Modeling scenarios to enhance energy connectivity in Central Asia

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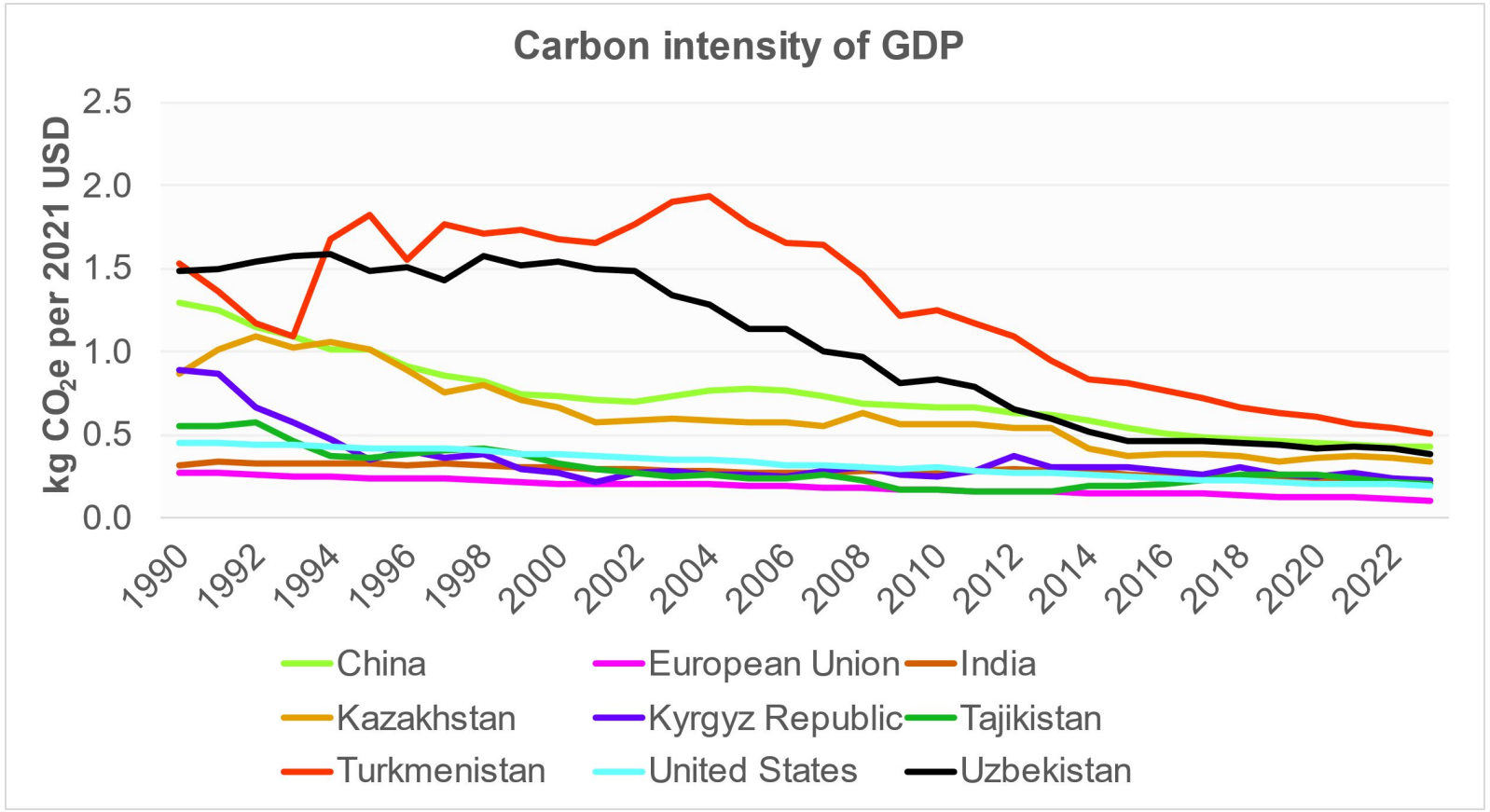
UNECE in UN system

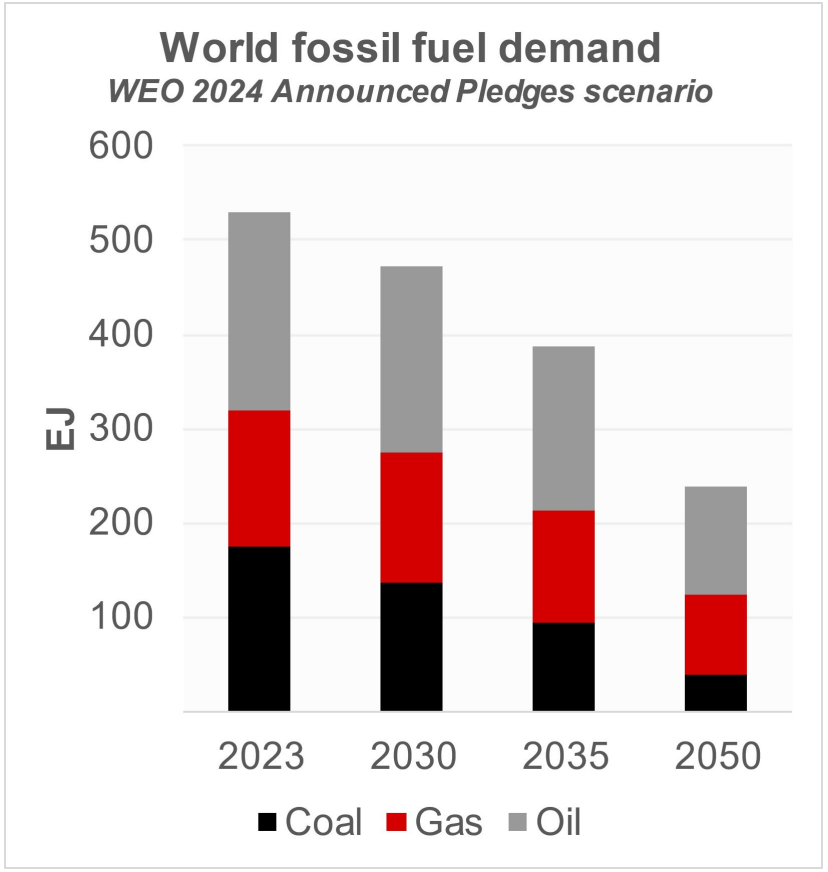
- The UN Economic Commission for Europe (UNECE) is **1 of 5 UN Regional Commissions**
  - Set up in 1947 by ECOSOC
  - 56 member States
- UNECE aims to **promote pan-European economic integration and sustainable development** through:
  - **Policy dialogue**,
  - Negotiation of **international legal instruments**,
  - Development of **regulations and norms**,
  - Exchange and **application of best practices and technical expertise**,
  - **Technical cooperation**

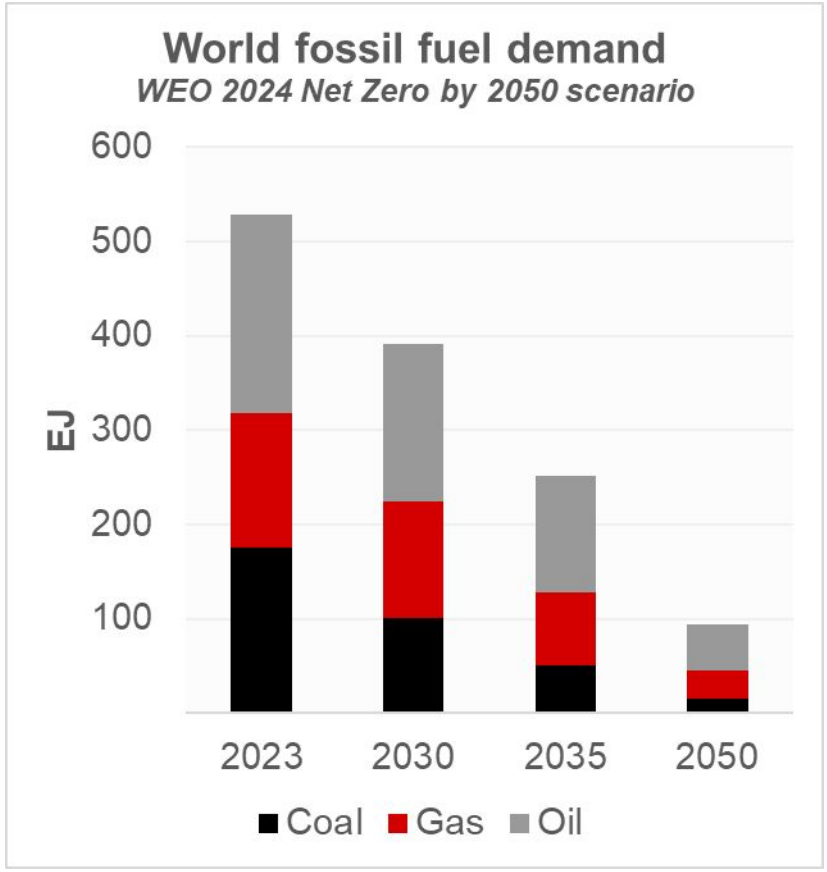
The economies of Central Asia are among the most carbon-intensive in the world



Source: World Bank

This creates risks as the world decarbonizes

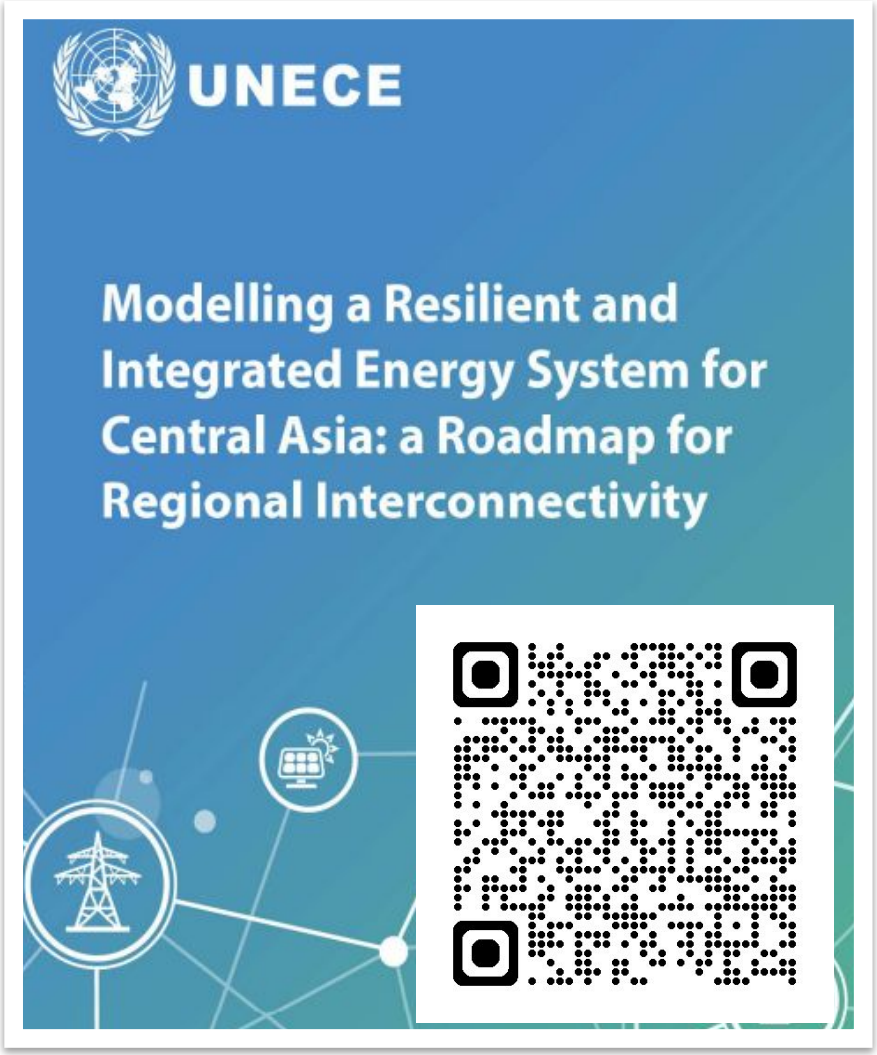




Source: IEA World Energy Outlook (WEO) 2024

Modeling Project. Phase 1 Report

Modeling of the resilient and integrated energy system of Central Asia: a roadmap for regional interconnectivity



Supported by:

Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection

IKI INTERNATIONAL CLIMATE INITIATIVE

based on a decision of the German Bundestag

Modeling toolkit

Graphical user interface, model inputs and outputs

Optimization of energy supply (co-optimization of production, storage, and transmission)

Two SEI modeling tools

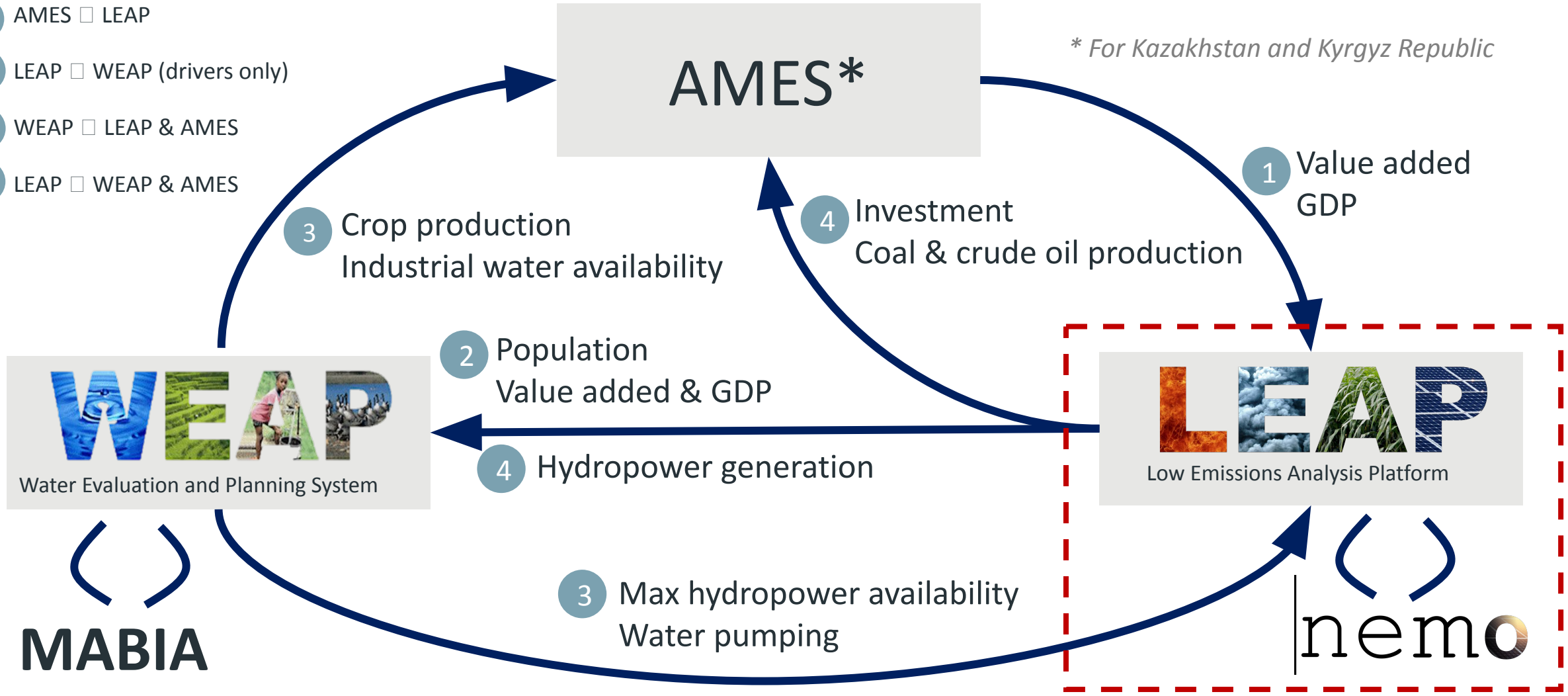
- **LEAP: L**ow **E**missions **A**nalysis **P**latform
  - Multi-method, flexible scope and structure
  - Graphical user interface
  - Scenario-based
  - Open access – free to governments, non-profits, and academics in Central Asia
  - Over 70,000 users worldwide
- **NEMO: N**ext **E**nergy **M**odeling system for **O**ptimization
  - Energy system optimization
  - Designed to integrate with LEAP
  - Open source
  - High performance

https://leap.sei.org | https://www.sei.org/tools/nemo

SEI's water-energy-food modeling platform for Central Asia

Iterate to convergence:

1. AMES ⇄ LEAP
2. LEAP ⇄ WEAP (drivers only)
3. WEAP ⇄ LEAP & AMES
4. LEAP ⇄ WEAP & AMES



Modeling scope

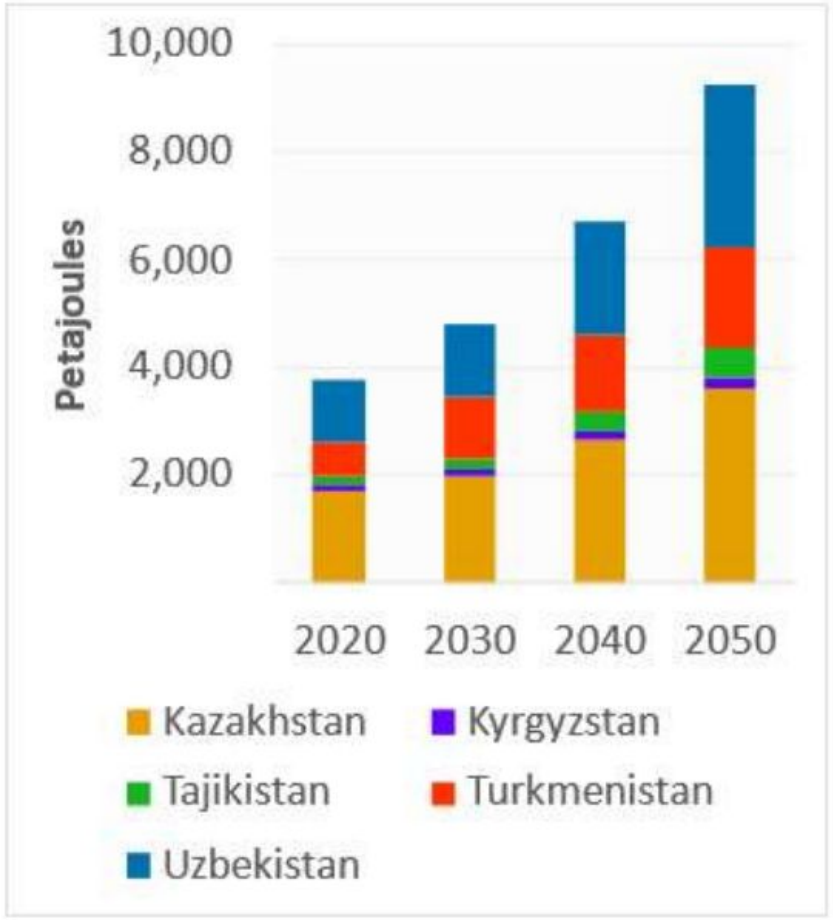
- Model energy systems of 5 Central Asian countries (KAZ, KGZ, TJK, TKM, UZB)
- Simulate four main scenarios from now through 2050
  - National energy self-sufficiency
  - Regional connectivity
  - Full connectivity (regional connectivity + energy trade with third countries)
  - Unlimited connectivity (full connectivity + unlimited electricity transmission capacity between Central Asian countries)
- Assess impacts of increased connectivity and identify key connectivity improvements that decision makers should target

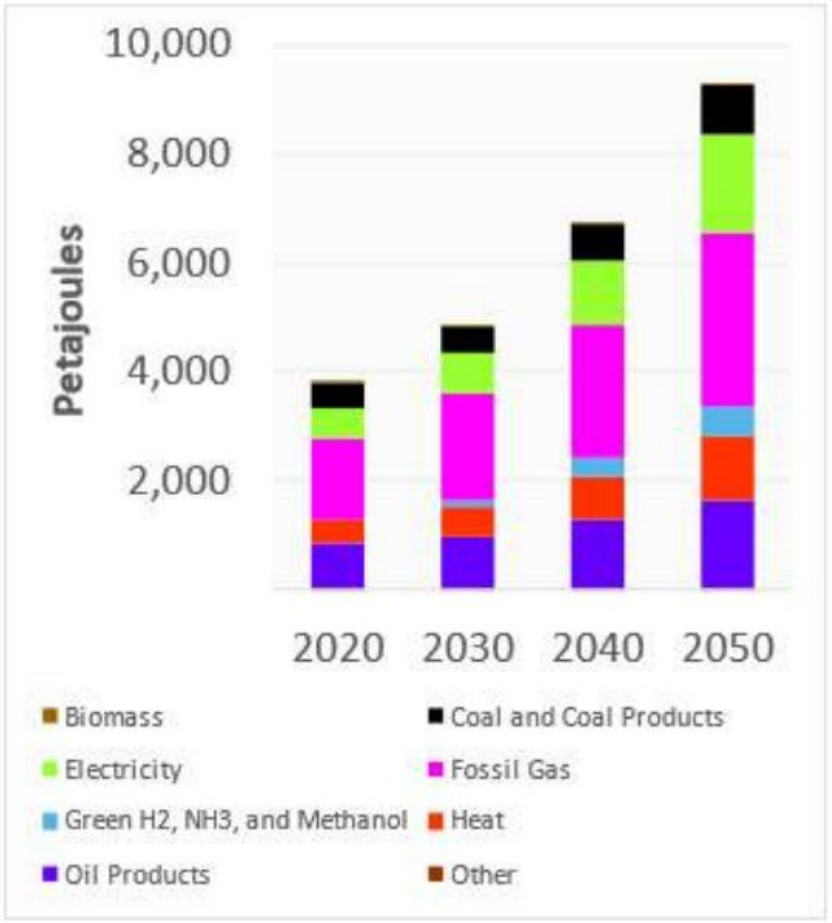
Main findings of the modelling:

Enhanced interconnectivity in the region by 2050:

- lowers GHG emissions from electricity production by 3%
- creates 1.4 billion USD of annual savings in electricity production
- allows to better integrate renewables into grids
- drives adoption of low-cost power sources and pushes away fossil fuels
- creates economy by possibility to share reserves and decreasing the need in redundant capacity
- facilitates power trading creating additional sources of economic growth

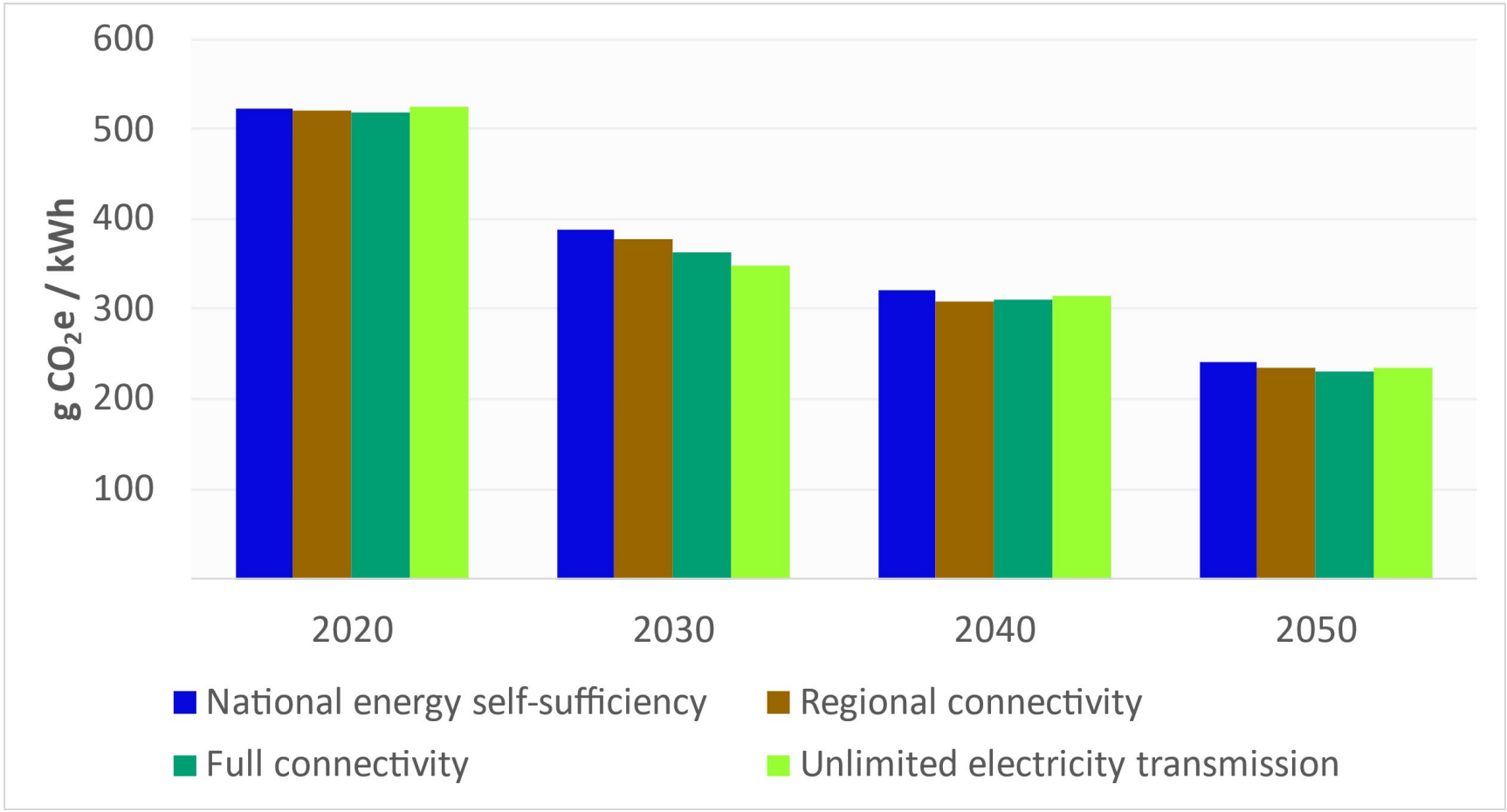
Modelled final energy demand in CA



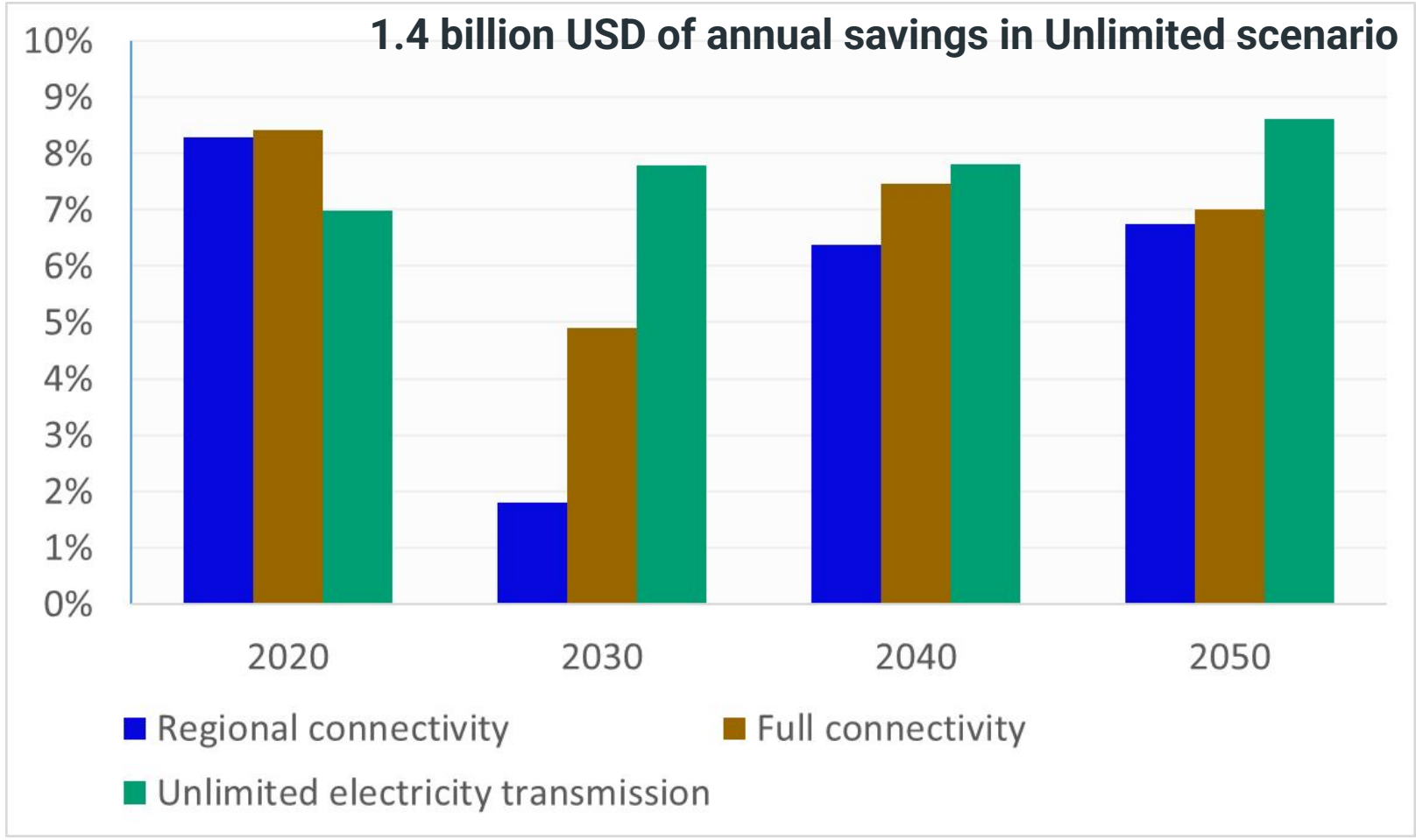


- Significant demand growth in all countries (the highest in TJK, TJM, and UZB)
- Increasing share for electricity (from ~15% today to 19% in 2050) and heat
- Major roles for gas and oil
- Green H2 , NH3 , and methanol account for 6% of total demand by 2050

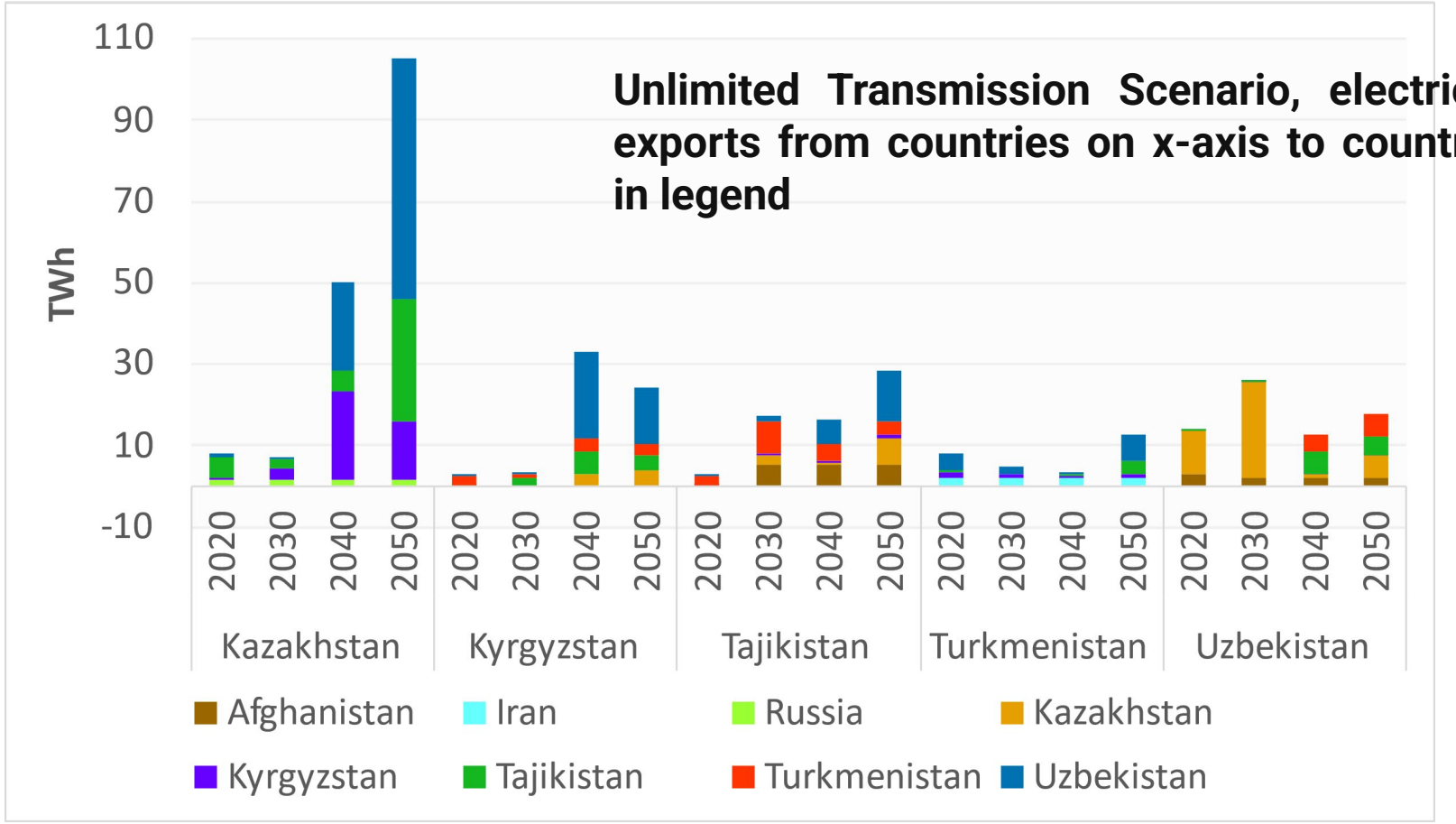
Assuming consistent climate policies, improved regional connectivity lowers GHG emissions from electricity production



Savings in annualized costs of electricity production (generation, storage and transmission) relative to National Self-Sufficiency Scenario

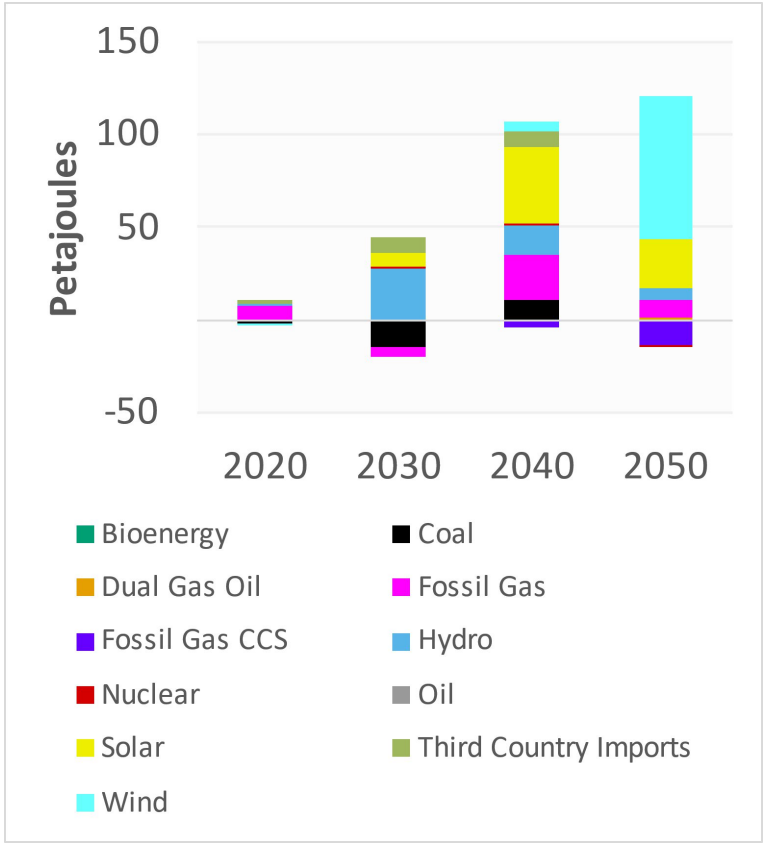


Enhanced connectivity opens up new opportunities for cross-border energy trade, but the primary focus remains on meeting domestic energy needs and intra-regional exchanges



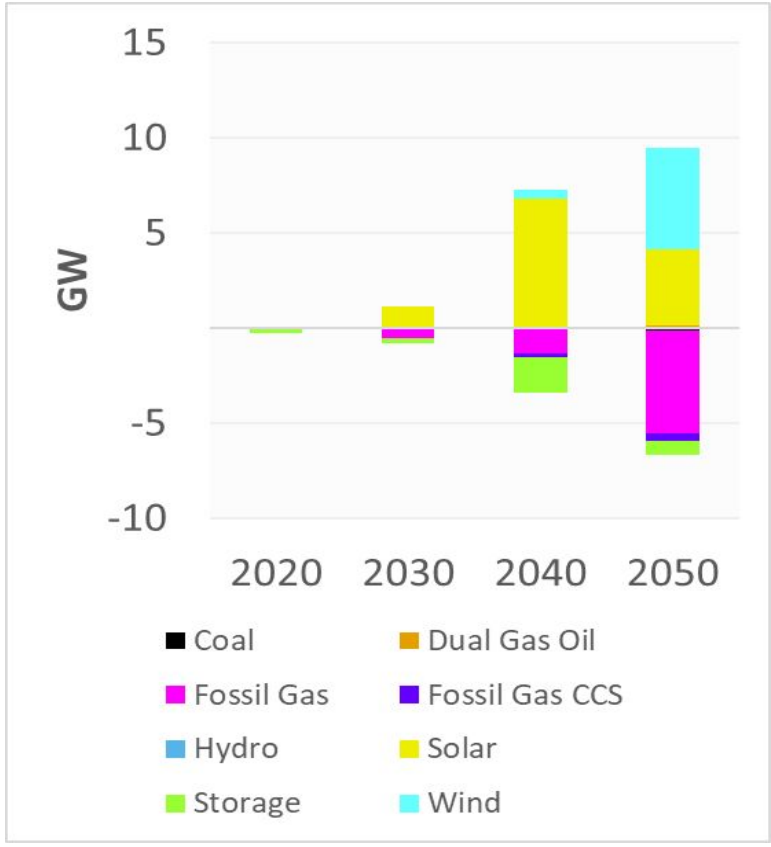
Improved connectivity drives adoption of low-cost clean power sources

Power generation in Central Asia



Excludes generation by battery storage

Power capacity in Central Asia



Excludes third country imports

*Results from **Full connectivity** scenario*

minus

*Results from **National energy self-sufficiency** scenario*

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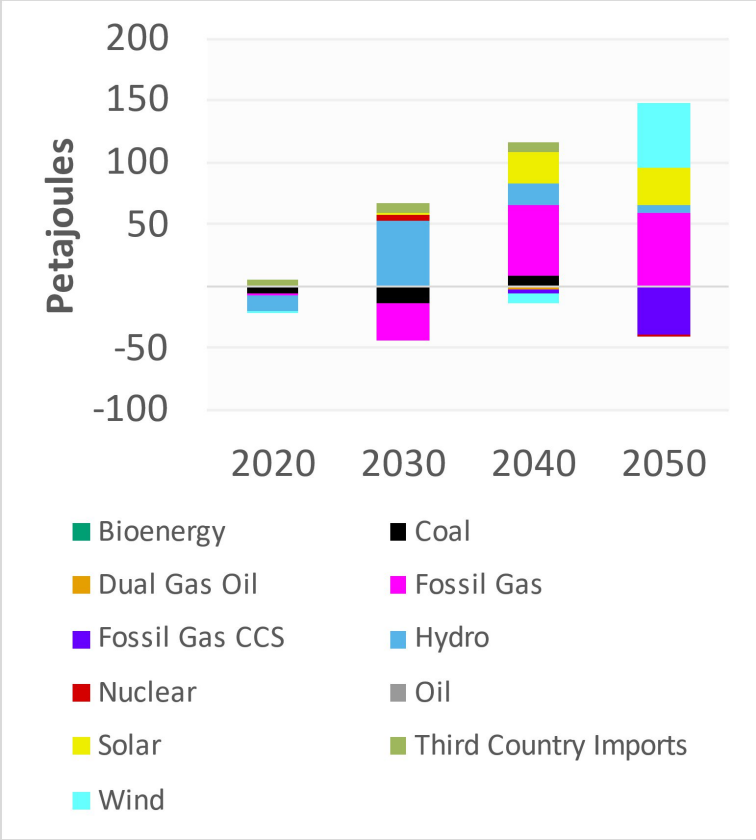
Power generation in Central Asia



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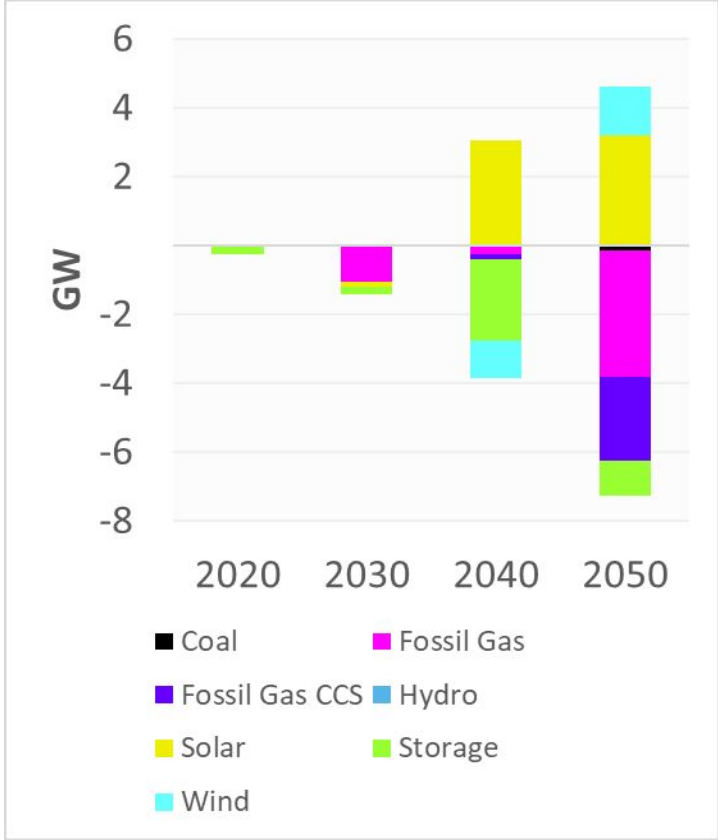
Power capacity in Central Asia



Excludes third country imports

Results from ***Unlimited connectivity*** *scenario*

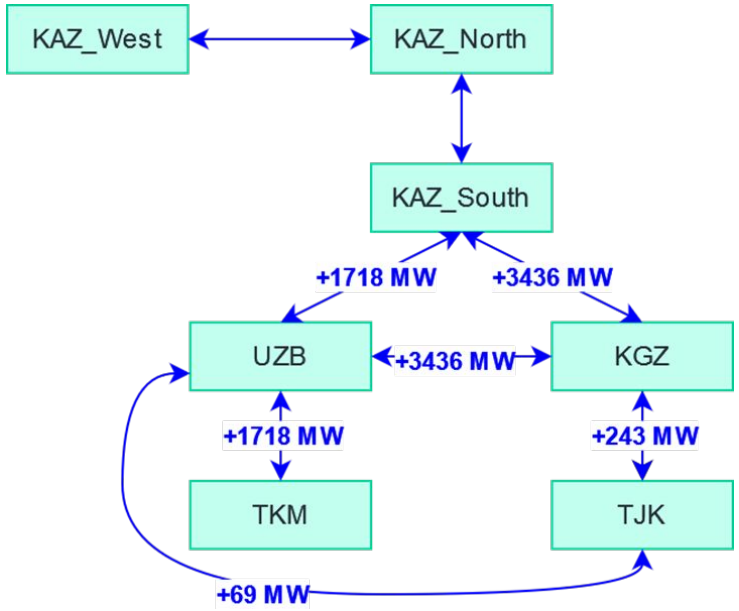
minus

Results from ***National energy self-sufficiency*** *scenario*

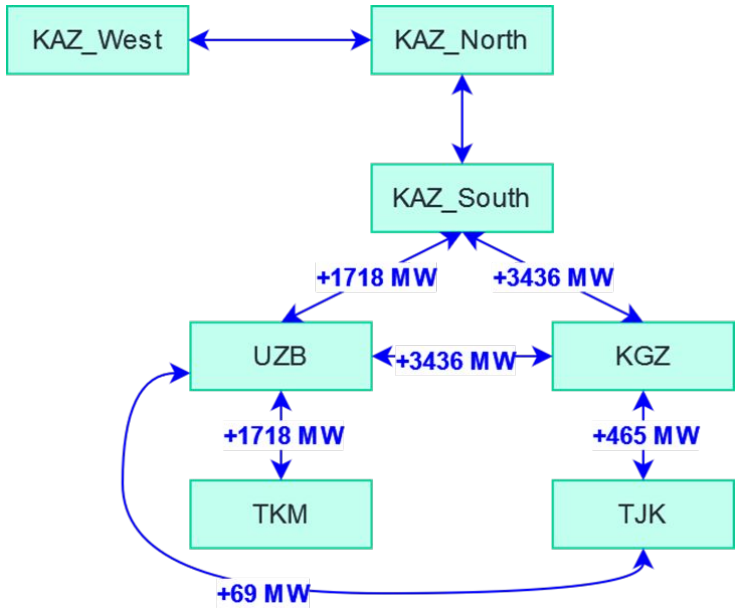
Enhanced energy connectivity requires greater electricity transmission capacity

Most ambitious scenario unlocks potential for electricity trade within Kazakhstan and across UES CA

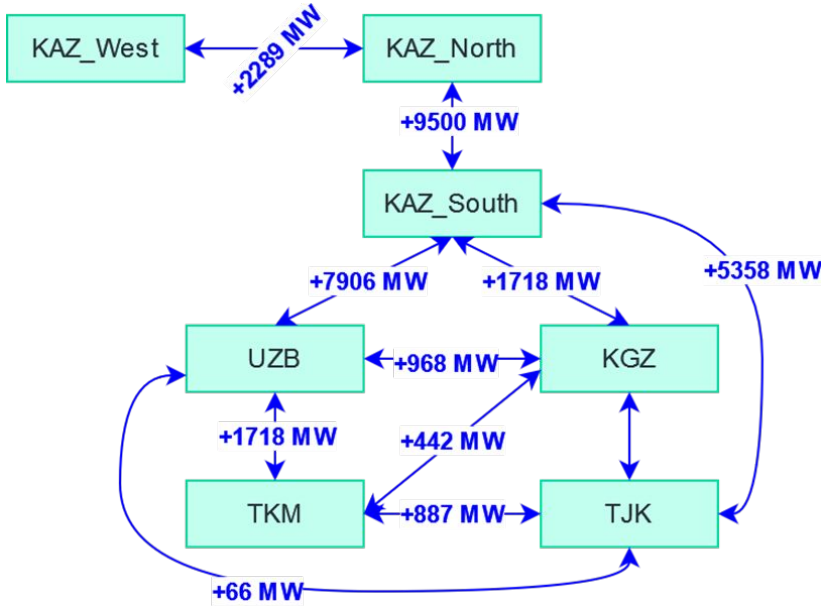
Regional connectivity



Full connectivity

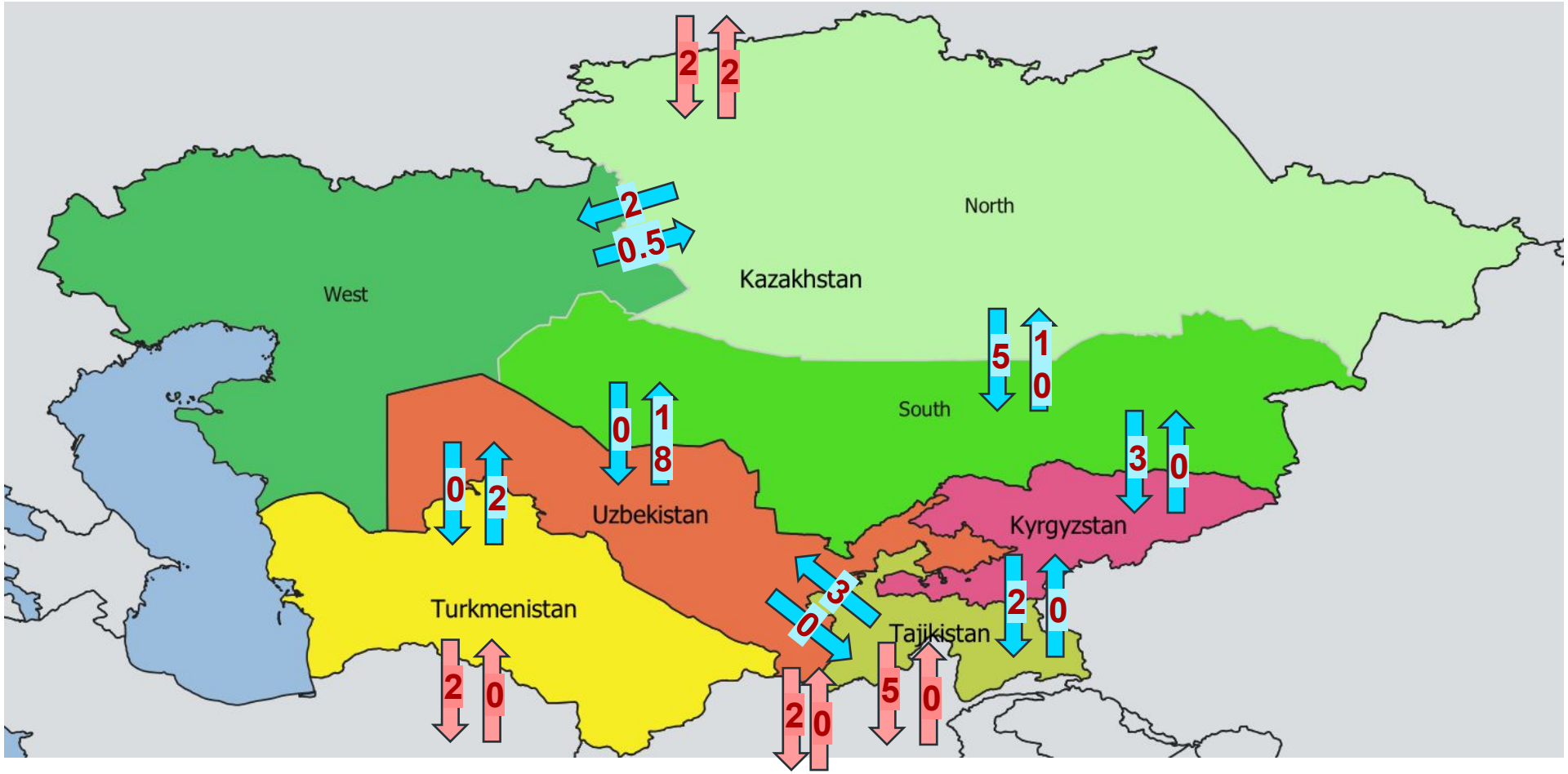


Unlimited connectivity



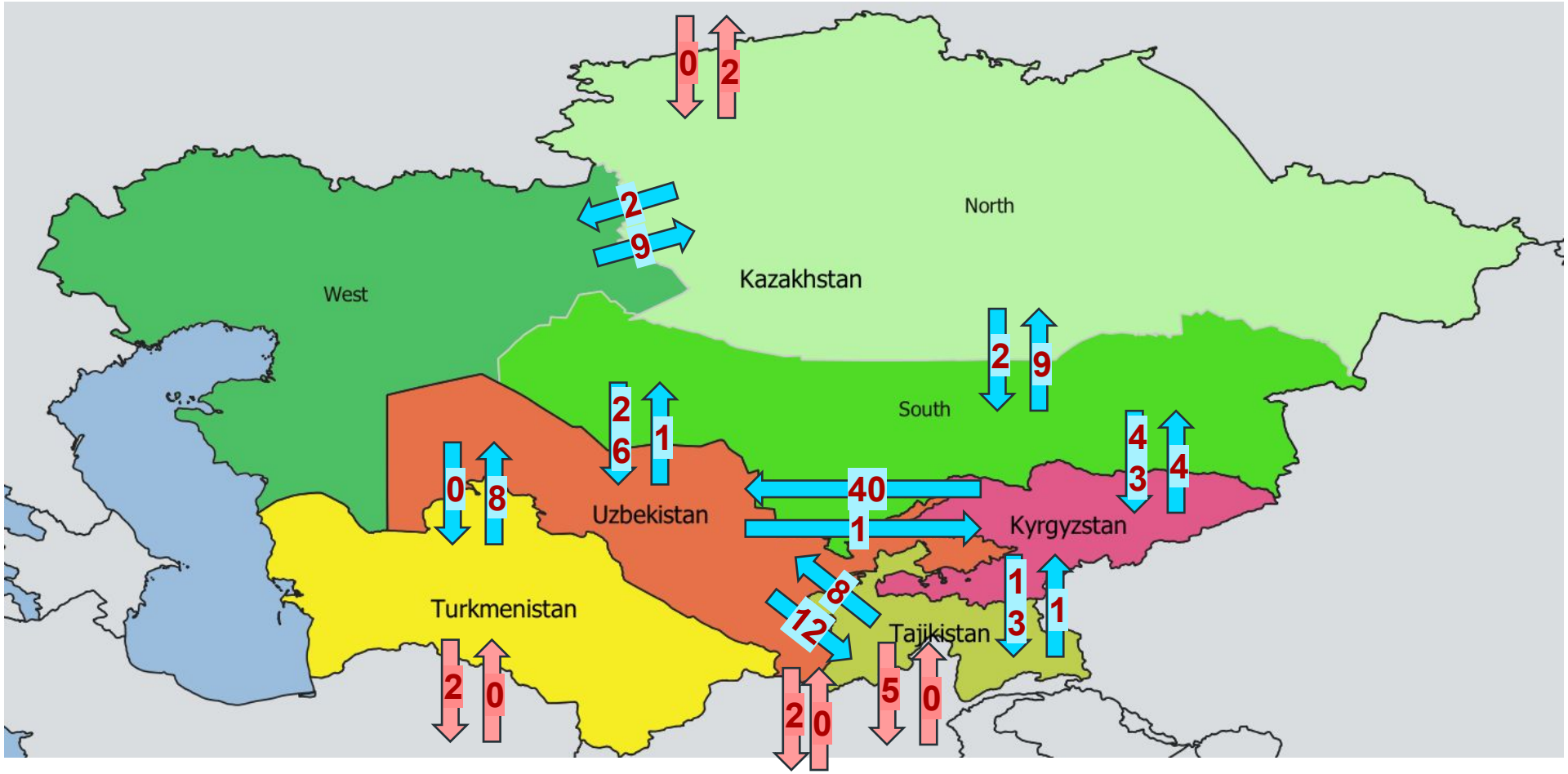
Transmission enhancements support multiple modes of electricity trading: bidirectional, export-oriented PPAs, power wheeling

Electricity trade in 2030: Full connectivity (in TWh)



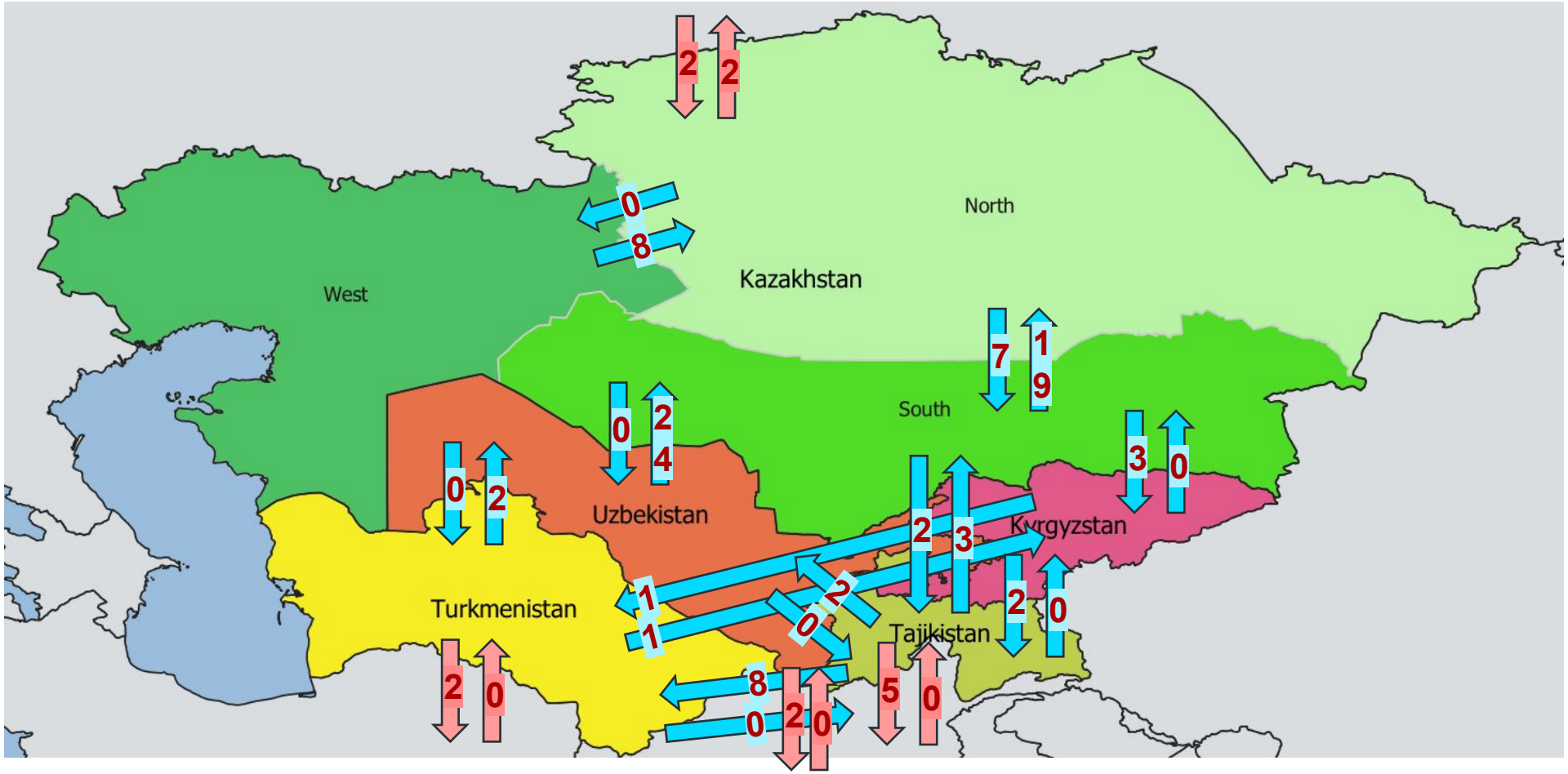
Transmission enhancements support multiple modes of electricity trading: bidirectional, export-oriented PPAs, power wheeling

Electricity trade in 2050: Full connectivity (in TWh)



Cost-effective trade in Unlimited connectivity scenario is 60% higher than in Full connectivity scenario

Electricity trade in 2030: Unlimited connectivity (in TWh)



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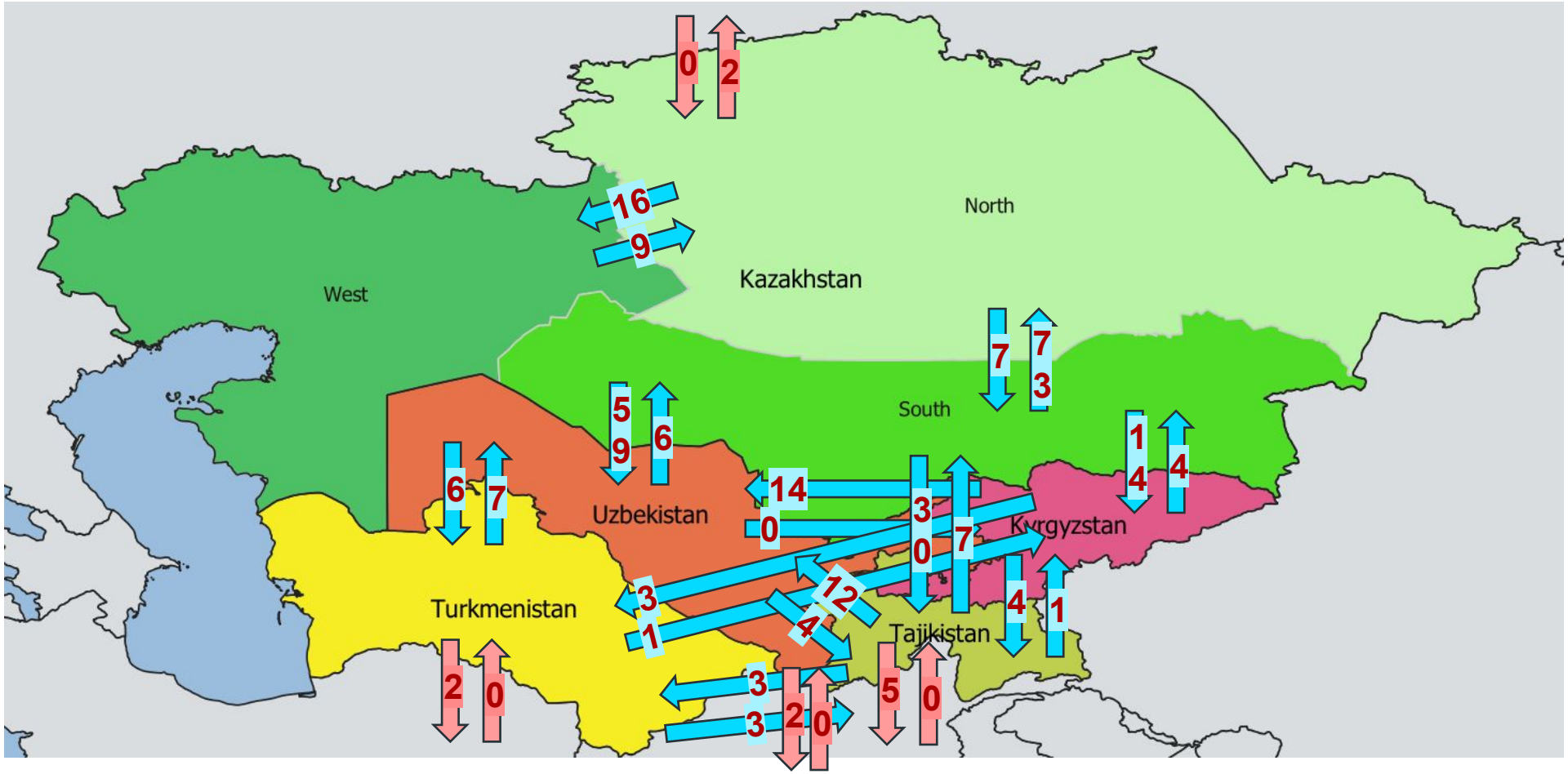
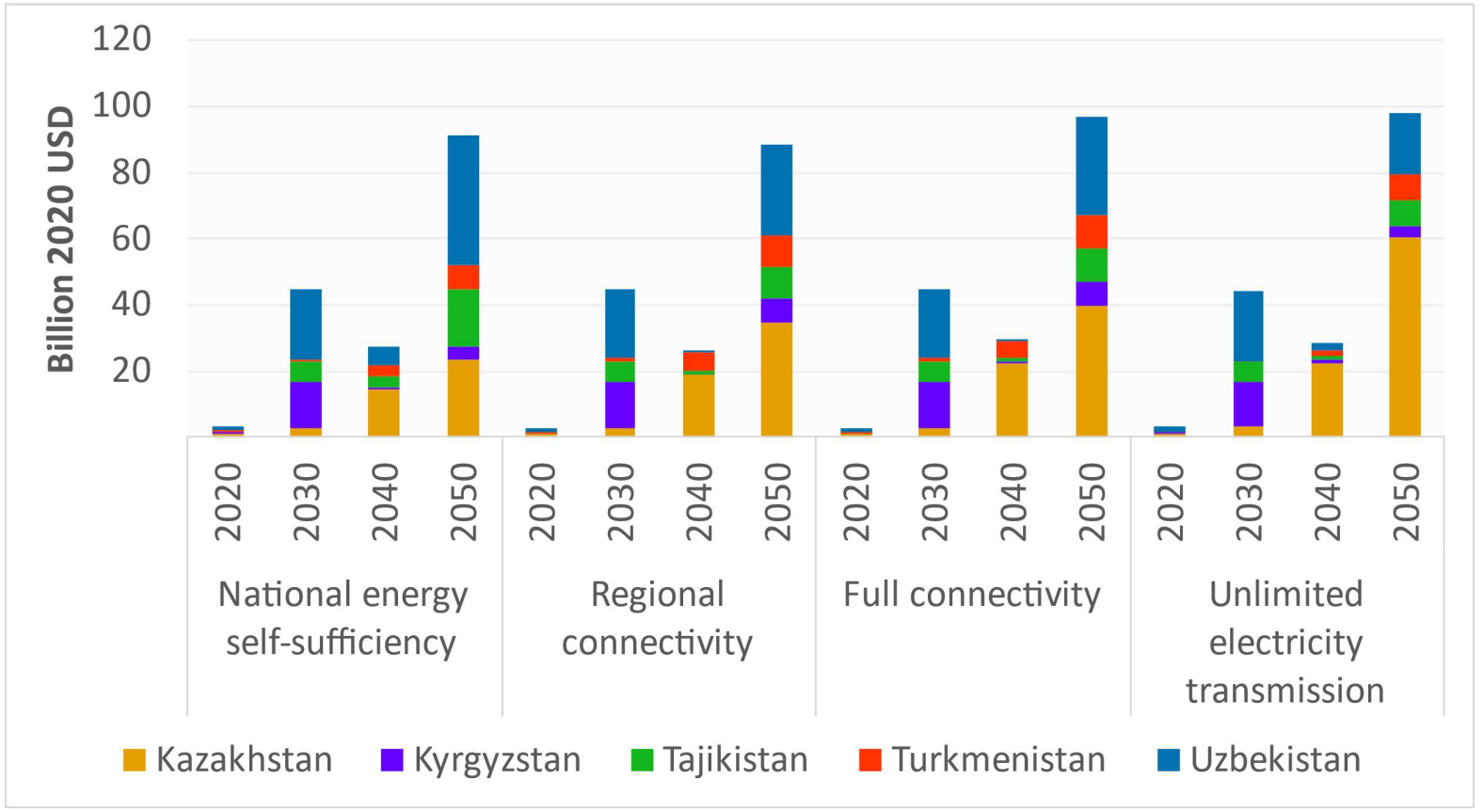
Electricity trade in 2050: Unlimited connectivity (in TWh)



Increased connectivity changes locations of electricity sector investments



Non-annualized decadal investments: electricity generation, storage, and transmission

Summarizing key findings (1)

- The economies and energy systems of CA are expected to grow significantly
- By allowing resources to be utilized more efficiently, enhanced energy connectivity would lower the costs of energy supply and facilitate meeting higher energy demands
- If the CA countries adopt markedly different decarbonization objectives, increased energy connectivity raises the potential for carbon leakage – hence the need for a regional approach vs only national efforts

Summarizing key findings (2)

- On the other hand, if the countries pursue similar emission mitigation goals, improved connectivity could increase the use of cost-effective renewable energy and help reduce emissions – without compromising the stability or reliability of the energy supply
- Within the power system, enhancing connectivity within KAZ, between KAZ and the rest of UES CA, and between TKM and other countries would be particularly beneficial
- At the levels currently being considered in national and regional plans, increased trading of electricity and low-carbon fuels between CA and other regions could have an impact on CA energy systems, but it is not likely to be a main driver of their development – domestic demands, intra-regional trade, and fossil fuel exports are more important

Phase 2. Modelling objectives

- Building on Phase 1, **explore additional factors with high potential to influence investment and finance requirements for energy transitions in Central Asia**
  - **Fossil fuel subsidies**
  - **Revenue from fossil fuel exports**
  - **Carbon prices**
  - **CBAM**
  - **Water availability**
- Model scenarios assessing interplay of these factors and implications for investment and finance

Scenario rubric

Scenario Assumptions	Scenarios			
	Baseline	**Climate Ambition**	**Climate and Connectivity Ambition**	**Climate and Connectivity Ambition (CCA), Reduced Water Scarcity**
Fossil fuel subsidies	Retained	Removed	Removed	Removed
Climate action in rest of world (driving fossil fuel exports)	Low	High	High	High
Carbon prices	Low/moderate	High	High	High
CBAM compliance (not yet fully implemented)	*None/low*	*High*	*High*	*High*
Water availability under climate change	Low	Low	Low	Improved
Energy connectivity	Full	Full	Unlimited electricity transmission	Unlimited electricity transmission
Cross-cutting assumptions	Implementation of 2020 NDCs and net-zero commitments in Central Asia			

Phase 2. Further events on energy connectivity

- UNECE Sustainable Energy Week, Geneva

- 14th International Forum on Energy for Sustainable Development, Skopje, North Macedonia, October 2025

- SPECA Working Group on Water, Energy and Environment – Turkmenistan, Nov-Dec 2025

Thank you!

UNECE

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