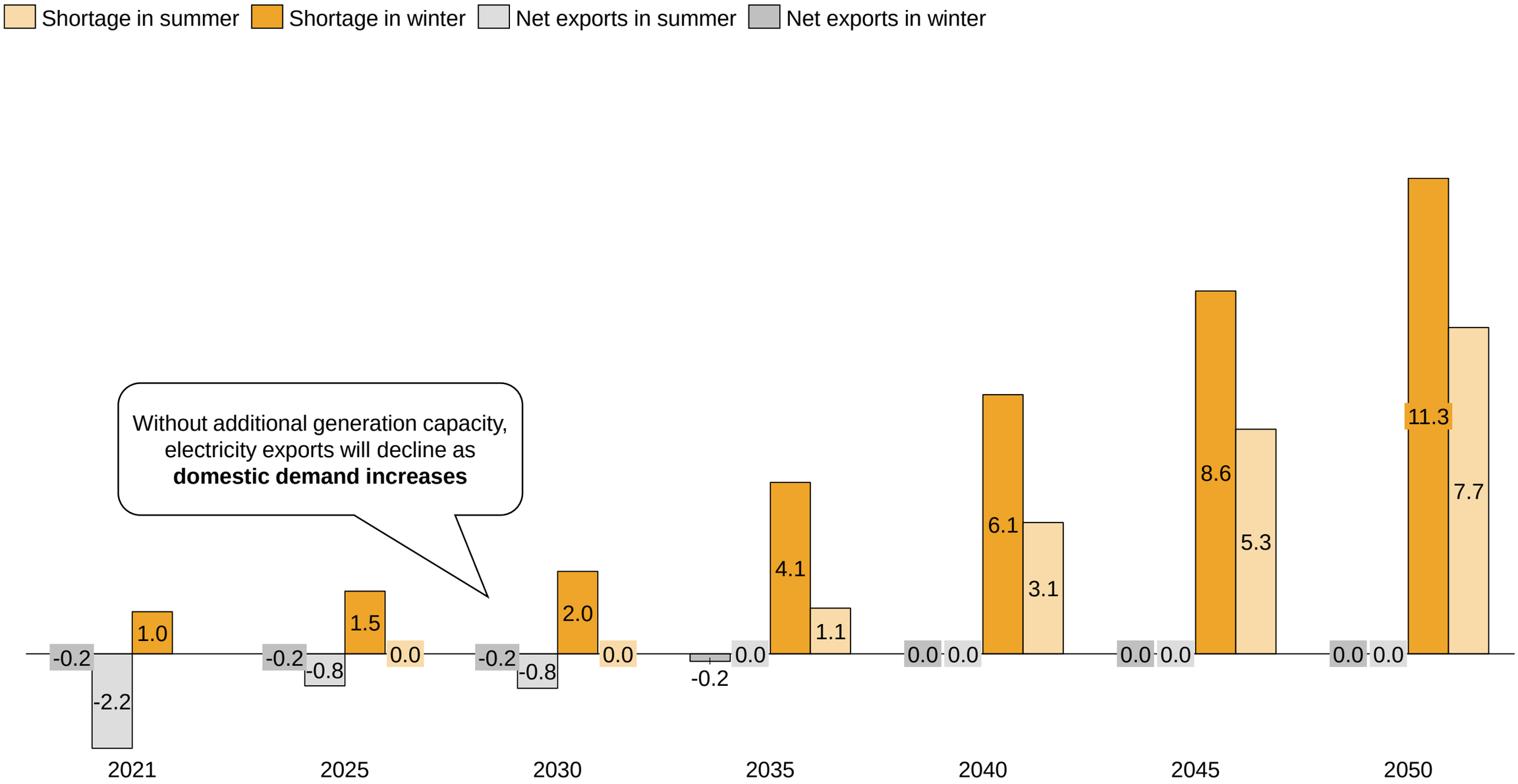
Tajikistan, actual 2020-2021, forecast 2022-2030, TWh



Source: Barki Tojik, Tajstat, Petromarket RG

Without construction of new power plants beyond those planned, Tajikistan will have an electricity deficit of 19 TWh by 2050

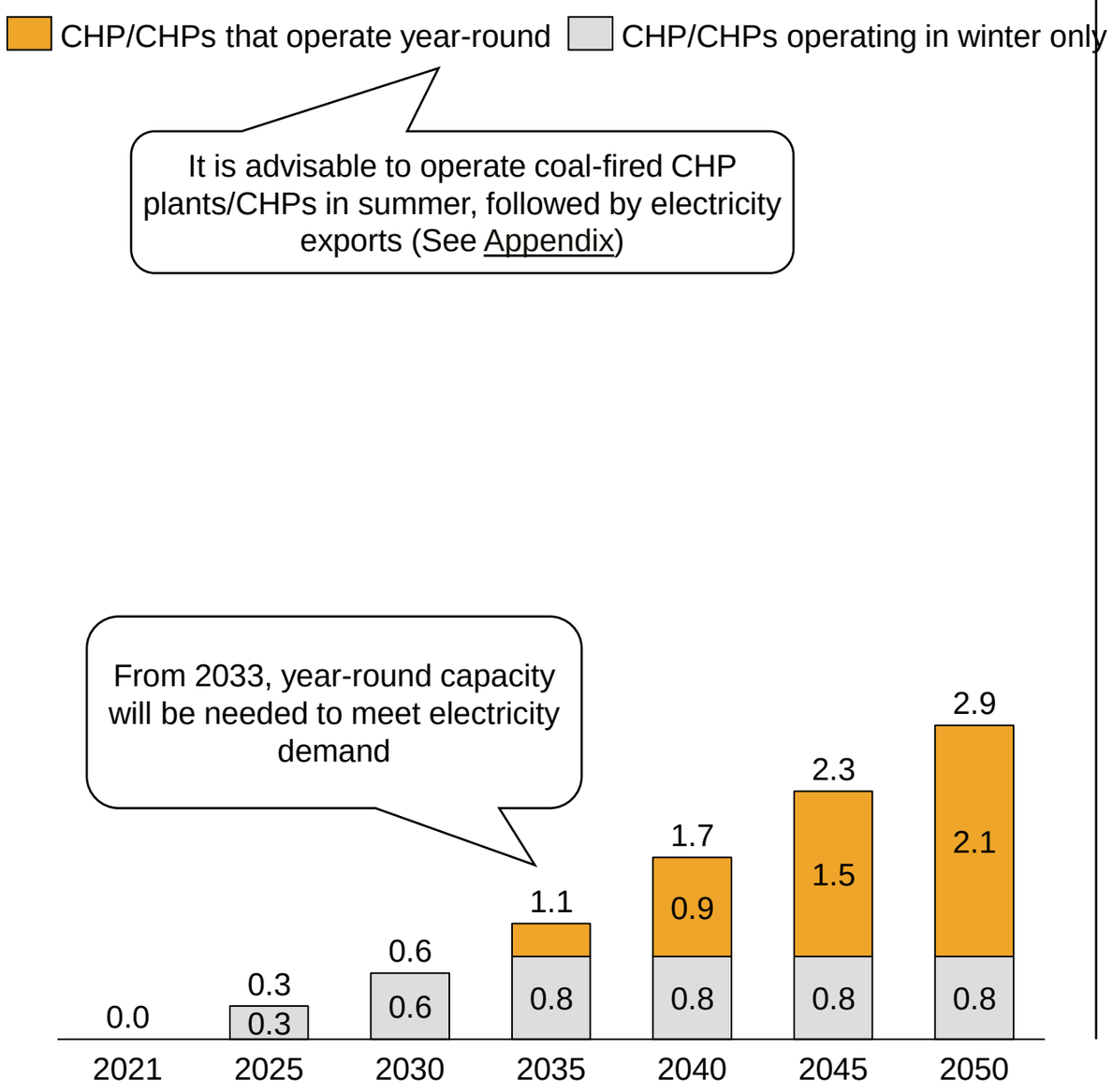
Net electricity export and deficit in spring-summer (April-September) and autumn-winter (October-March) periods
Tajikistan, actual 2021, forecast 2022-2050, TWh



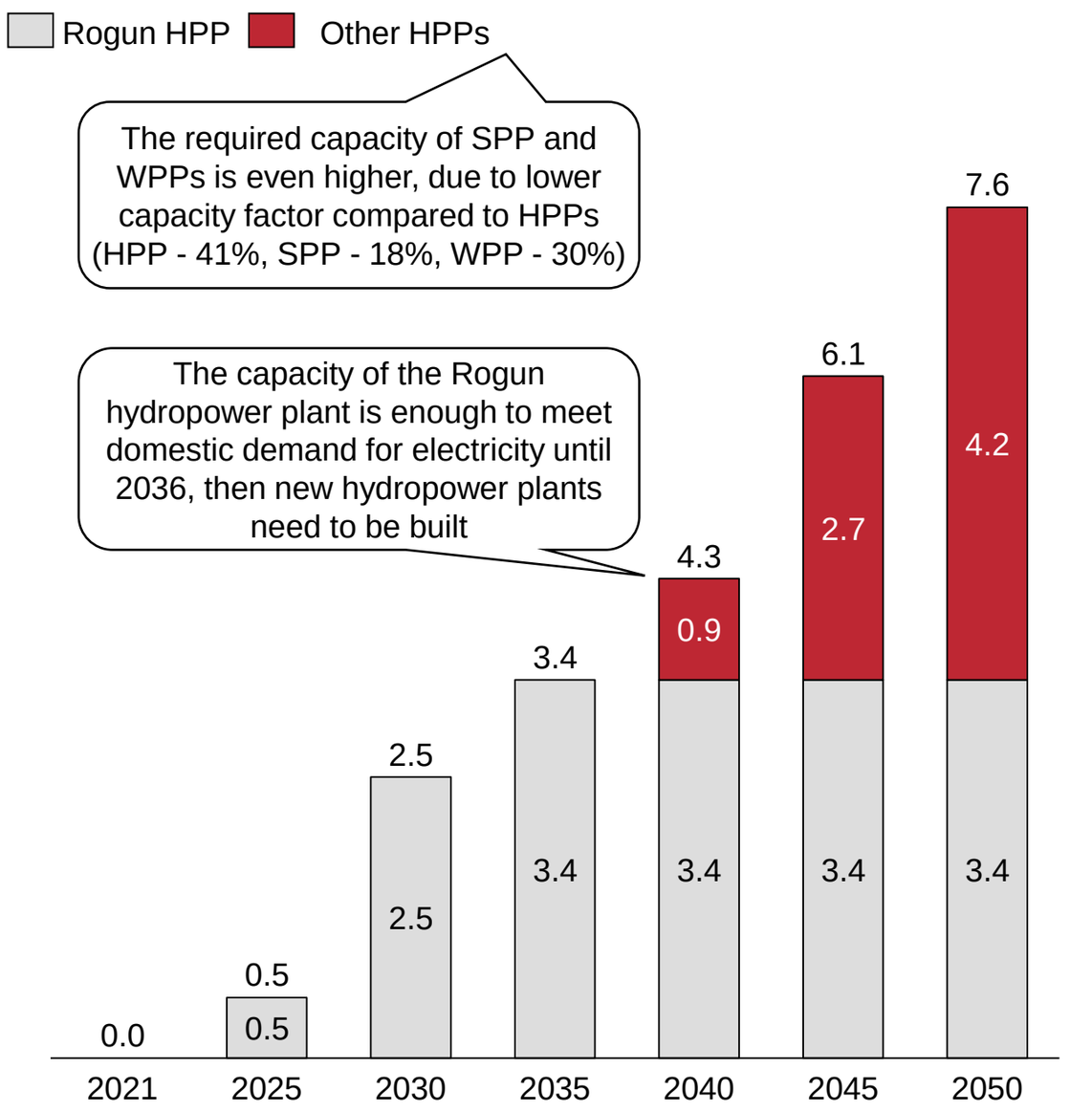
Source: Petromarket RG

To meet future electricity demand through the development of coal-fired generation, a measurably smaller number of power plant installations will be needed than for hydro/ renewable energy based generation.

Required increase in coal-fired generation capacity to meet electricity demand
Tajikistan. actual 2021, forecast: 2022-2050, GWh



Required increase in hydropower capacity to meet electricity demand
Tajikistan, actual 2021, forecast 2022-2050, GWh



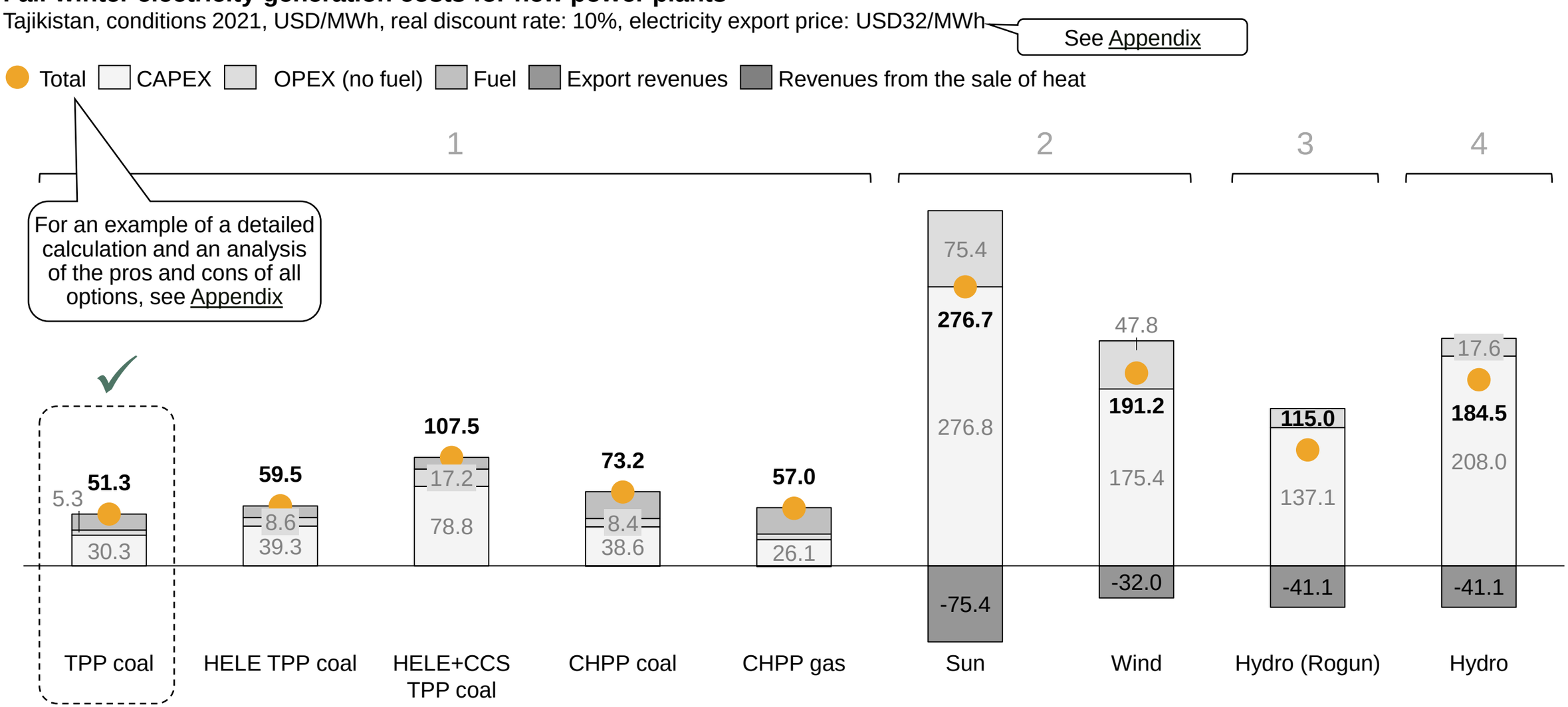
Source: Petromarket RG

The cheapest way to increase generation in autumn and winter is to build a coal-fired thermal power plant at Fon Yaghnob

Fall-winter electricity generation costs for new power plants

Tajikistan, conditions 2021, USD/MWh, real discount rate: 10%, electricity export price: USD32/MWh

See Appendix



Notes:

1. CAPEX, OPEX and fuel costs were based on construction costs and characteristics of Dushanbe CHP-2 (built by a Chinese company; CAPEX of coal-fired power plants in China is 3 times lower than the world average).

2. CAPEX and OPEX of SPP and WPP calculated based on the world average (CAPEX of SPP and WPP built in China is 25% lower than the world average).

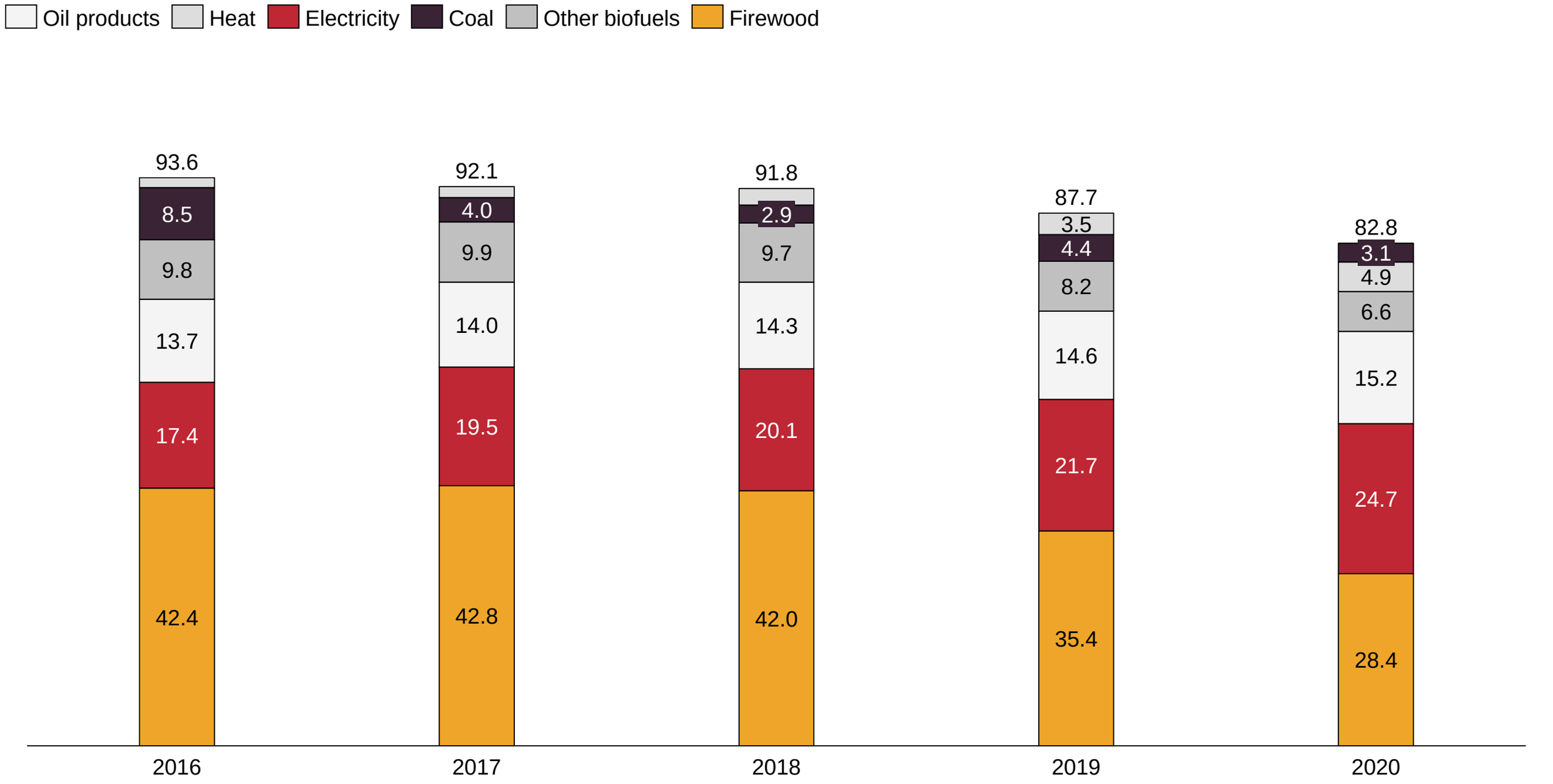
3. CAPEX is stated net of costs already incurred of $3.8 billion.

4. CAPEX shown for run-of-the-river hydropower (without or with a small reservoir)

Source: ADB, IEA, BP, MINT, Barki Tojik, Petromarket RG

People cover electricity shortages in autumn and winter mainly by burning firewood,...

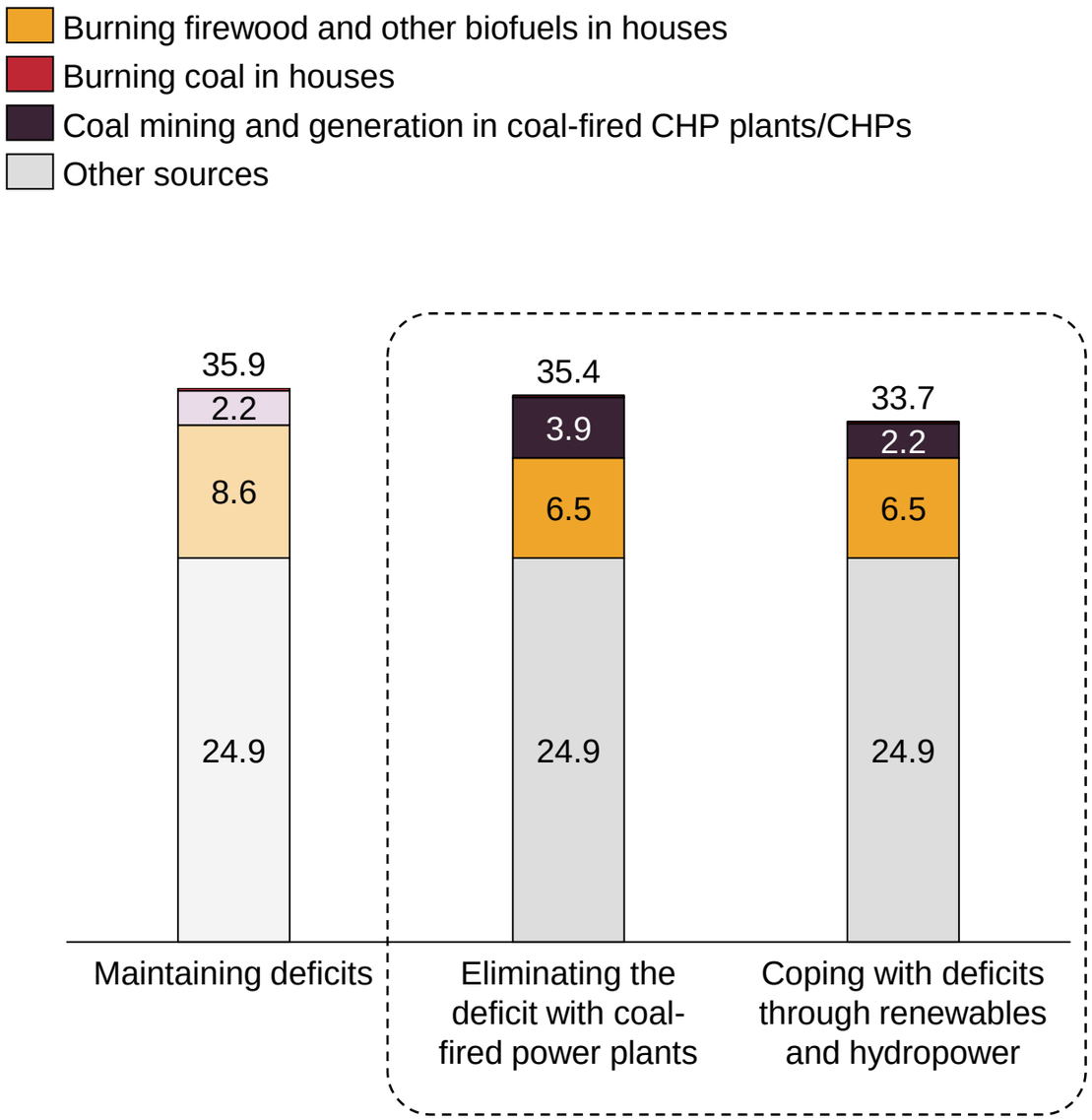
Gross residential energy consumption
Tajikistan, actual 2016, estimate 2017-2020, TJ



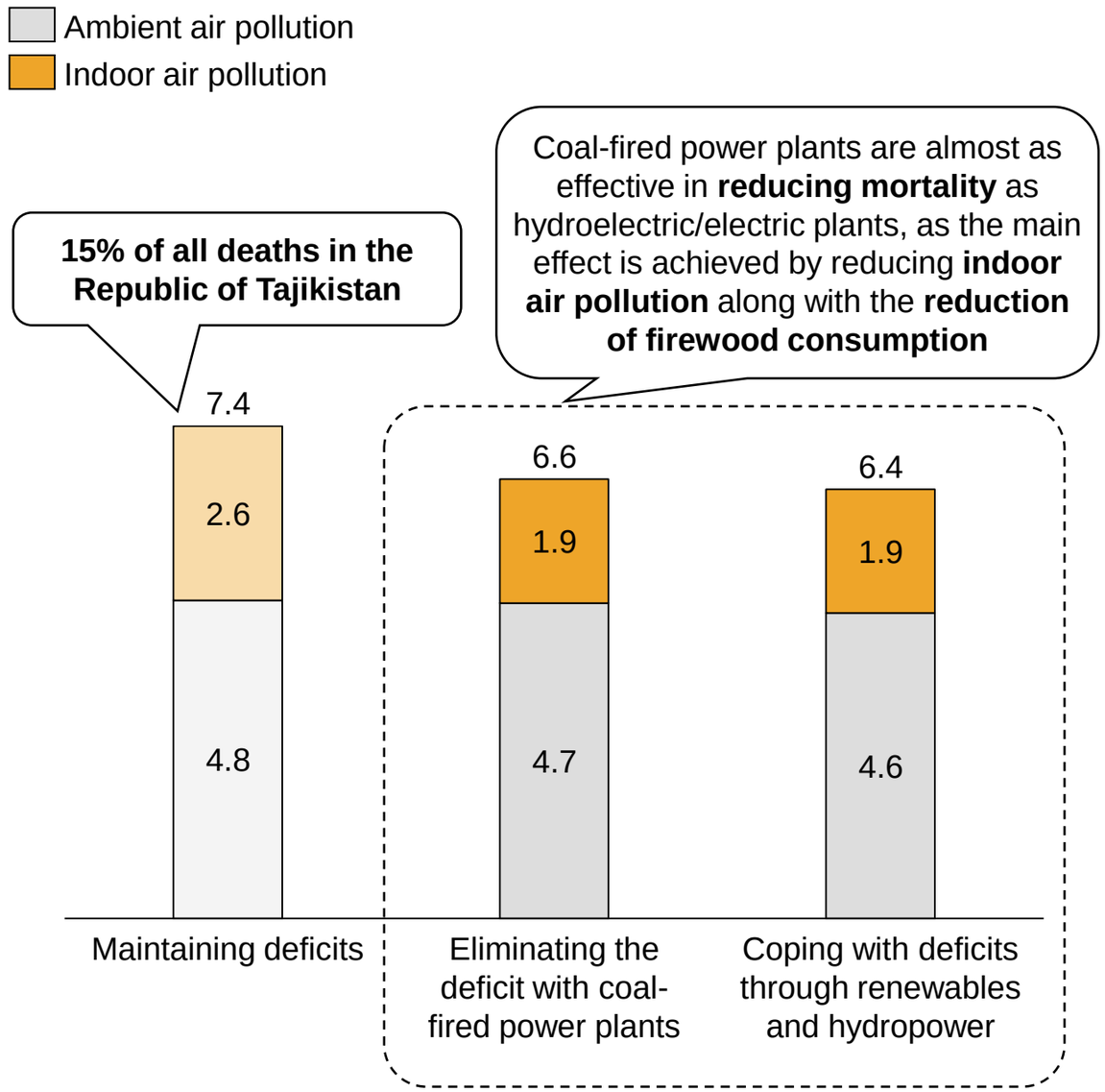
Source: Tajstat, MINT, Barki Tojik, Petromarket RG

... which is markedly increasing mortality in Tajikistan

Contribution of different sources to air pollution
Tajikistan, 2017, μg PM2.5 particles/m^3



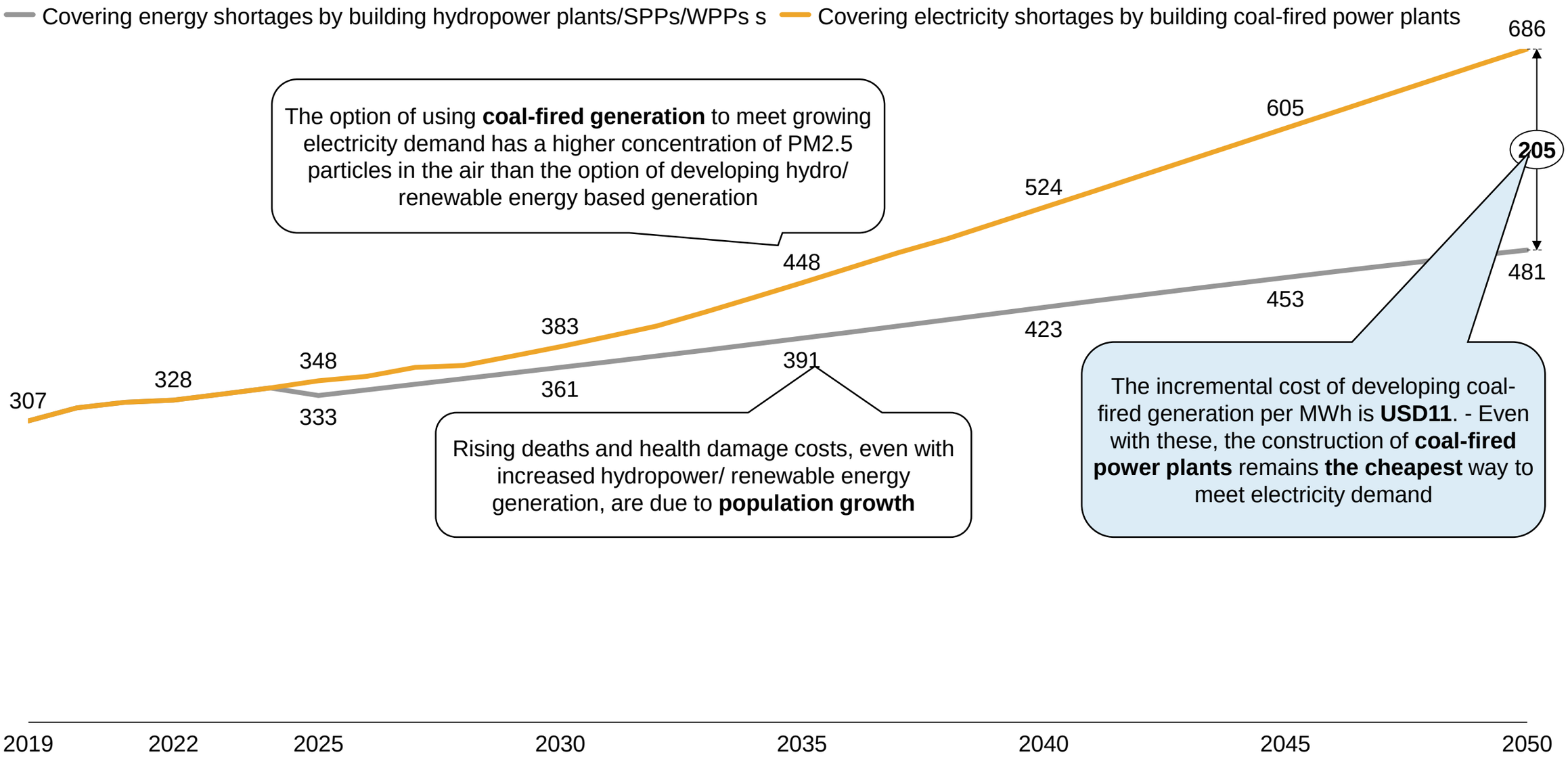
Reduction of deaths from PM2.5 particle air pollution when elimination the 1TWh electricity deficit through coal-fired TPPs and HPPs/SPPs/WPPS
Tajikistan, 2019, thousand people/year



Source: Global Burden of Disease, Petromarket RG

Even if one considers that the development of coal-fired generation is worse than the development of hydropower/ renewable energy generation in Tajikistan in terms of health damage reductions, it remains the cheapest way to meet electricity demand in the country

Costs of health damage from air pollution when meeting growing electricity demand from coal-fired CHP or HPP/SPP/WPP, assuming that the contribution of other sources of pollution does not change after the elimination of electricity shortages
Tajikistan, actual 2019, estimate 2020-2021, forecast 2022-2050, mln USD/year



Source: Global Burden of Disease, Petromarket RG

When Tajikistan receives funding from international organisations for generation development, it is more suitable for the country to build HPPs rather than TPPs

Fall-winter electricity generation costs for new power plants at different real discount rates
Tajikistan, 2021 conditions, USD/MWh, export price: USD32/MWh

Total | CAPEX | OPEX (no fuel) | Fuel | Export revenues | Revenues from heat sales

At a **discount rate of 5%,** completing Rogun is more profitable than building a new HPP, but building a TPP is still less expensive than building a HPP

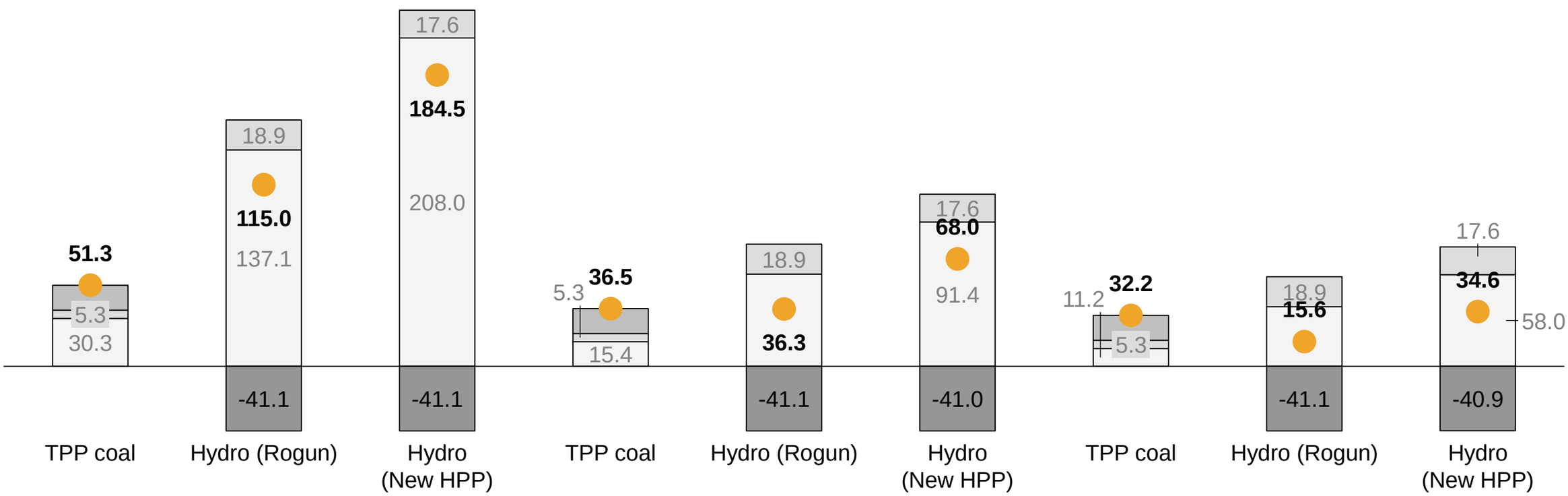
At a discount rate of 3%, building a new HPP is as profitable as building a TPP

Corresponds to a nominal rate of 5% - the overwhelming majority of Barki Tojik's loans from international organisations (see Annex) are at or below this rate.

10% discount rate

5% discount rate

3% discount rate

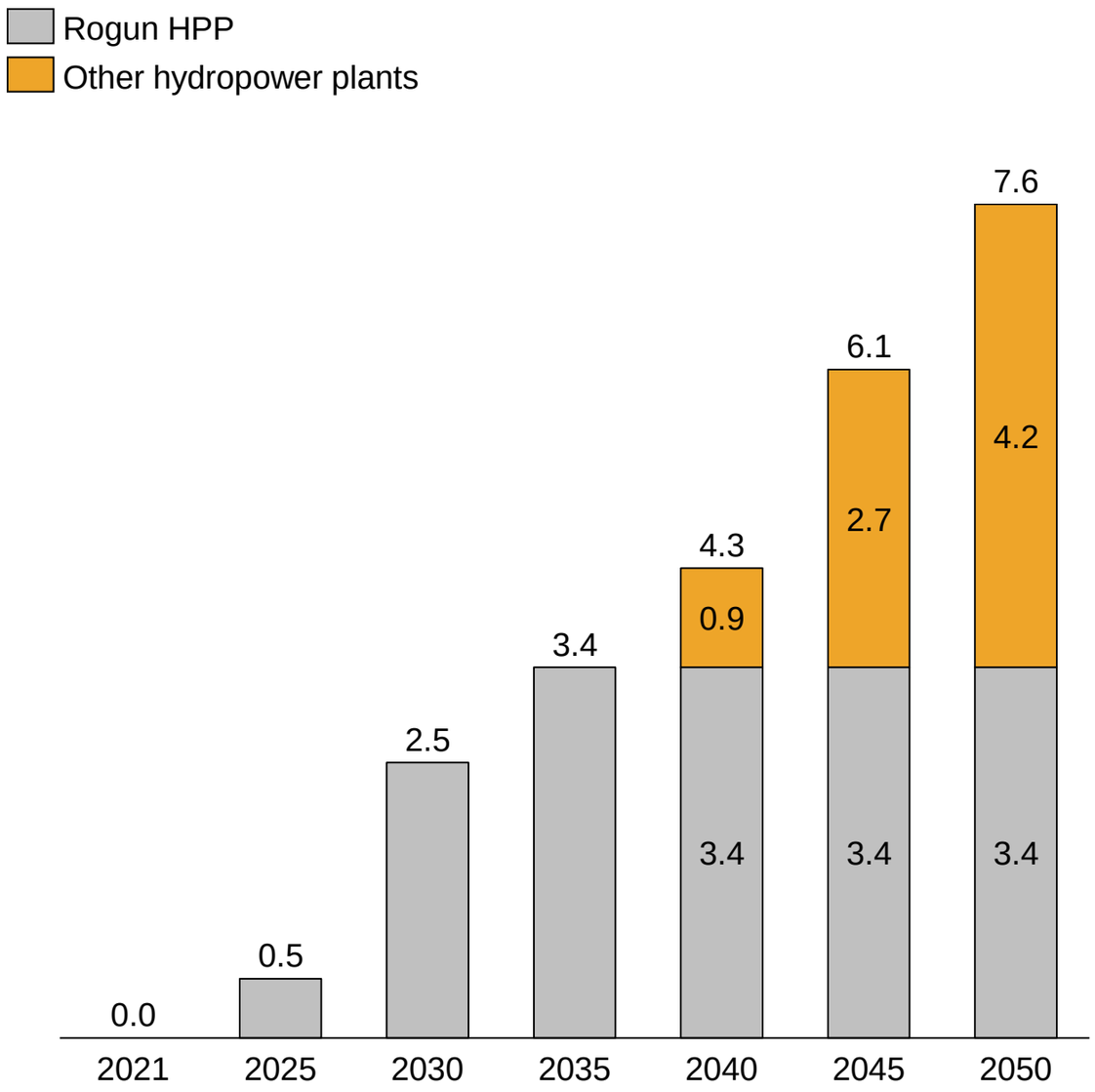


Source: ADB, IEA, Petromarket RG

Development of hydropower generation will generate tangible electricity exports from Tajikistan

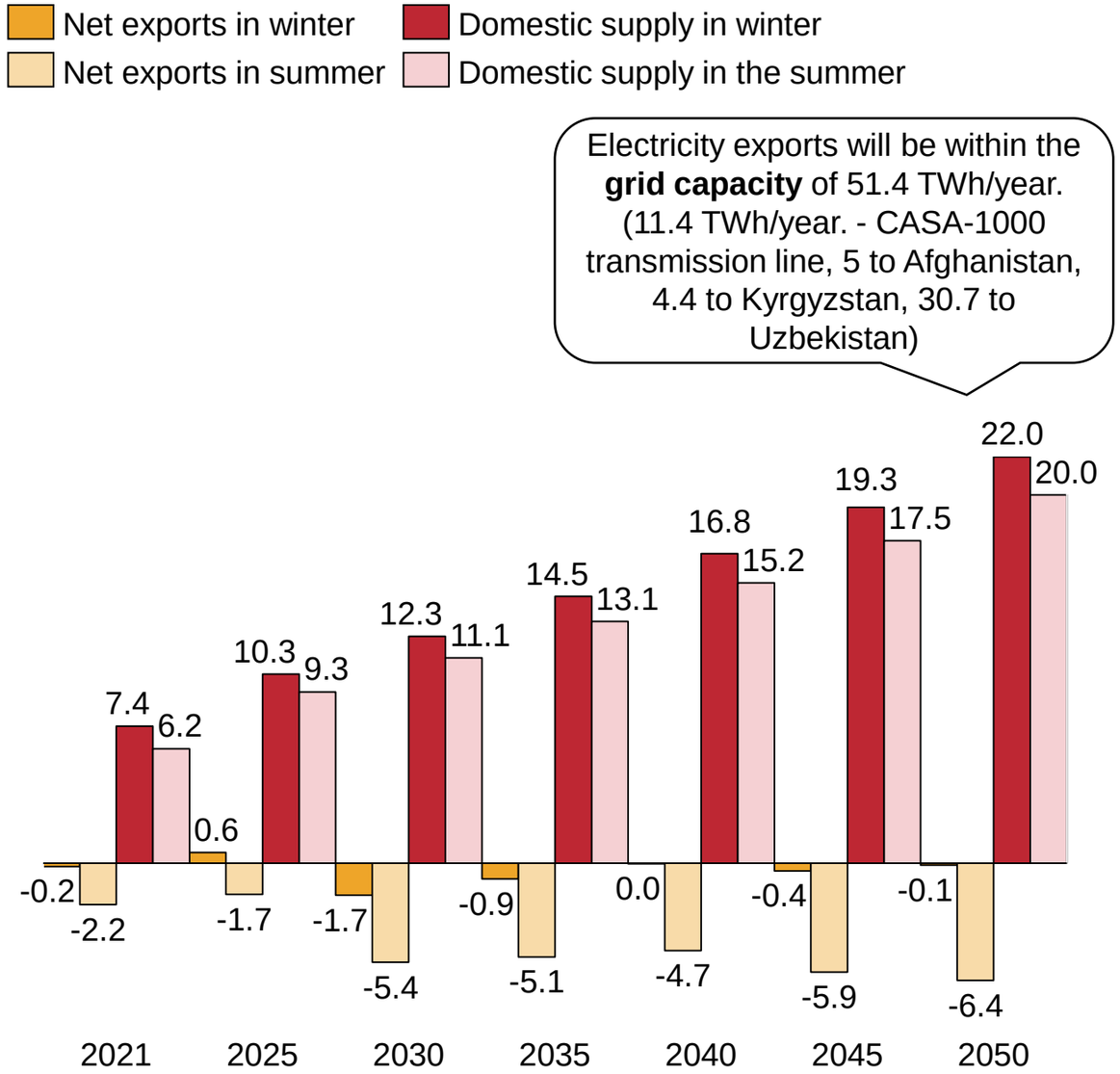
Required increase in hydropower capacity to meet electricity demand

Tajikistan, actual 2021, forecast 2022-2050, GWh



New export and supply to the domestic electricity market in spring-summer (April-September) and autumn-winter (October-March) periods

Tajikistan, actual 2021, forecast 2022-2050, TWh



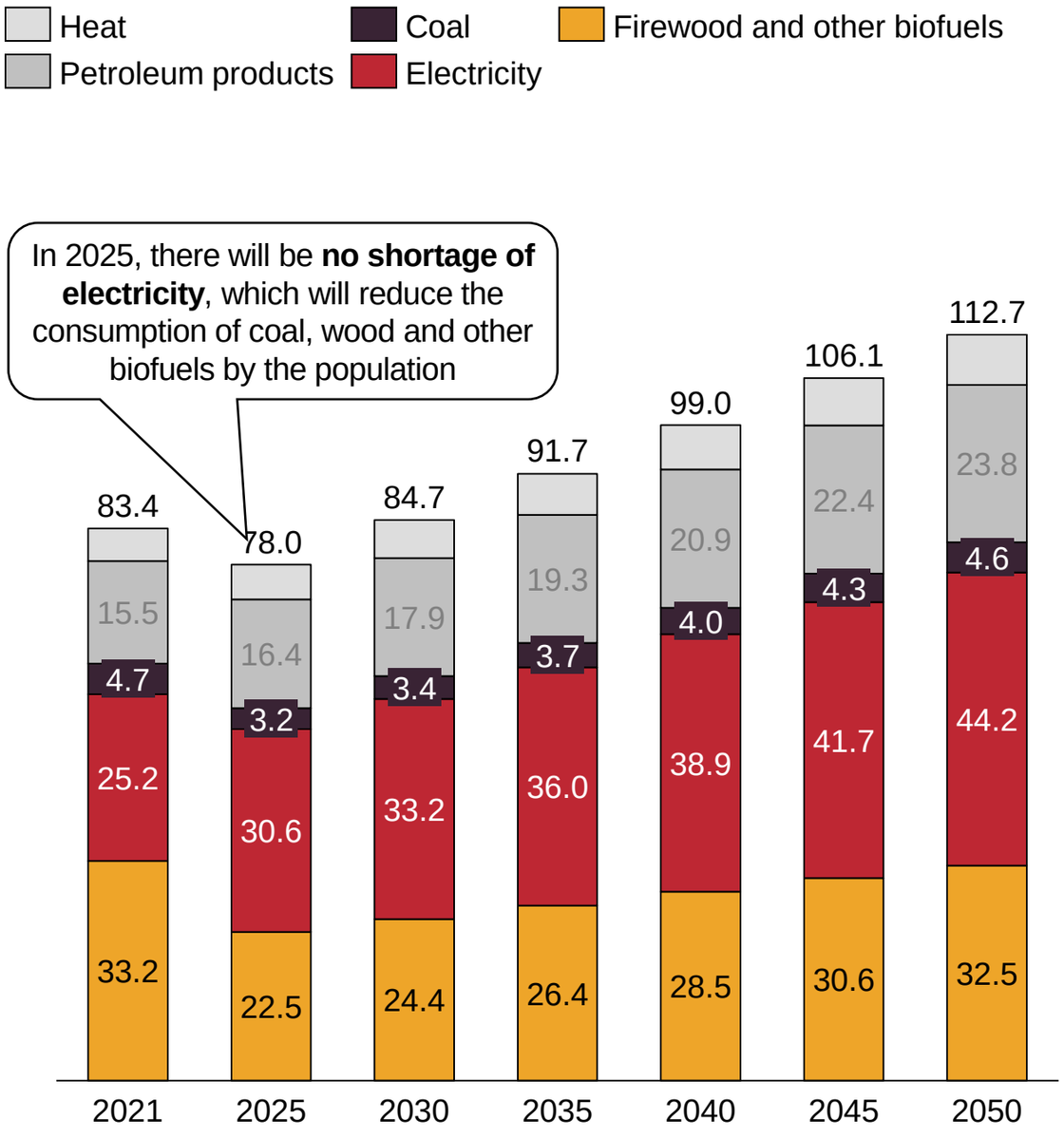
Source: Petromarket RG

Household demand forecast

Demand for coal from the population will decrease in 2025 due to the elimination of electricity shortages, then increase at the rate of population growth

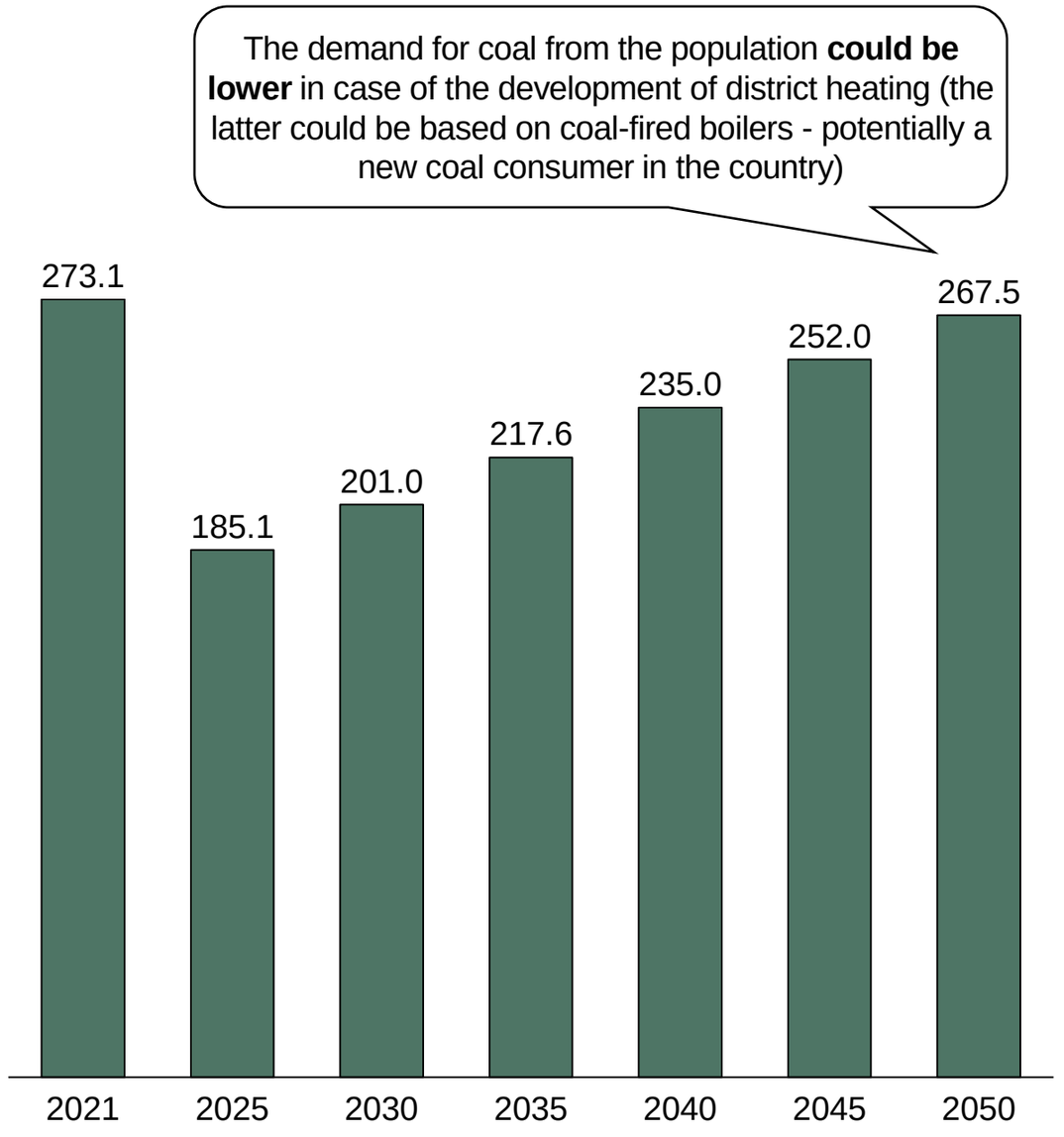
Gross residential energy consumption

Tajikistan, estimate 2021, forecast 2022-2050, GJ



Demand for coal from the population

Tajikistan, actual 2021, forecast 2022-2050, thousand tonnes

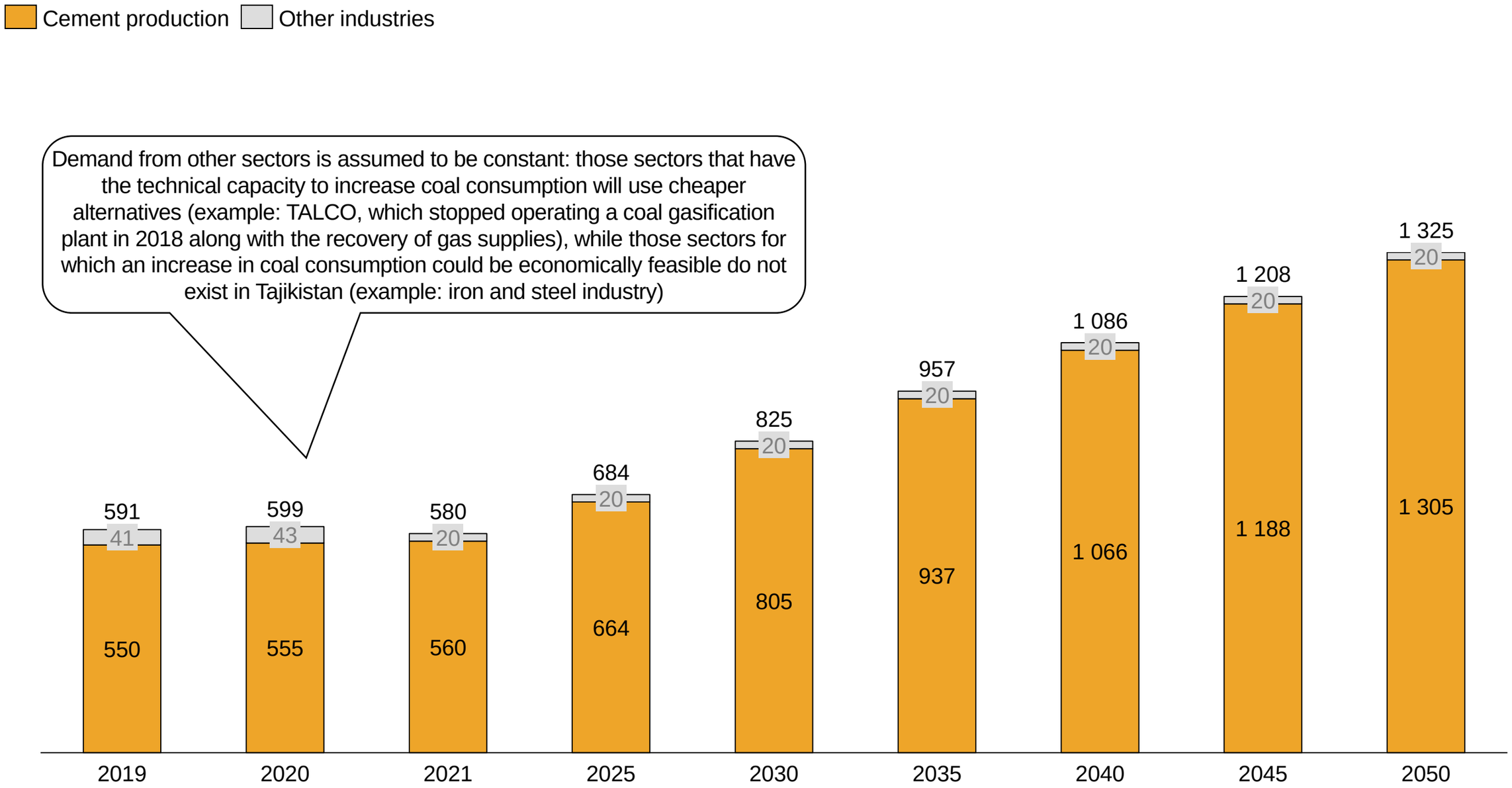


Source: MINT, Petromarket RG

Industry demand forecast

Industrial demand for coal will be driven by cement production: coal consumption by this industry will more than double by 2050 compared to 2021

Industrial demand for coal
Tajikistan, actual 2019-2021, forecast 2022-2050, thousand tonnes

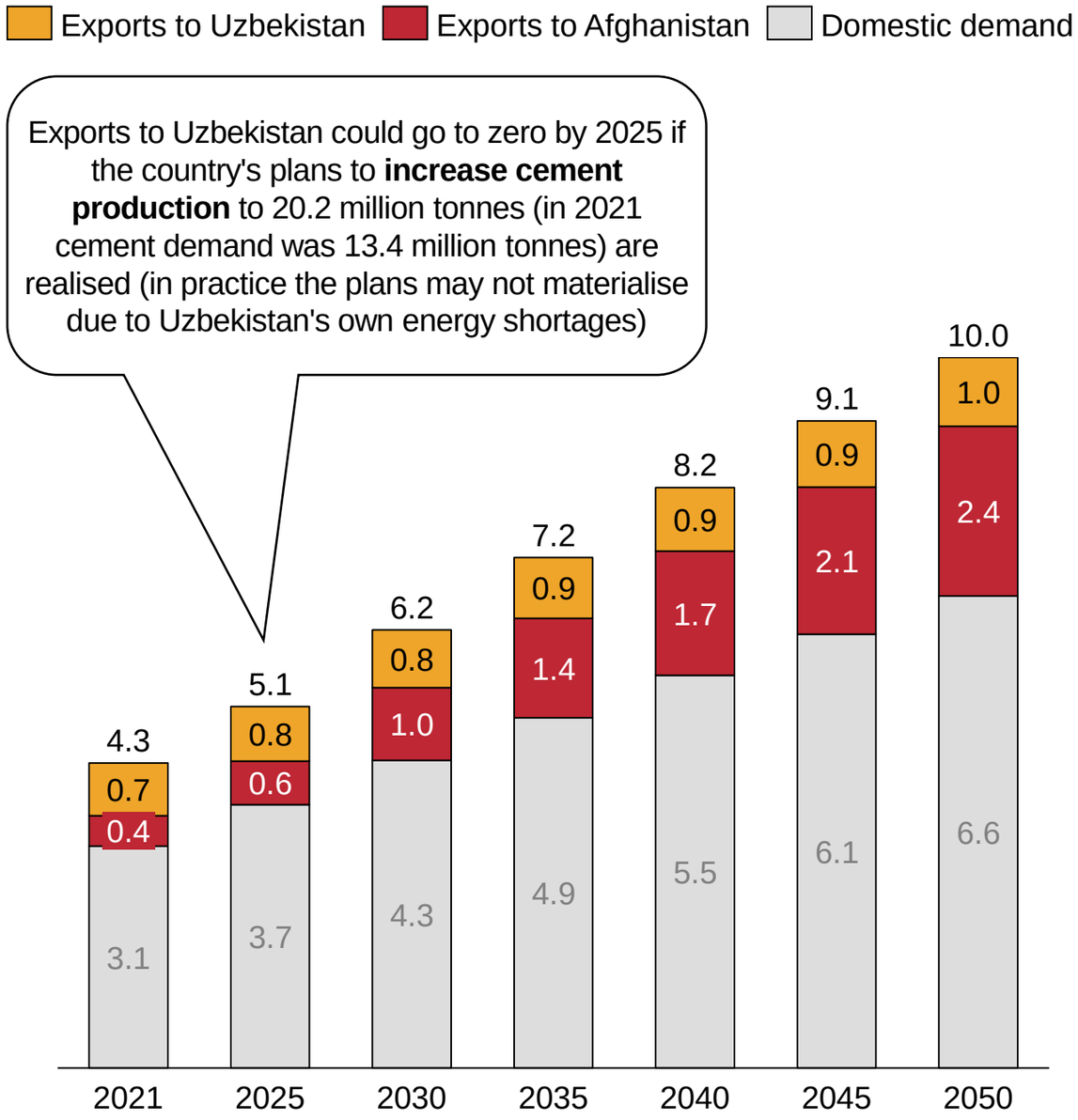


Source: MINT, Petromarket RG

Attempts to substitute coal for alternative fuels in cement production could lead to a significant reduction in cement exports (especially in light of plans by some cement-importing countries in Tajikistan to become import-independent)

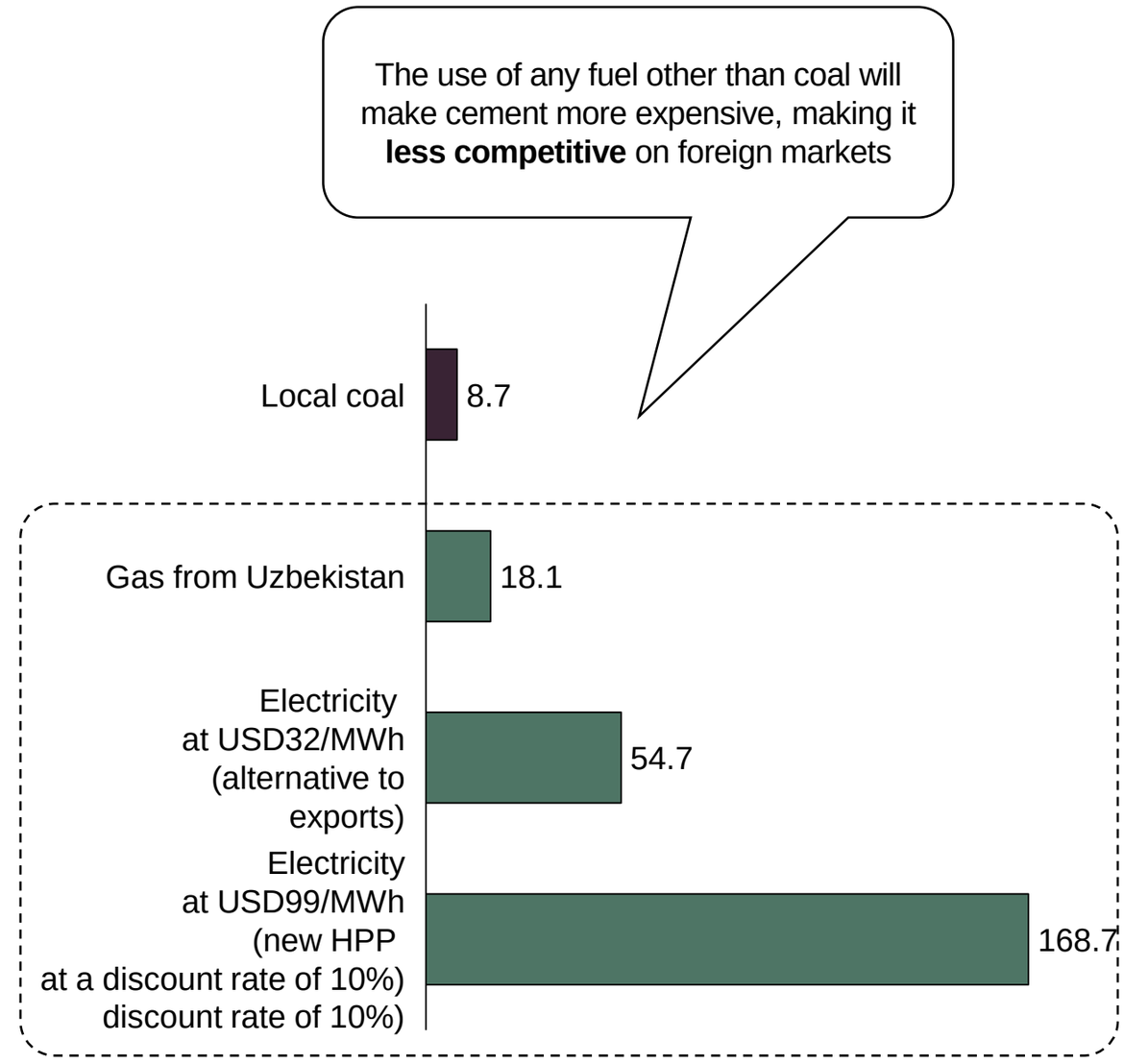
Demand for cement produced in Tajikistan

Actual 2021, Forecast: 2022-2050, million tonnes



Fuel costs of different fuels per unit of cement production

Tajikistan, 2021 conditions, USD/tonne of cement



Source: MINT, Petromarket RG

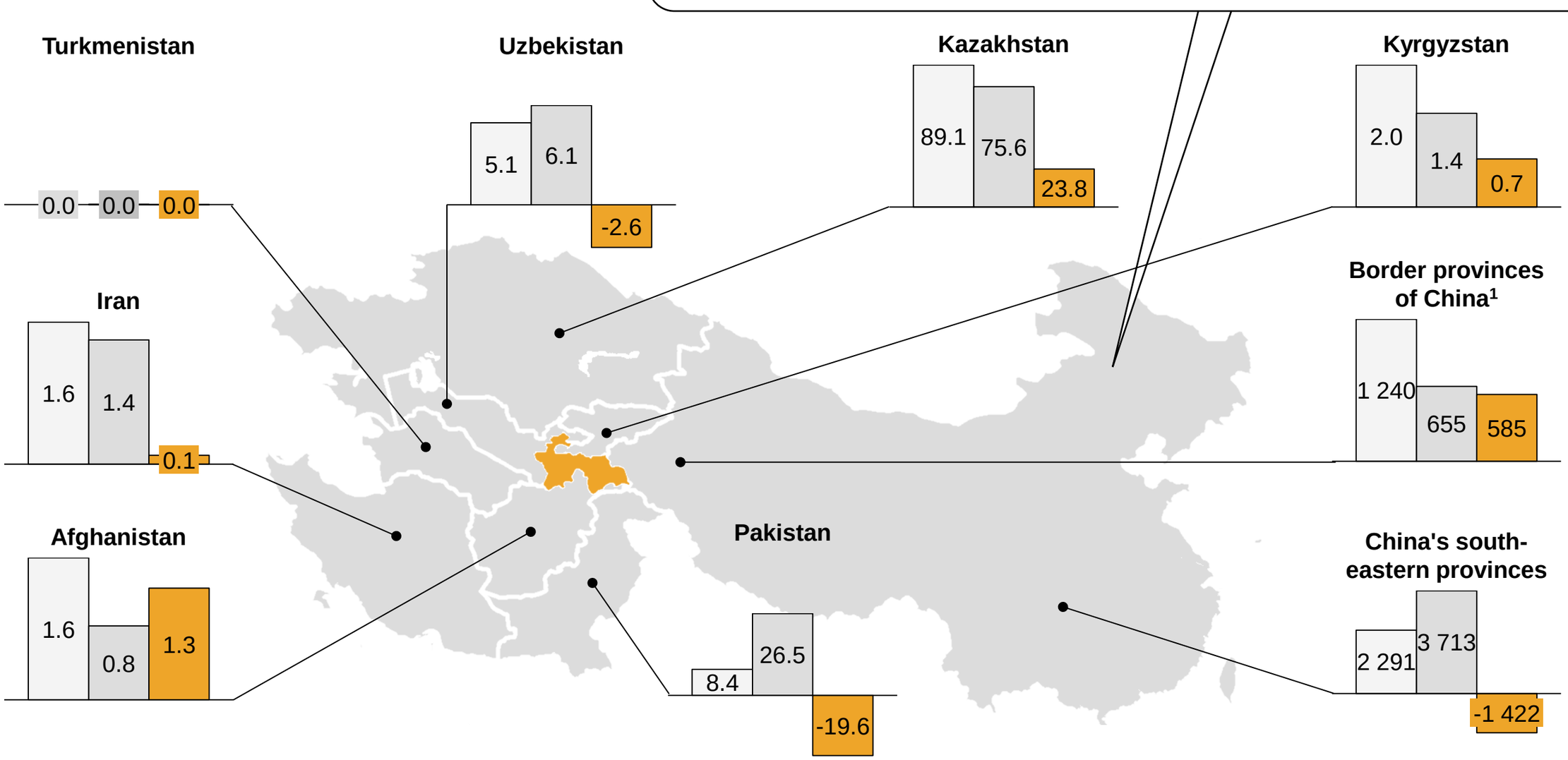
Exports forecast

Potential buyers of Tajik coal are neighbouring net importers of coal: Uzbekistan and Pakistan

Coal markets in Tajikistan's neighboring countries
China: 2018, other countries: 2021, million tonnes

Mining Consumption Net exports

Although **China** is generally a **net importer** of coal, the provinces bordering Tajikistan have no import requirements (are **net exporters** of coal), and exports from Tajikistan to the south-eastern provinces of China are **uncompetitive** compared to alternative supplies due to high logistics costs (transport by road)

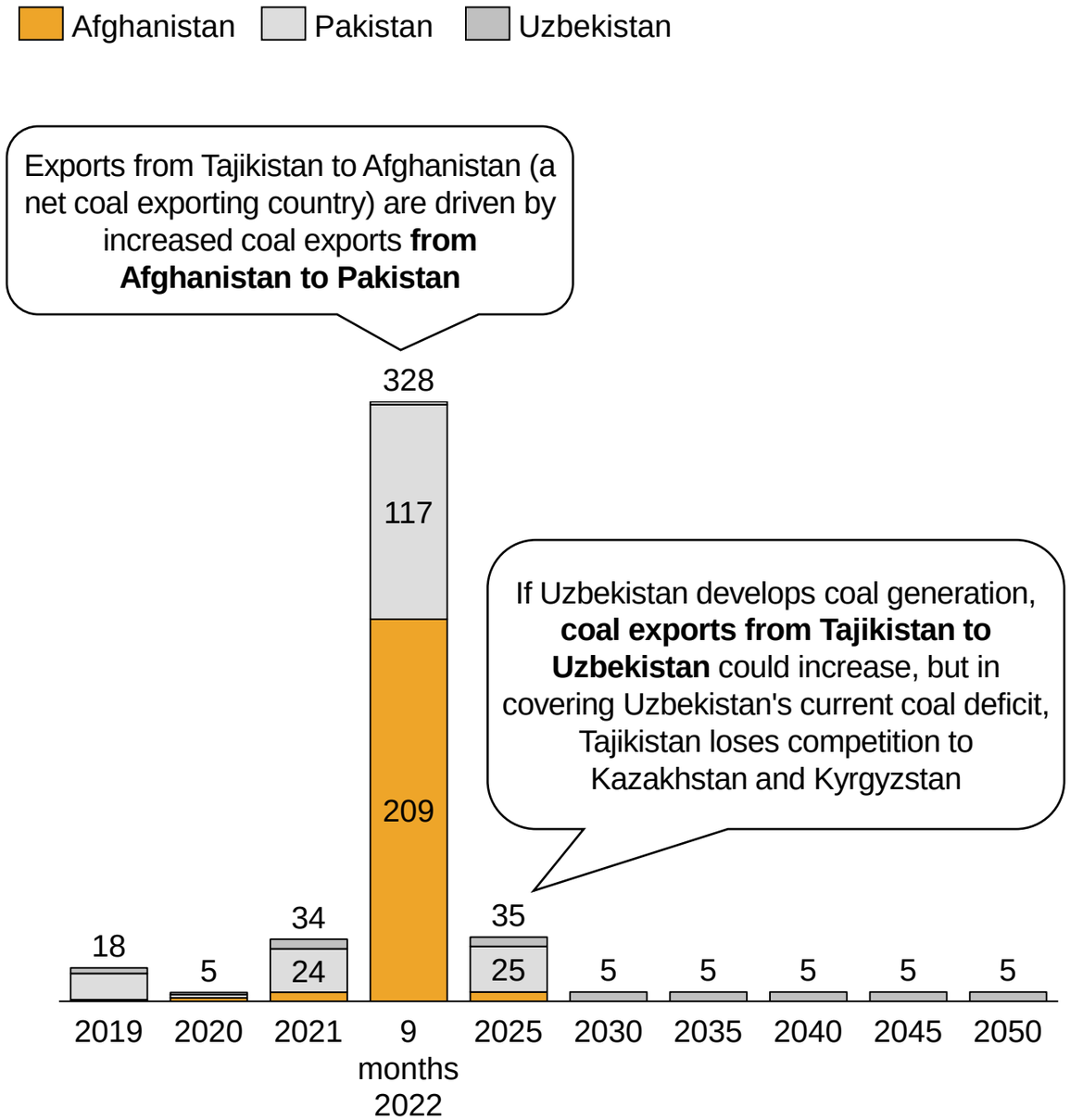


Notes:
1. Chinese border provinces include Gansu, Inner Mongolia, Xinjiang UAR, Qinghai and Tibet

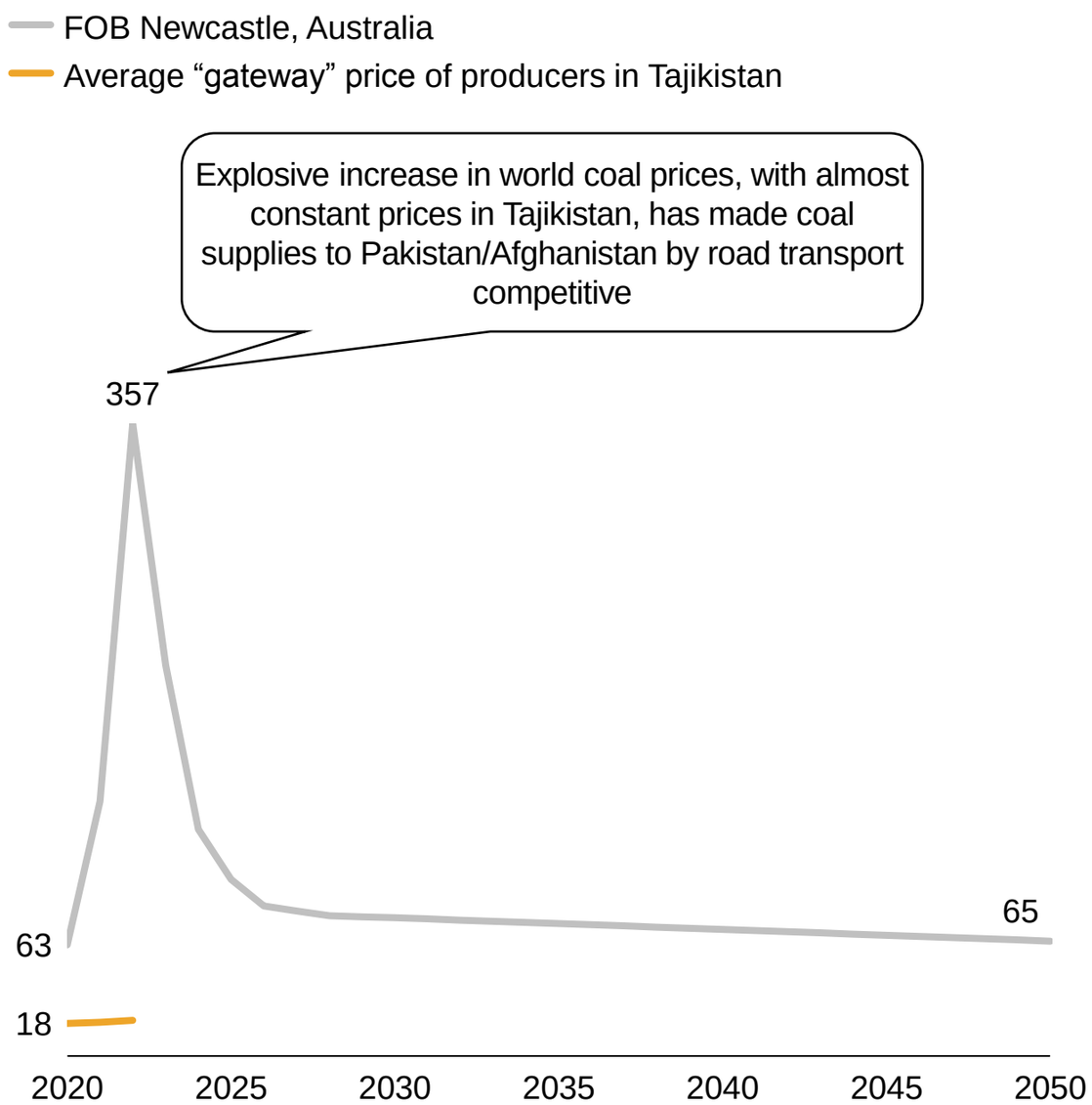
Source: EIA, UN, Petromarket RG

The sharp increase of coal exports from Tajikistan in 2022 is caused by an equally sharp increase of coal prices on the international market, but by 2025 prices will return to their 2021 level, leading to a decline in exports

Coal exports
Tajikistan, actual 2019-2022, forecast 2023-2050, thousand tonnes



Steam coal prices at FOB Newcastle and average "gateway" price of producers in Tajikistan
Actual 2020-2022, forecast 2023-2050, USD/tonne in 2021 prices



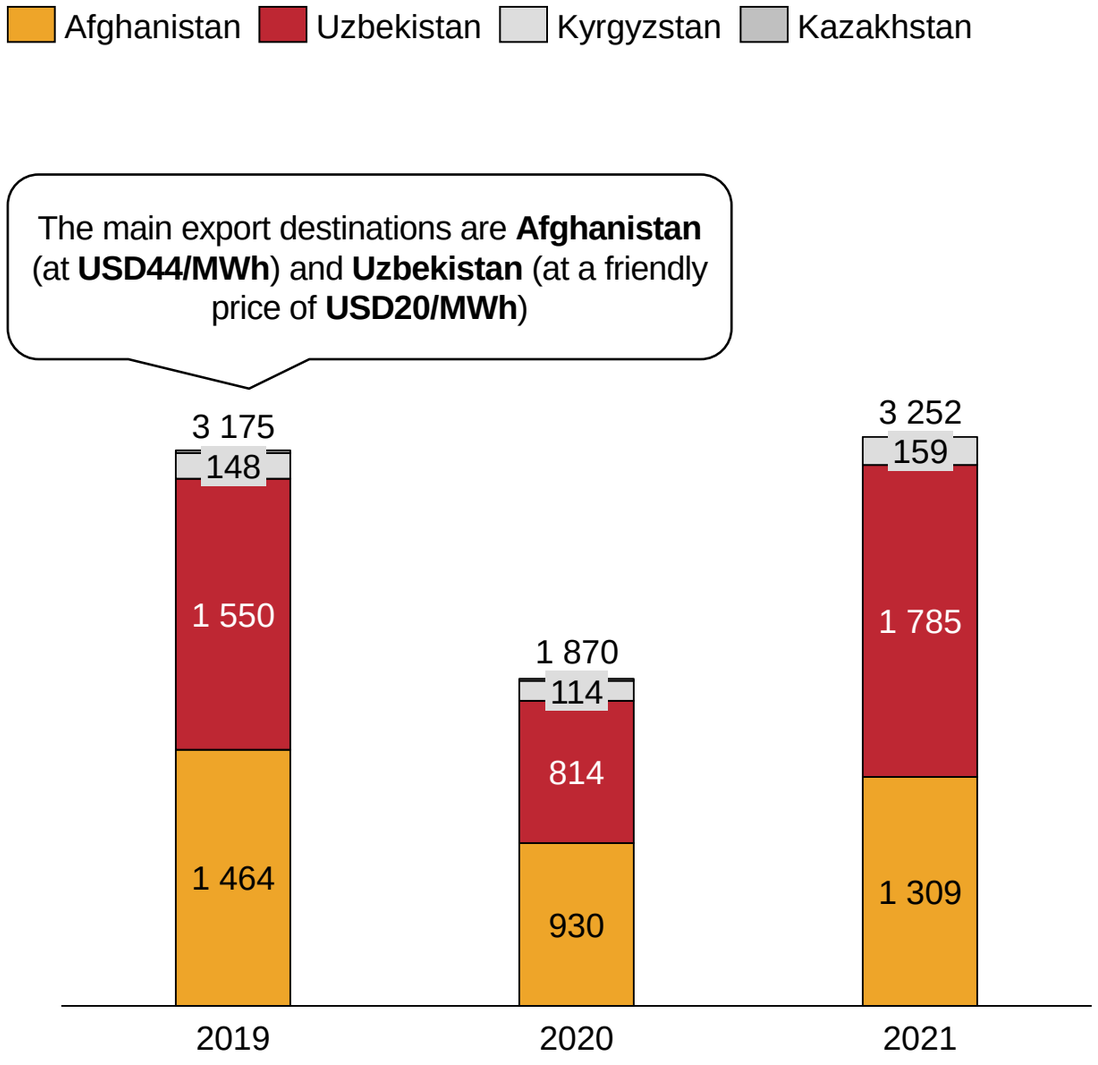
Source: MINT, Petromarket RG

F

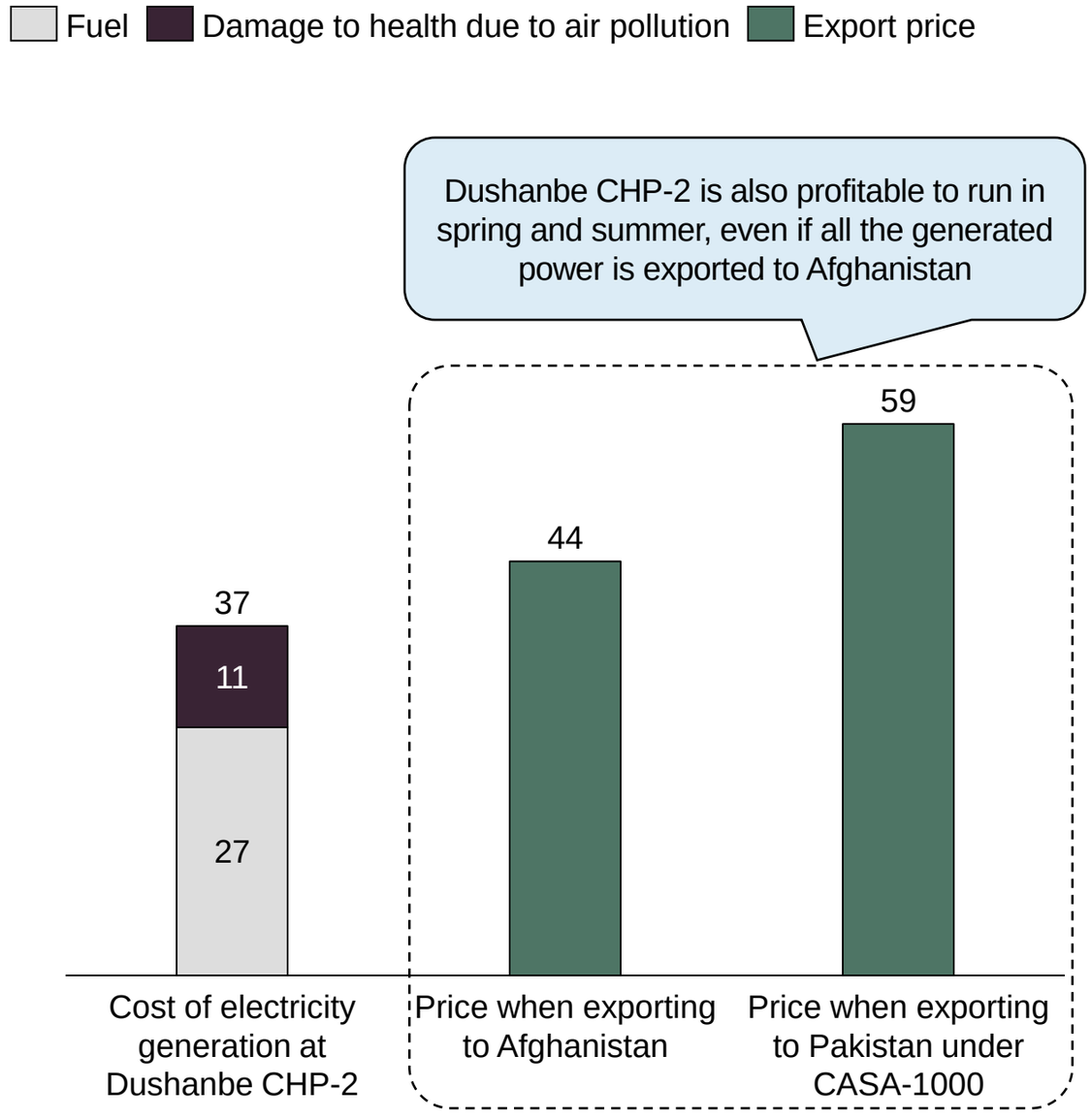
Appendix

Dushanbe CHP-2 is profitable to run in spring and summer for the purpose of generating electricity for export

Electricity exports by destination
Tajikistan, 2019-2021, GWh



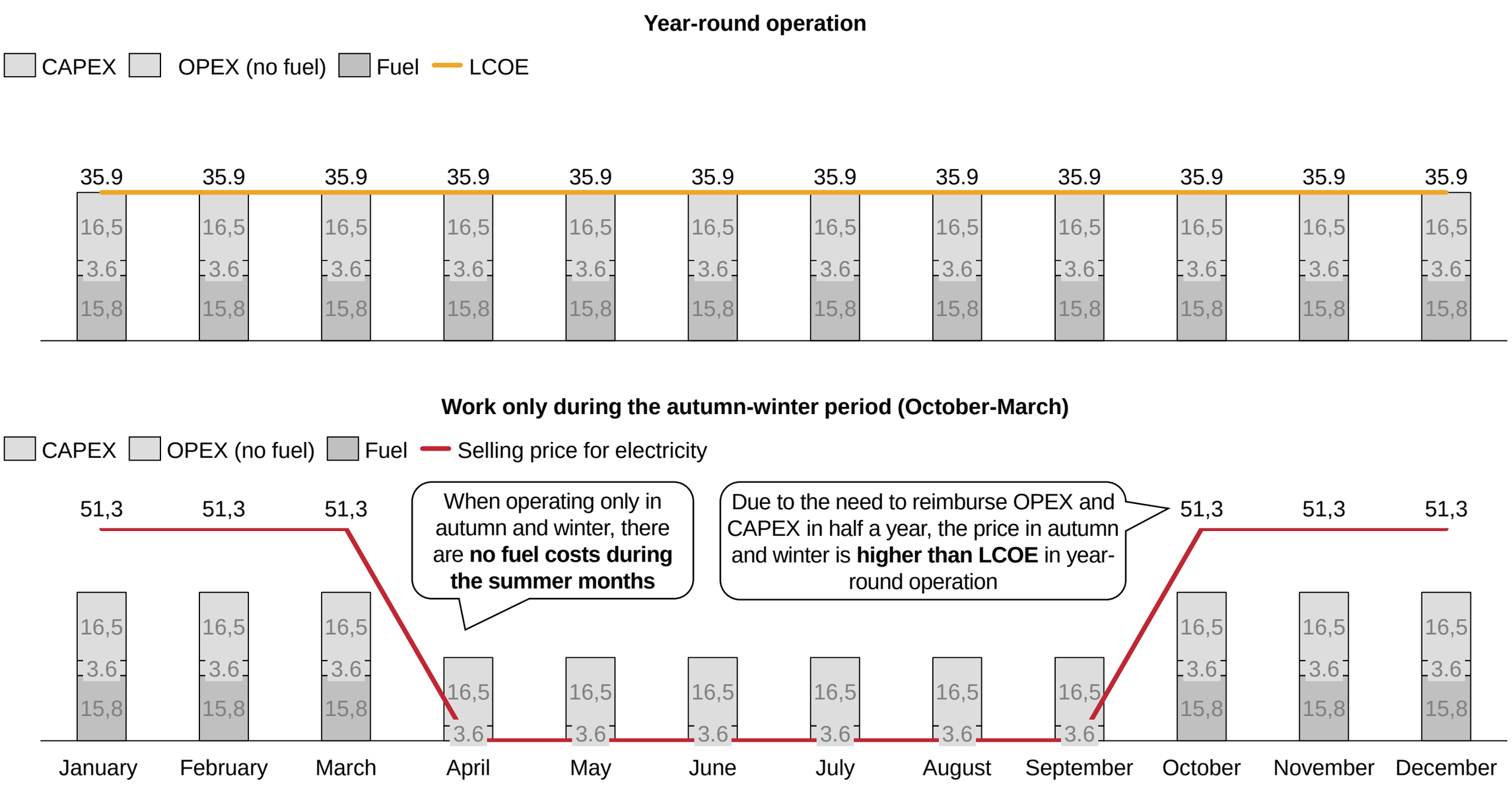
Potential electricity export prices and the cost of generating additional MWh from an already built coal-fired CHP plant
Tajikistan, USD/MWh, at 2021 prices



Source: Barki Tojik, Customs Committee of Tajikistan, Petromarket RG

The advantage of coal or gas-fired power plants is that they can only be run in autumn and winter

Cost of generating electricity from a coal-fired CHP plant
Tajikistan, 2021 conditions, USD/MWh, real discount rate: 10%

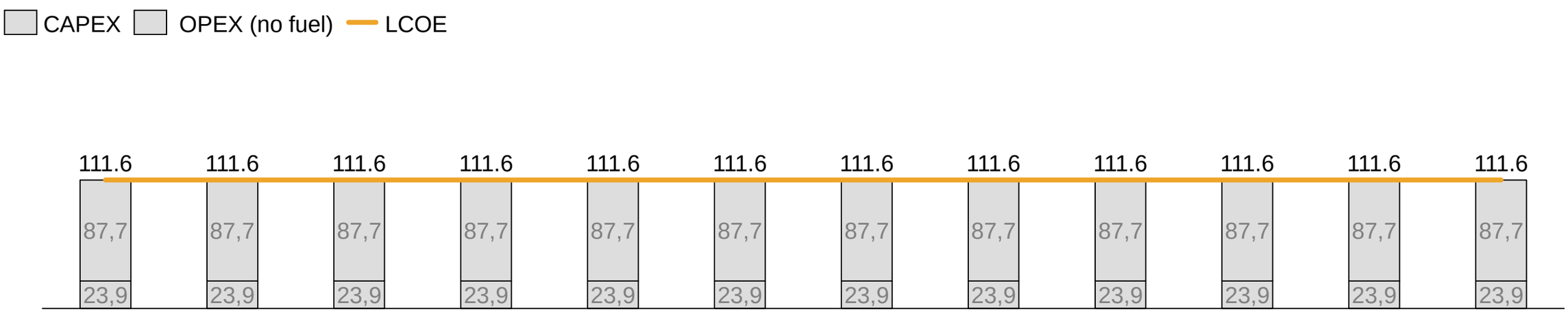


Source: ADB, IEA, Petromarket RG

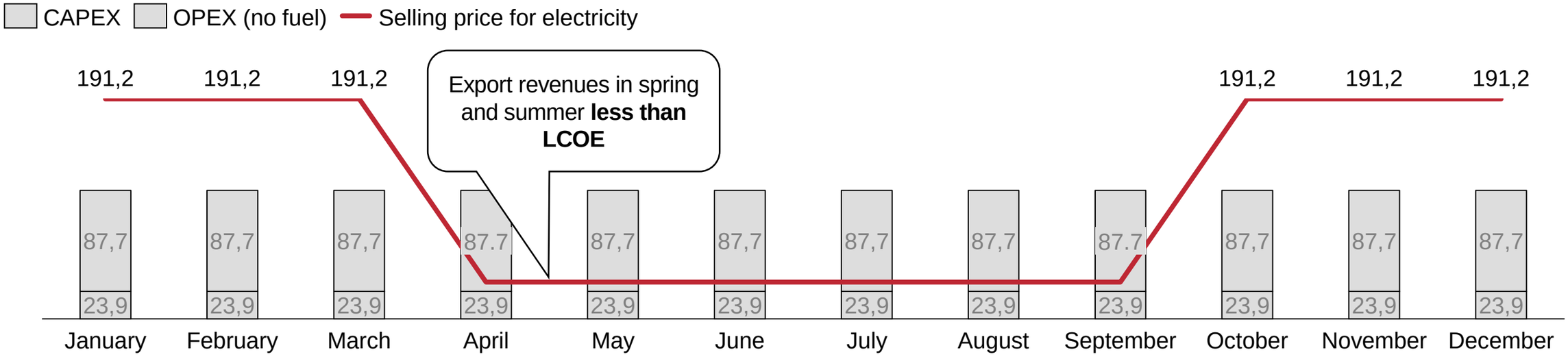
Renewable power plants have to sell electricity generated in the spring and summer to exports

Cost of wind power generation
Tajikistan, conditions 2021, USD/MWh, discount rate: 10%, export price: USD32/MWh

Year-round domestic supply



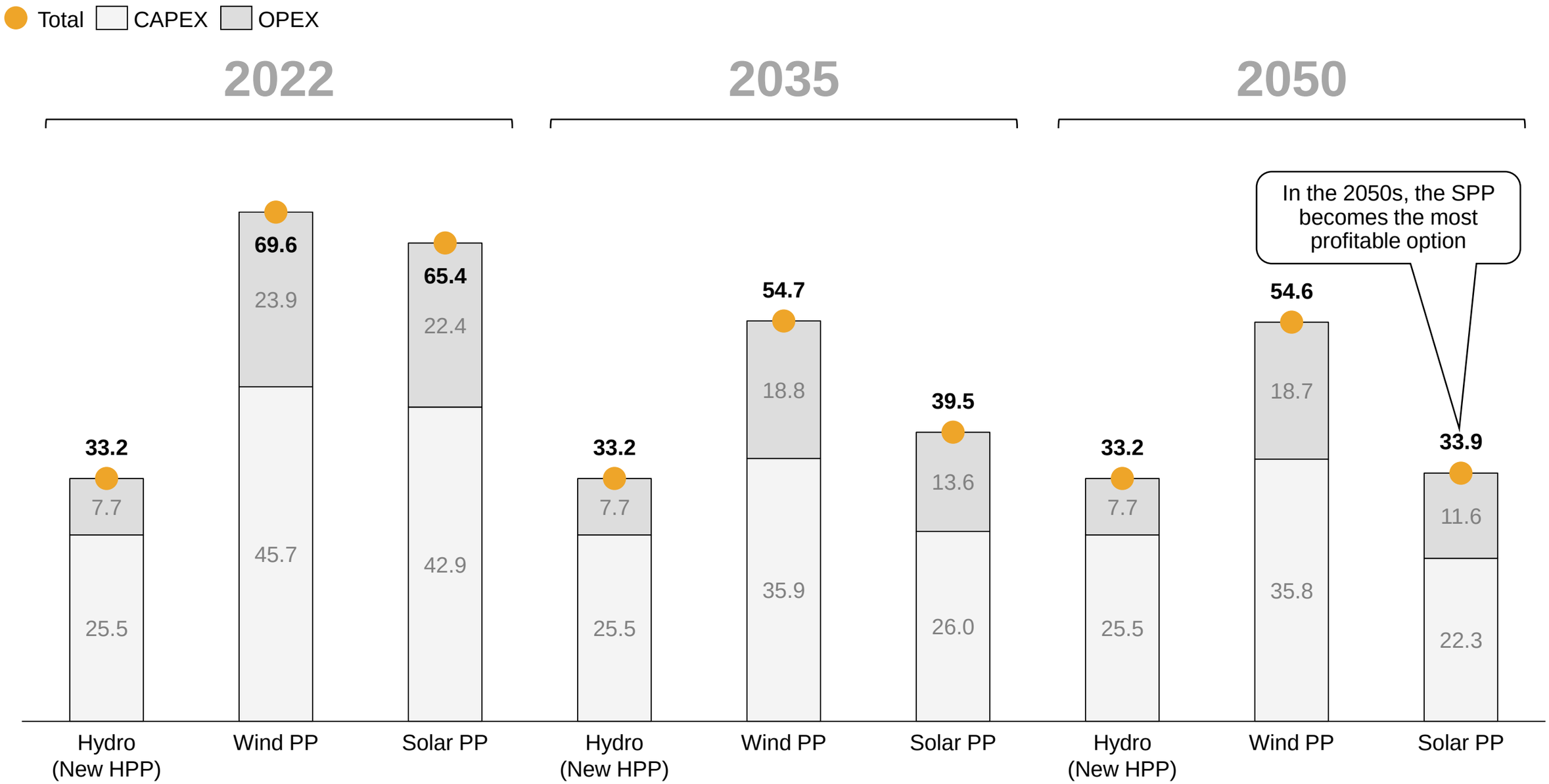
Exports in April-September and domestic supplies in October-March



Source: ADB, IEA, Petromarket RG

Despite the decline of the costs of generation at SPP and WPP new HPP is still the most profitable option even in 2050

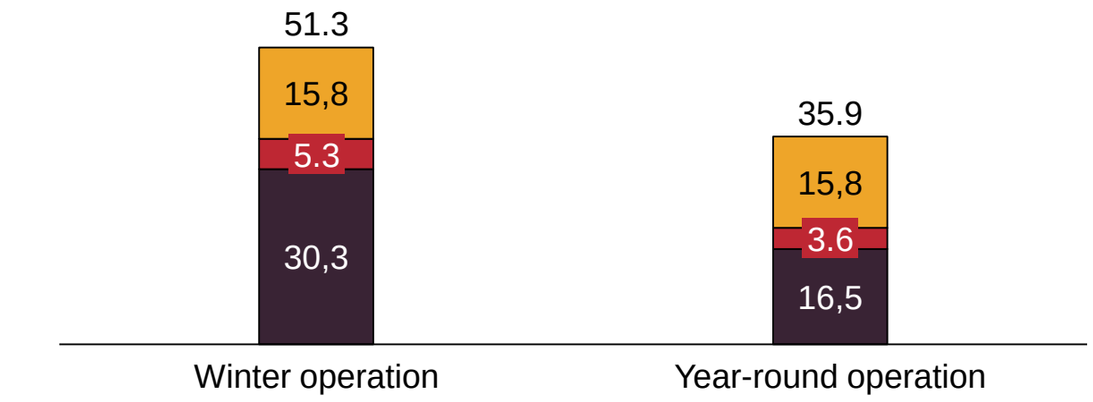
Electricity generation costs for new HPPs, SPP and WPPs depending on the year of project implementation
Tajikistan, 2021 conditions, USD/MWh, real discount rate: 3%



Source: ADB, IEA, BP, Petromarket RG

The coal-fired TPP, located in the Fon Yaghnob coal field, is the cheapest way to reduce electricity shortages in autumn and winter

Cost of electricity generated by coal-fired TPP in different modes of operation
Tajikistan, conditions 2021, USD/MWh



Pros and cons of coal-fired TPP
Tajikistan, conditions 2021

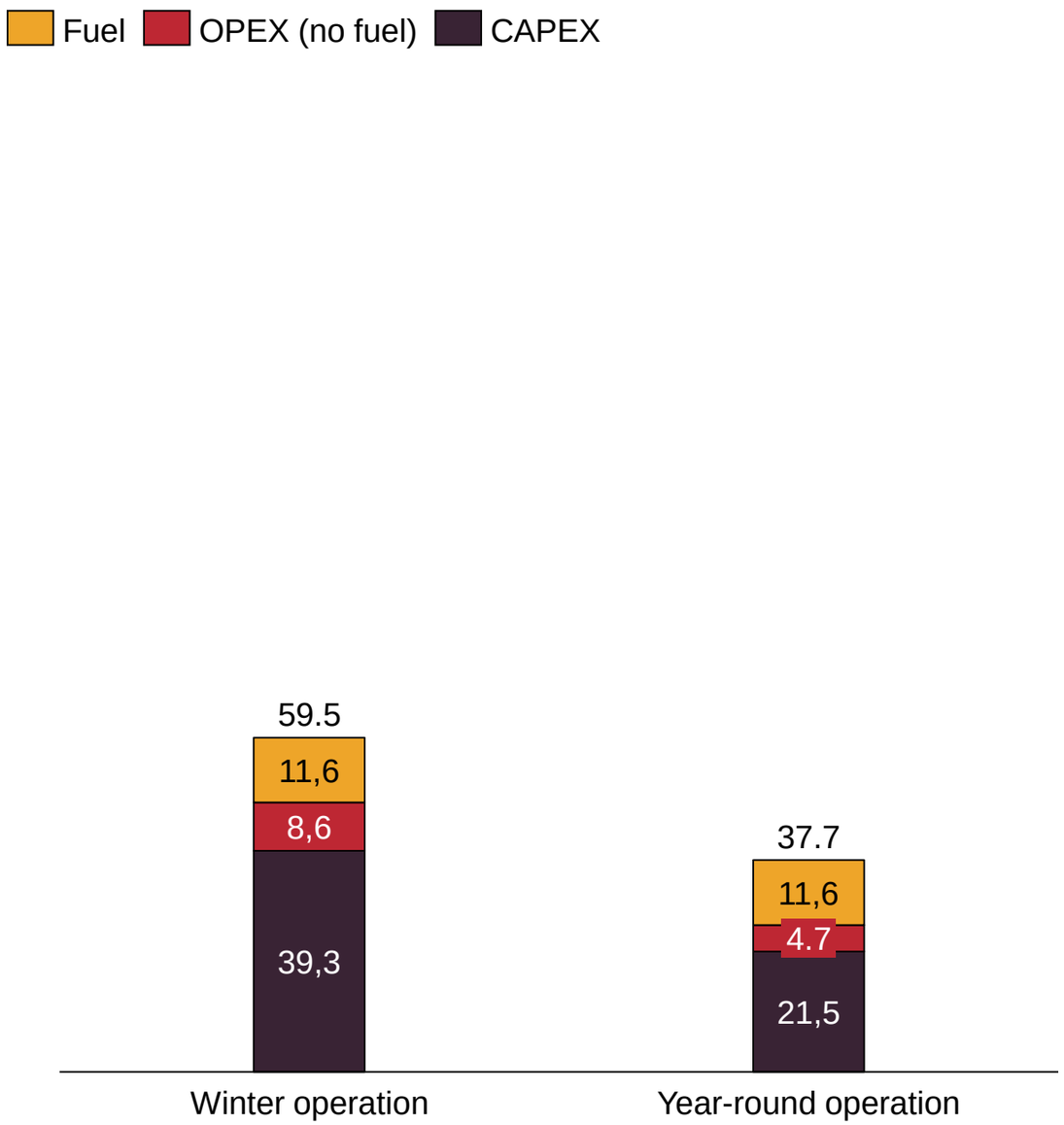
- **The cheapest option** for generation electricity in autumn and winter
- The location near the Fon-Yaghnob **mine will save on the cost of delivering**

- **Highest GHG emissions per MWh**

Source: MINT, Barki Tojik, Petromarket RG

Generating electricity from a coal-fired HELE power plant (high efficiency, low emissions, supercritical power plant operation) will cost 16% more, but will reduce coal consumption and greenhouse gas emissions by 27%

Cost of electricity generated by coal-fired HELE TPP in different modes of operation
Tajikistan, conditions 2021, USD/MWh



Pros and cons of coal-fired HELE TPP
Tajikistan, 2021 conditions

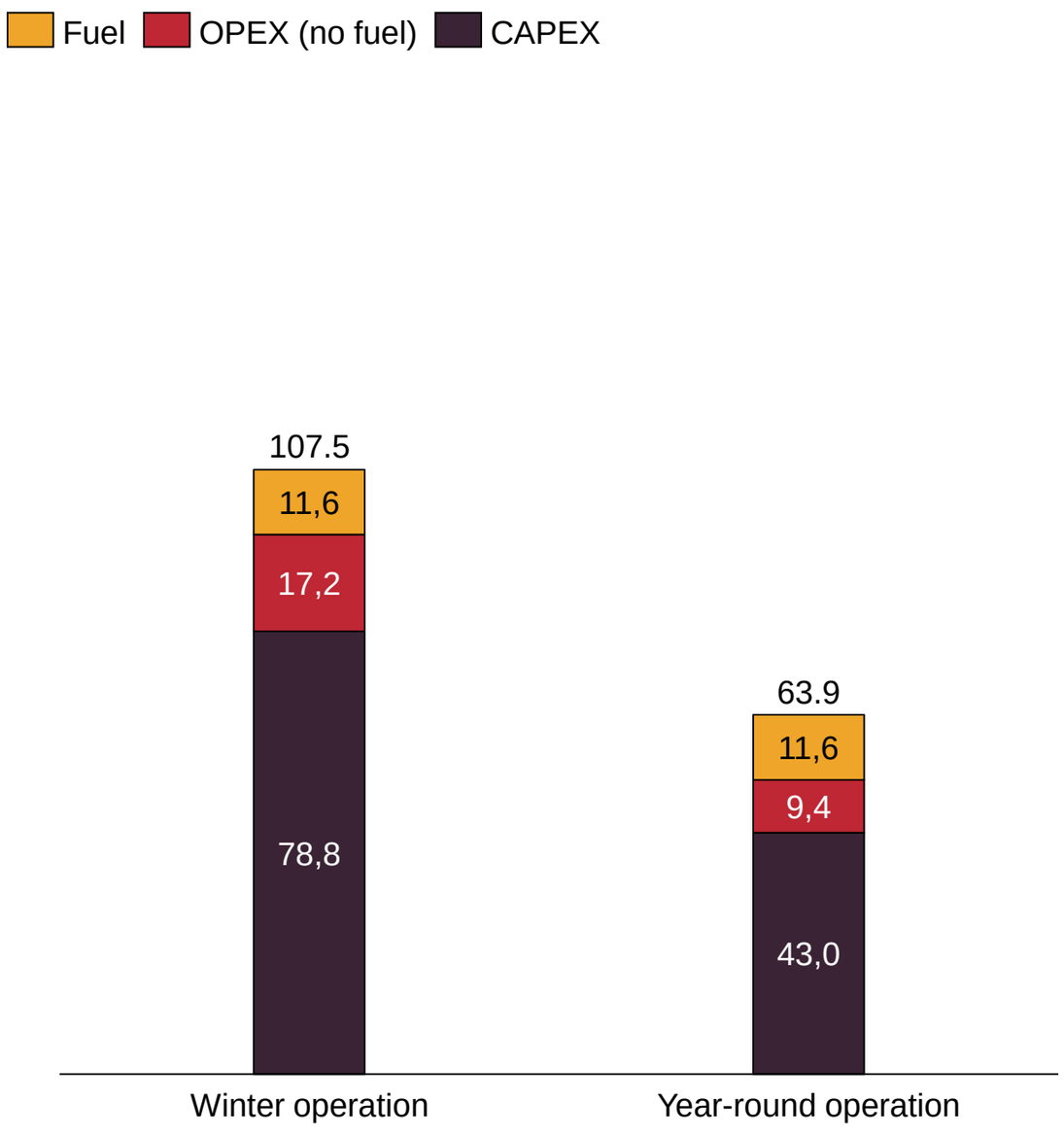
✓
- **Specific coal consumption** per kWh and, consequently, GHG emissions from coal combustion per 1 MWh are **27% lower** than those from a conventional coal-fired TPP
- Location near the Fon-Yaghnob coal deposit will enable to **save on the cost of coal delivery** to the power plant

✗
- Due to the cheapness of coal and lack of CO_2 emission charges in Tajikistan, fuel savings **do not pay off higher CAPEX**

Source: MINT, Barki Tojik, Petromarket RG

Generation of electricity at coal-fired HELE TPP with carbon capture and sequestration (CCS) is twice as expensive as generation at a conventional TPP, and more expensive than generation at the Rogun HPP, while not completely reducing greenhouse gas emissions

Cost of electricity generated by coal-fired HELE+CCS TPP in different modes of operation
Tajikistan, conditions 2021, USD/MWh



Pros and cons of coal-fired HELE + CCS TPP
Tajikistan, 2021 conditions

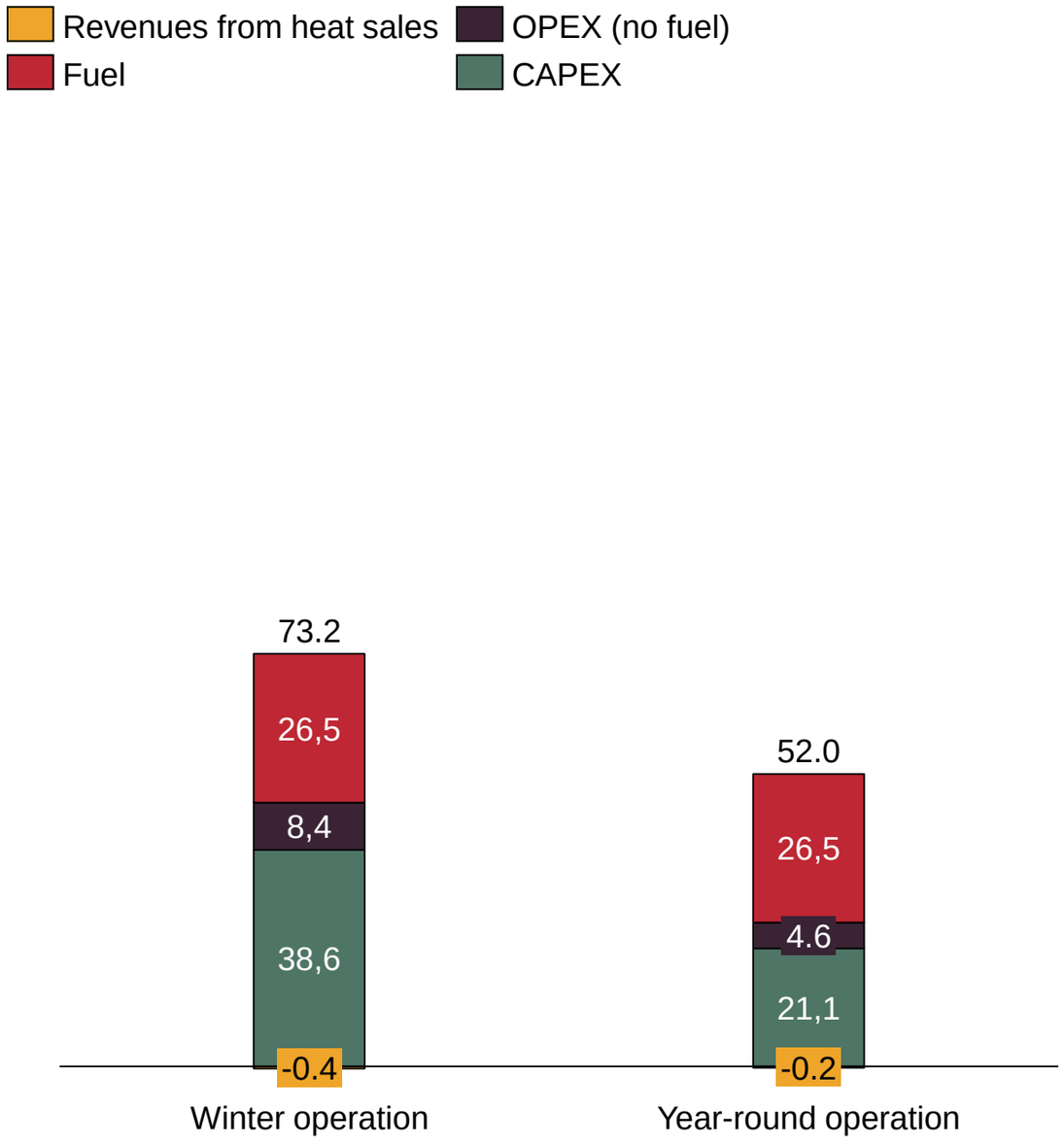
✓
- **Emissions** per 1 MWh are 93% lower than those of conventional TPP
- Location near the Fon-Yaghnob mine **will save on the cost** of coal delivery to the TPP

✗
- The cost of electricity will be **twice as high** as in a conventional TPP
- Tajikistan **lacks infrastructure** for transportation and injection if CO_2
  - the most common option in the world to inject CO_2 – into oil reservoirs to enhance oil recovery – **is not applicable in Tajikistan** in the form of almost no oil production (less than 25 thousand tons in 2021)

Source: MINT, Barki Tojik, Petromarket RG

Construction of Dushanbe's coal-fired CHP-3 will make it possible to produce heat in addition to electricity, but the price at which heat is sold is not enough to recoup the higher cost of coal, including delivery

Cost of electricity generated by coal-fired CHP in different modes of operation
Tajikistan, conditions 2021, USD/MWh



Pros and cons of coal-fired CHP
Tajikistan, conditions 2021

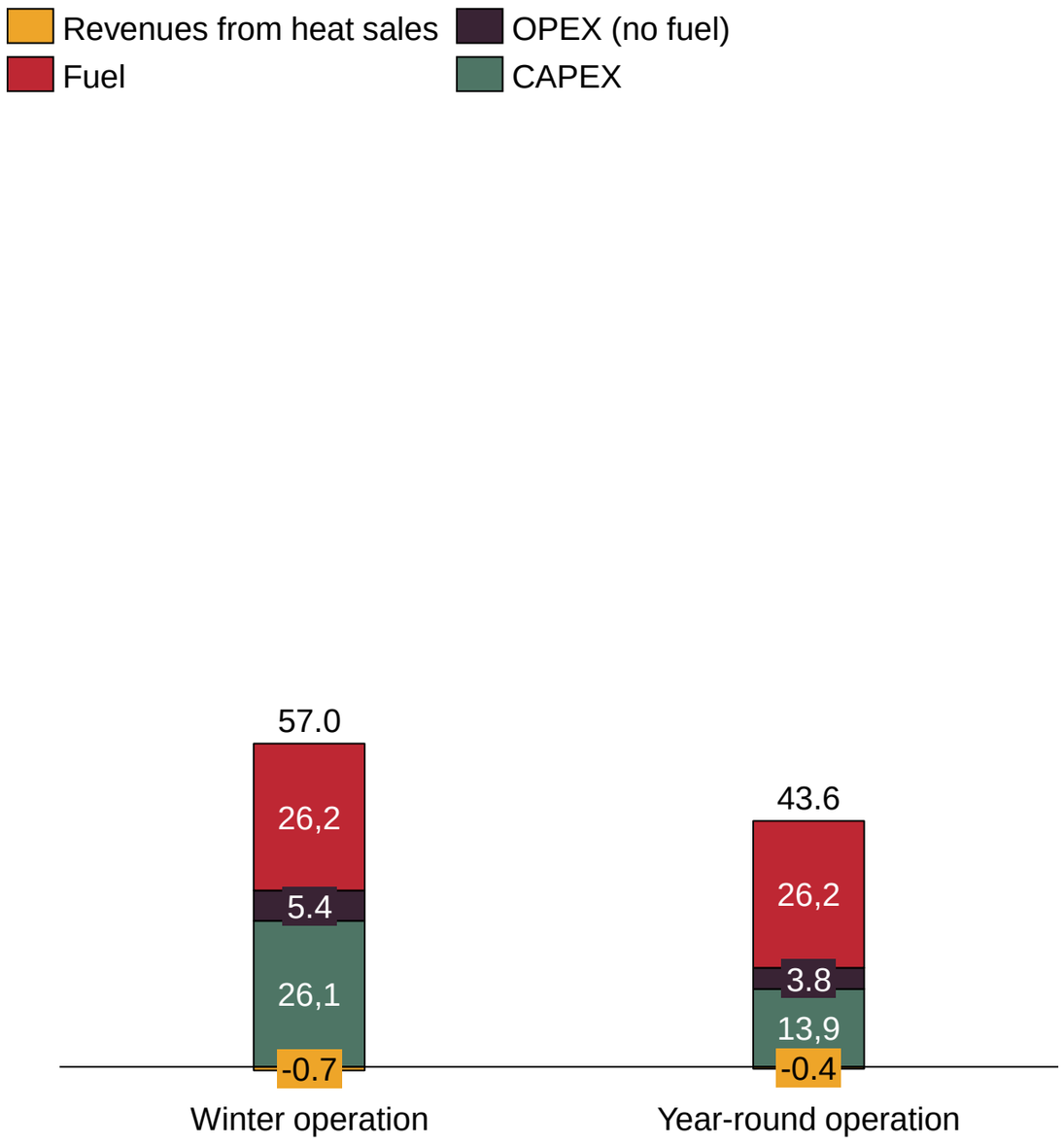
✓
- Generation of heal for supply to the district heating system in Dushanbe will reduce the demand for electricity for heating in the capital, which will further **reduce the electricity deficit**

✗
- Coal is **40% more expensive** than the TPPs located in the Fon-Yaghnob field due to logistics costs
- Dushanbe CHPs sell electricity for only 17 somoni/Gcal, which makes **it impossible to recoup the higher costs** compared to the CHPs

Source: MINT, Barki Tojik, Petromarket RG

Construction of Dushanbe CHP-3, which runs on natural gas, will make it possible to produce heat in addition to electricity, but Tajikistan depends on imported gas from Uzbekistan

Cost of electricity generated by gas-fired CHP in different modes of operation
Tajikistan, conditions 2021, USD/MWh



Pros and cons of gas-fired CHP
Tajikistan, conditions 2021

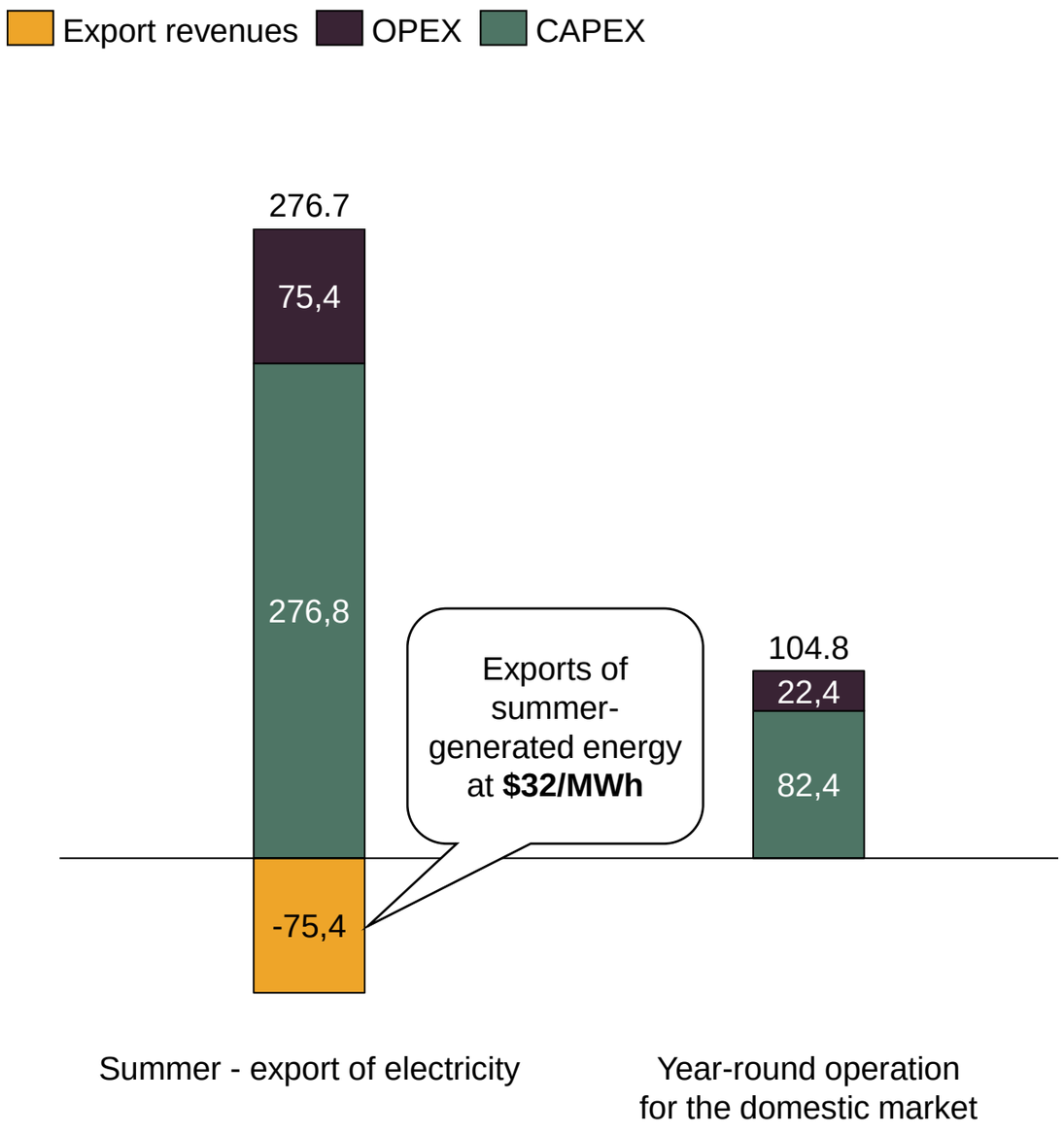
✓
- Generation of heal for supply to the district heating system in Dushanbe will reduce the demand for electricity for heating in the capital, which will further **reduce the electricity deficit**
- **Emissions** per 1 MWh are 33% lower than those of the coal-fired TPP

✗
- **Dependence** on gas supplies from Uzbekistan
  - there has already been a precedent of the partner state cutting off fuel supplies in the past

Source: MINT, Barki Tojik, Petromarket RG

Solar power plant is the most expensive option due to high capital costs, but SPP can be installed in hard-to-reach areas (e.g., GBAO)

The cost of electricity generated by solar power plants in different modes of operation
Tajikistan, conditions 2021, USD/MWh



Pros and cons of solar power plant
Tajikistan, conditions 2021

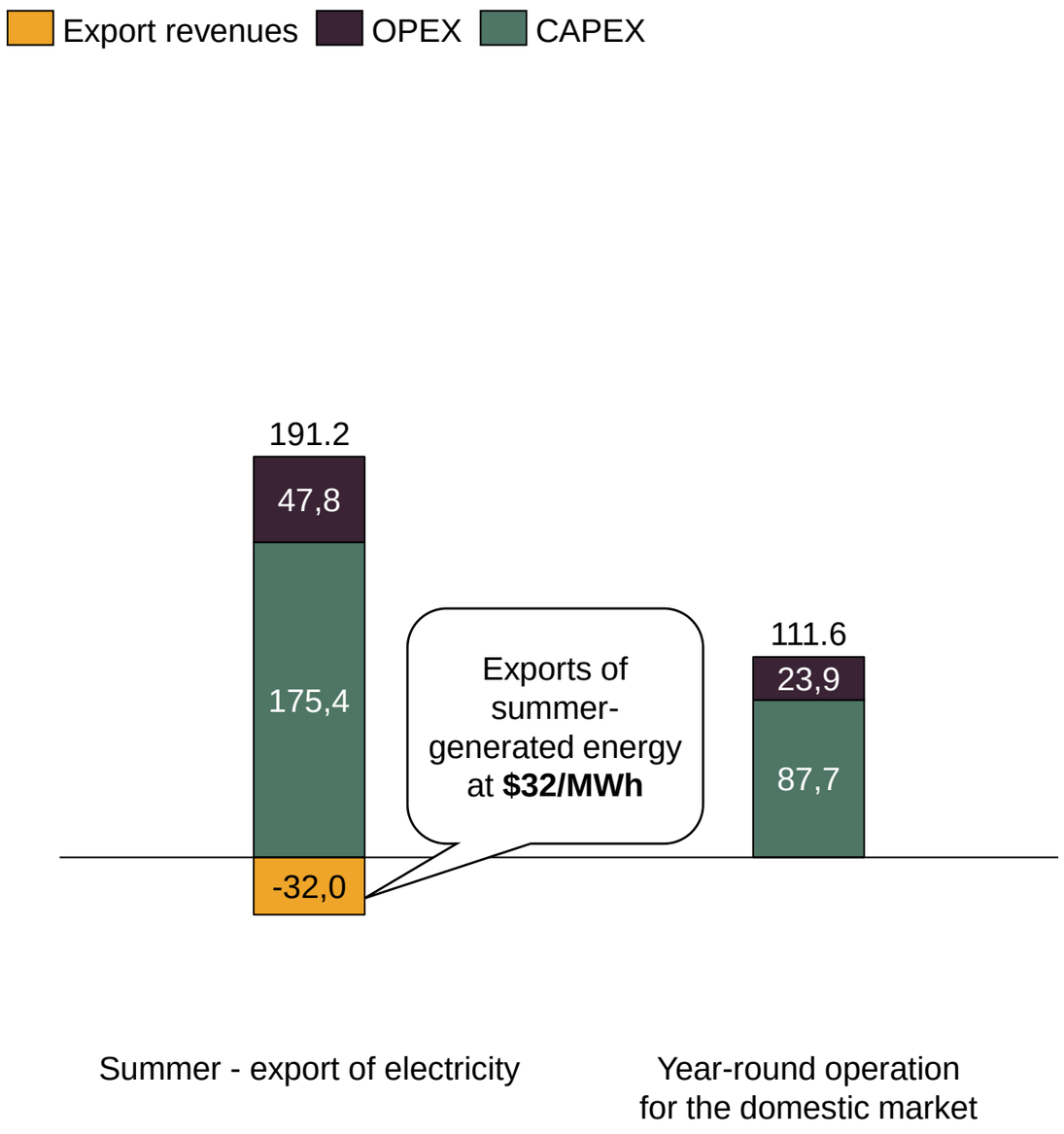
✓
- **No emissions**
- Can be installed in **hard-to-reach areas** (e.g., GBAO)

✗
- **Highest cost** among considered options
- **Low output** in winter

Source: ADB, IEA, BP, Petromarket RG

Building a wind power plant is more economically feasible than a solar power plant, and it can also be installed in areas that are difficult to access

Cost of electricity generated by wind power plants in different modes of operation
Tajikistan, conditions 2021, USD/MWh



Pros and cons of wind power plant
Tajikistan, 2021 conditions

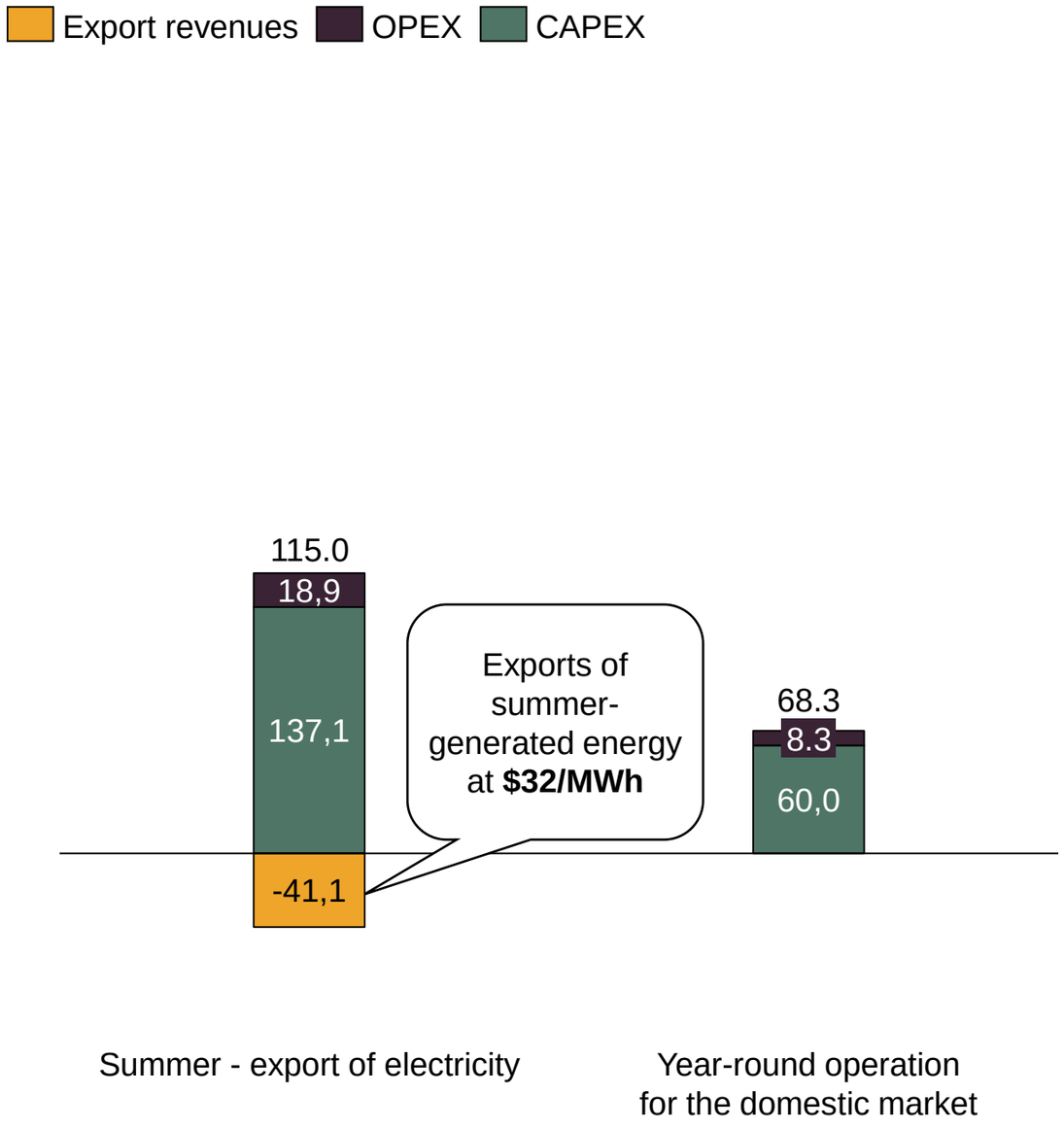
- **No emissions**
- Can be installed in **hard-to-reach areas** (e.g., GBAO)

- Maximum wind potential is achieved in the area of GBAO, which **is not connected to the general power grid** of Tajikistan

Source: ADB, IEA, BP, Petromarket RG

Electricity from Rogun HPP is cheaper than electricity from SPP and WPP, but requires construction of a water reservoir

Cost of electricity generated by Rogun HPP in different modes of operation
Tajikistan, conditions 2021, USD/MWh



Pros and cons of Rogun HPP
Tajikistan, conditions 2021

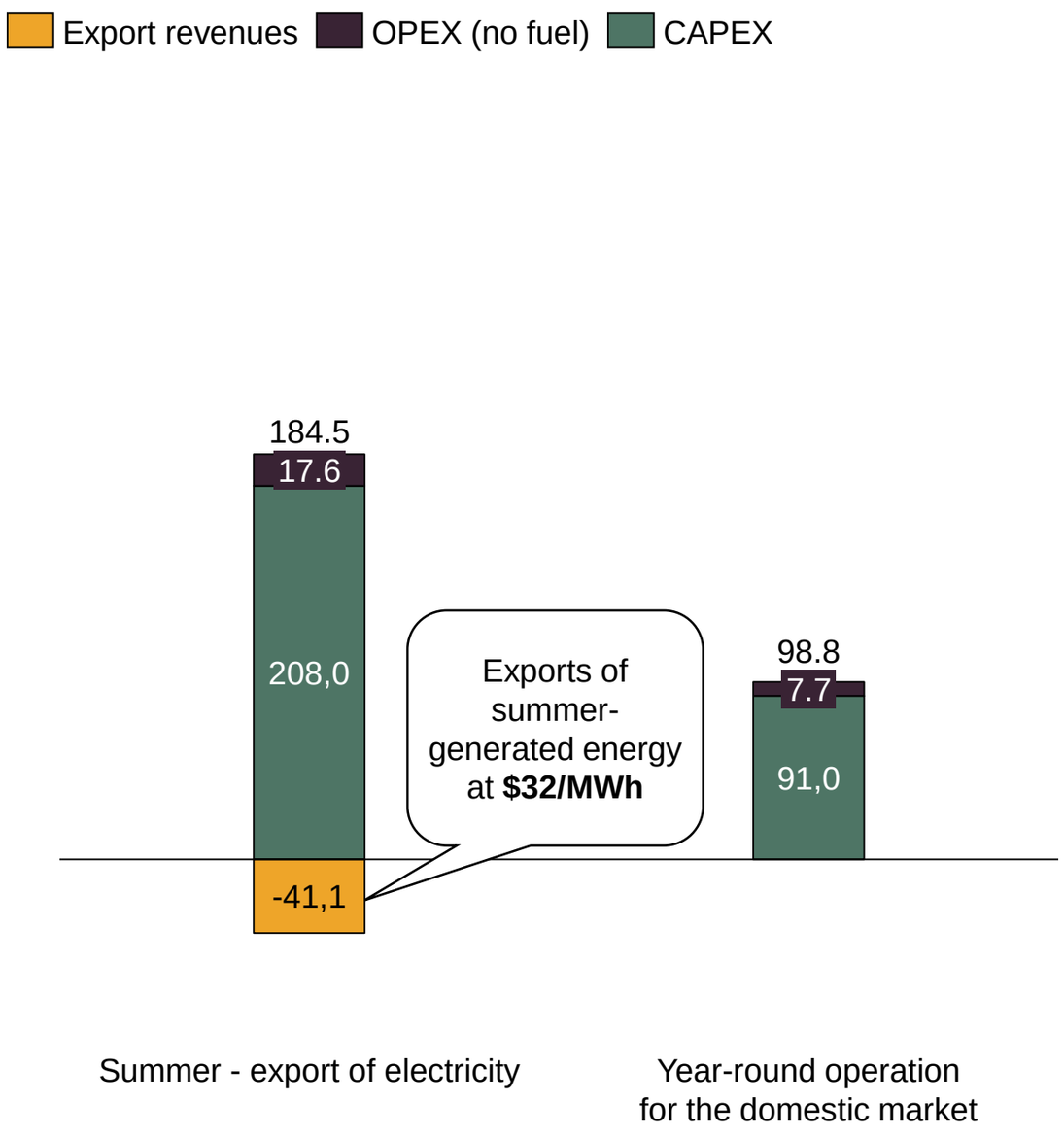
✓
- **No emissions**
- A substantial part of the work to build the plant **has already been completed**
- At the expense of the reservoir it partially **compensates lack of water flow** in the river in winter

✗
- **Does not contribute to diversifying** the energy balance of Tajikistan – one of the goals of the National Strategy
- May **cause tension** in relations with Uzbekistan, located downstream on the Vakhsh River
  - Uzbekistan was concerned at the likelihood of worsening irrigation water shortages due to the Rogun hydropower station

Source: MINT, Barki Tojik, Petromarket RG

The new HPP downstream the Vakhsh River relative to the Nurek HPP will not require the construction of an additional reservoir

Cost of electricity generated by HPP in different modes of operation
Tajikistan, conditions 2021, USD/MWh



Pros and cons of the new HPP downstream of the Vakhsh River
Tajikistan, 2021 conditions

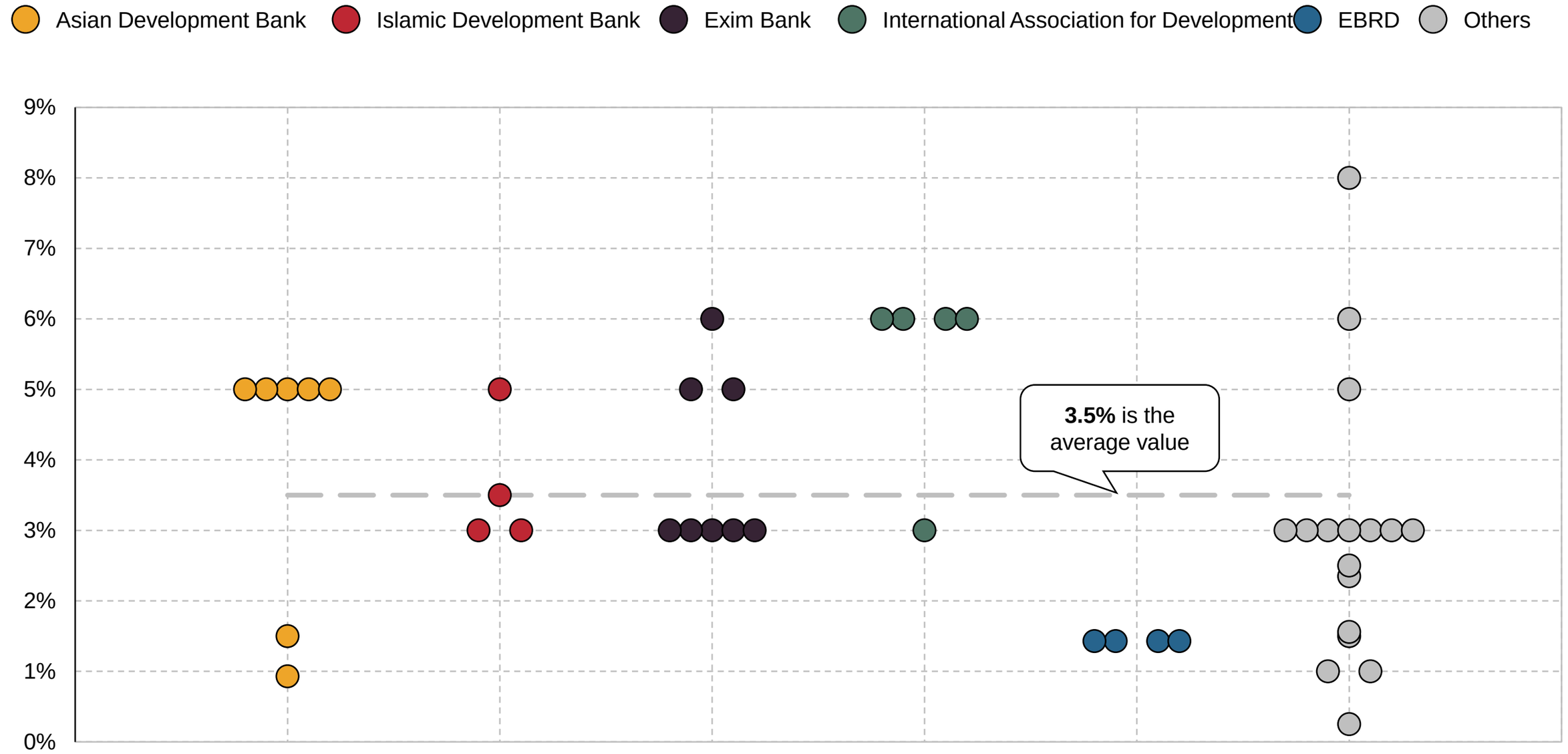
- **No emissions**
- The Nurek HEPS reservoir (in future – the Rogun HEPS) can partially compensate the lack of water flow in the river in winter

- **Does not contribute to diversification** of energy balance of Tajikistan – one of the goals of the National Strategy

Source: MINT, Barki Tojik, Petromarket RG

The average nominal interest rate on loans issued by various international development institutions for Barki Tojik's projects is 3.5% per annum

Interest rates for crediting projects of Barki Tojik by lending institutions
Tajikistan, terms on loans effective as of 31.12.2020, %



Source: Barki Tojik, Petromarket RG

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