Integrated Energy Planning for Sustainable Development and Net Zero Transitions

ACEF 2025

Thematic Track 2: Regional Power Trade and Market Integration

Option 1: Regional Energy Planning and Grid Integration.

Tuesday, 3 June 2025, 2:00 PM - 3:30 PM

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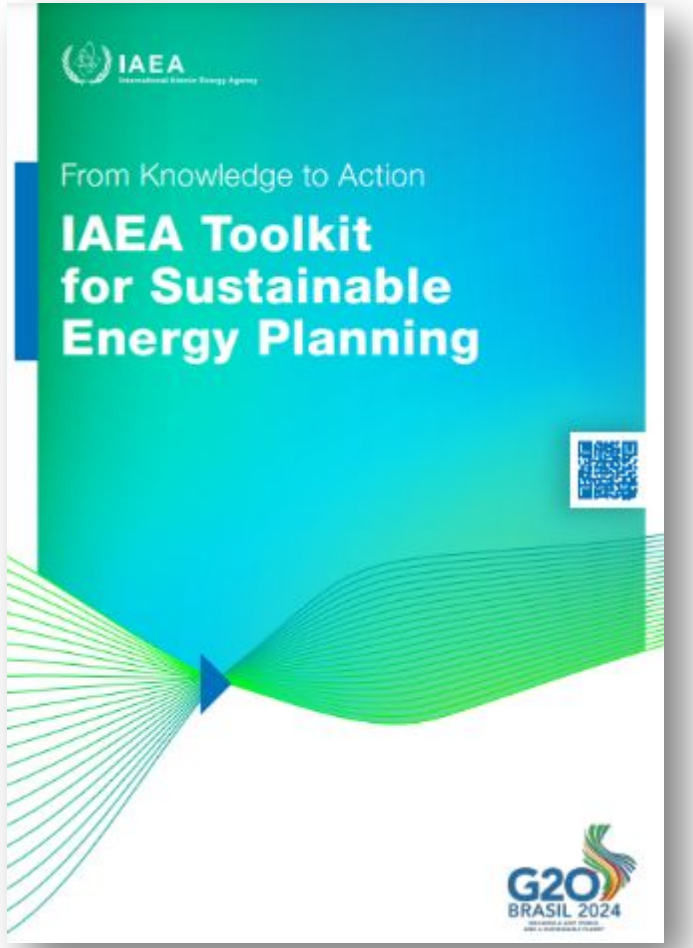
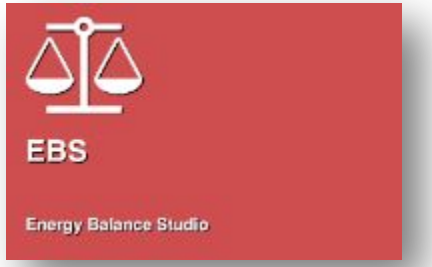
IAEA has a unique support programme

- ***Assist*** Member States in reinforcing national capabilities to conduct energy system analysis, so that countries can assess options and ***develop their own sustainable energy strategies***, i.e. support informed national decision and policy making



IAEA's Energy System Assessment Tools



Energy Statistics and Energy Balances compilation

Energy Demand Analysis and Projections

Energy Supply Optimization and Simulation

Energy Scenario Simulation Tool for fast estimates

Power Generation Investments and Expansion Planning

Analysis of Power Plants Environmental Impacts

Analysis of financial viability of power generation projects

Quantification of macroeconomic effects of strategies

Frameworks for Energy System Assessments

CLEW

Climate, Land, Energy and Water Nexus

Climate, Land and Water use and Energy Interactions

ISED

Indicators of Sustainable Energy Development

Energy, Economy, Environment and Social interactions

SEA

Strategic Environmental Assessment (Nuclear)

SEA of National Nuclear Power Program

- Concepts and sets of methodologies and approaches used to analyze various aspects of energy systems and interactions with other economic activities or elements

Case Study – CMP Africa

Continental Power Generation and Transmission Plan for Africa

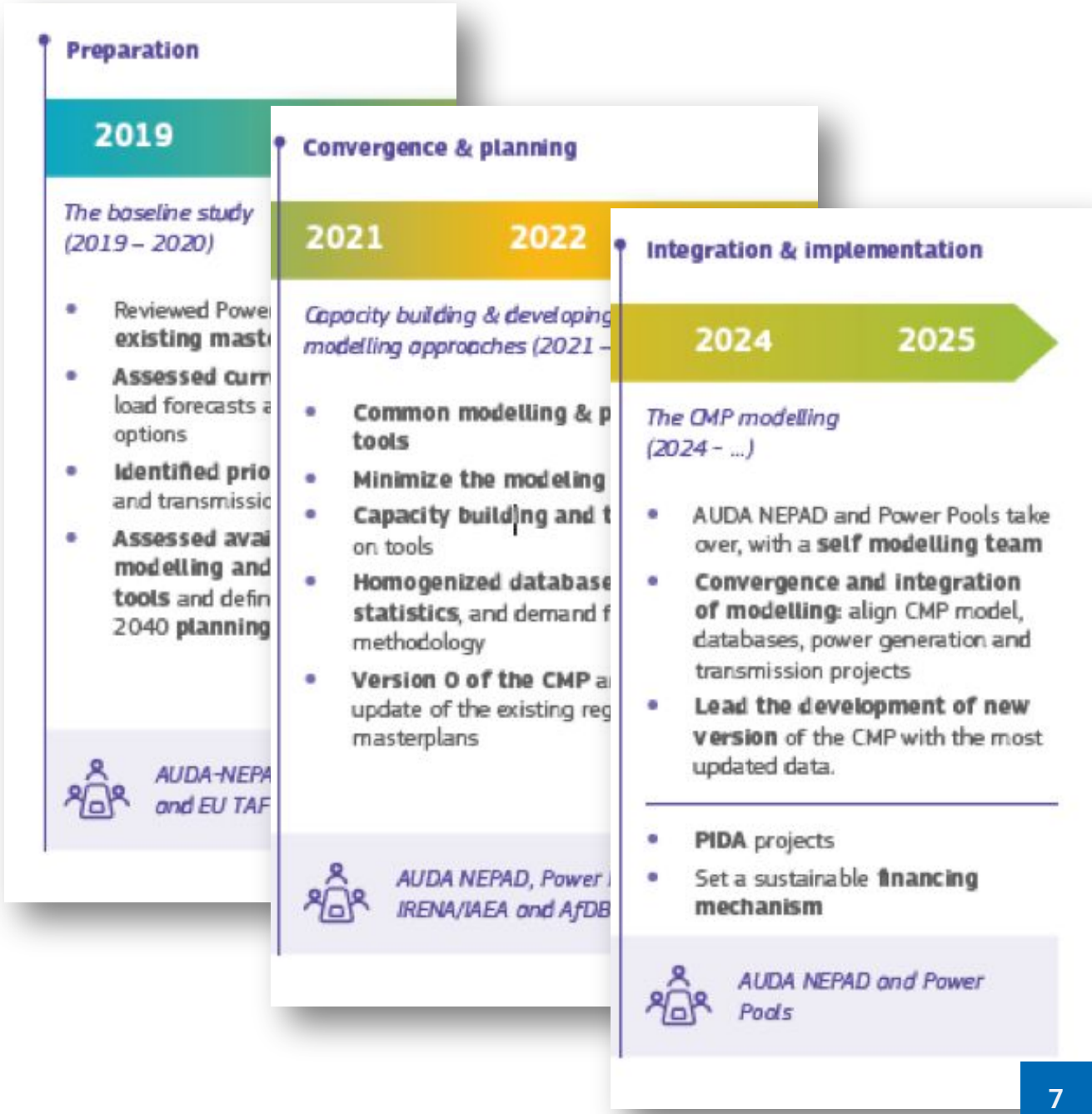
CMP Africa Impetus

Regional cooperation brings benefits to all parties

- Abudant energy resources, but not matching spatial distribution of demand/needs
    - Limited opportunity to exploit eocnomies of scale at national level (smaller markets)
- Increasing energy demand pressure due to economic and social development, industrialisation and urbanisation
    - 1.3 billion people, electricity demand expected to more than triple by 2040
- Need to connect, plan and coordinate power generation and transmission infrastructure on a continental scale
    - Unlock the most affordable projects
    - Offer stable investment framework and outline for the sector, identified projects and attract investor
    - Support development of African single Electricity Market (AfSEM)

CMP Africa Brief History

- In 2019, African energy ministers tasked African Union Development Agency (AUDA-NEPAD) to lead the development of a Continental Master Plan (CMP) for electricity generation and transmission
- Collaboration between five Power Pools: Central (CAPP), East (EAPP), Northern (COMELEC), Southern (SAPP) and Western (WAPP)
- CMP is designed to provide strategic roadmap for connecting Africa's five power pools, a blueprint for the AfSEM (African Single Electricity Market)



Methodology and Approach

Capacity building – Ownership of the planning process

- Bilateral consultation meetings with regional power pools
- **Weekly meetings with modelling partners: IAEA and IRENA**
- Meetings to validate CMP Deliverables held with AUC, AUDA-NEPAD, RECs, AfDB, regional power pools, regulators and Renewable Energy & Energy Efficiency Centres (CREEEs)
- **Road show events for decision makers (IAEA)**

Consultations

- Five energy demand training sessions to Power Pool – Planning Sub-Committee representatives
- **Four SPLAT/MESSAGE Africa training sessions for Power Pool, AUDA-NEPAD, AUC, EU – GTAF participants**
- Three PSS®E training sessions for Power Pool, AUDA-NEPAD, EU–GTAF participants
- **Follow up trainings for Power pools and national utilities (IAEA)**

Capacity building

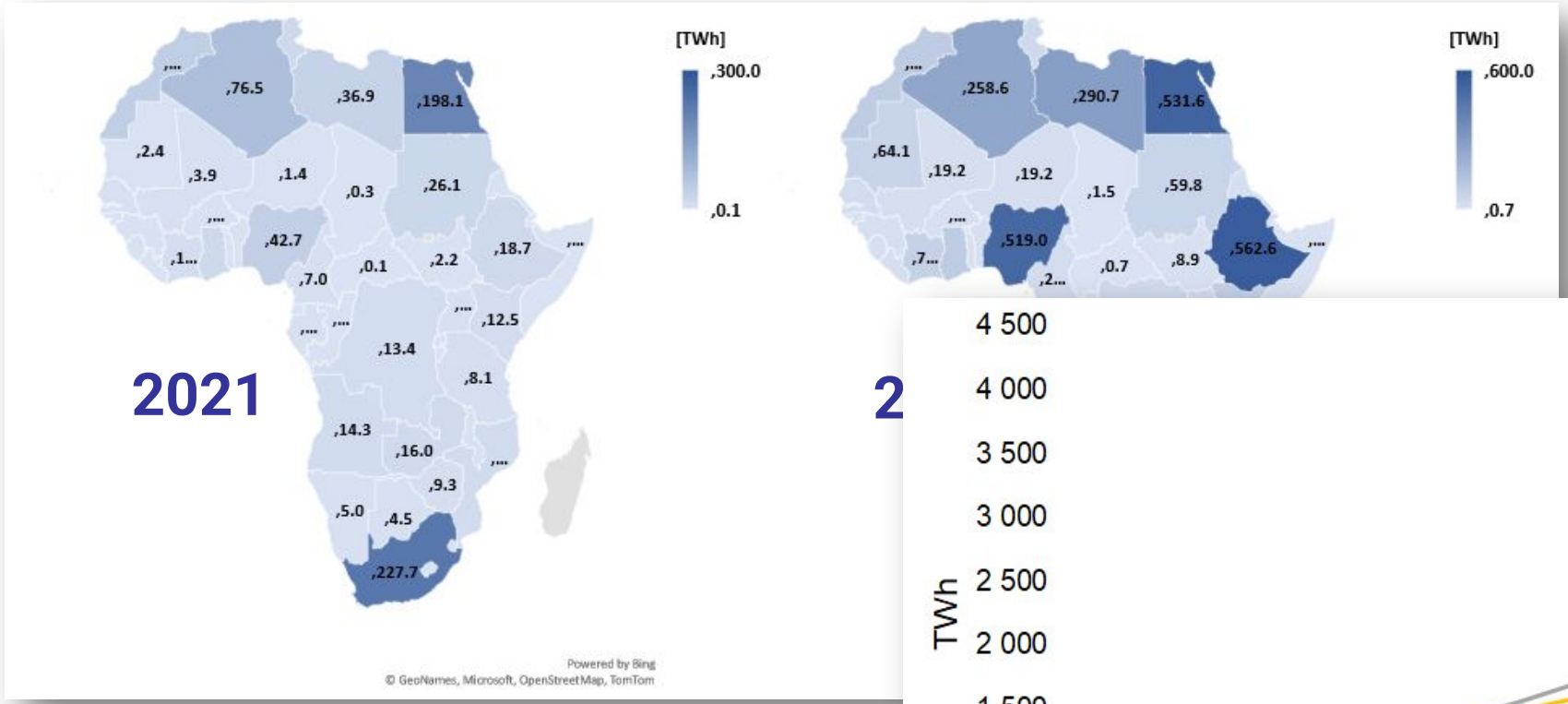
Selected CMP Scenarios

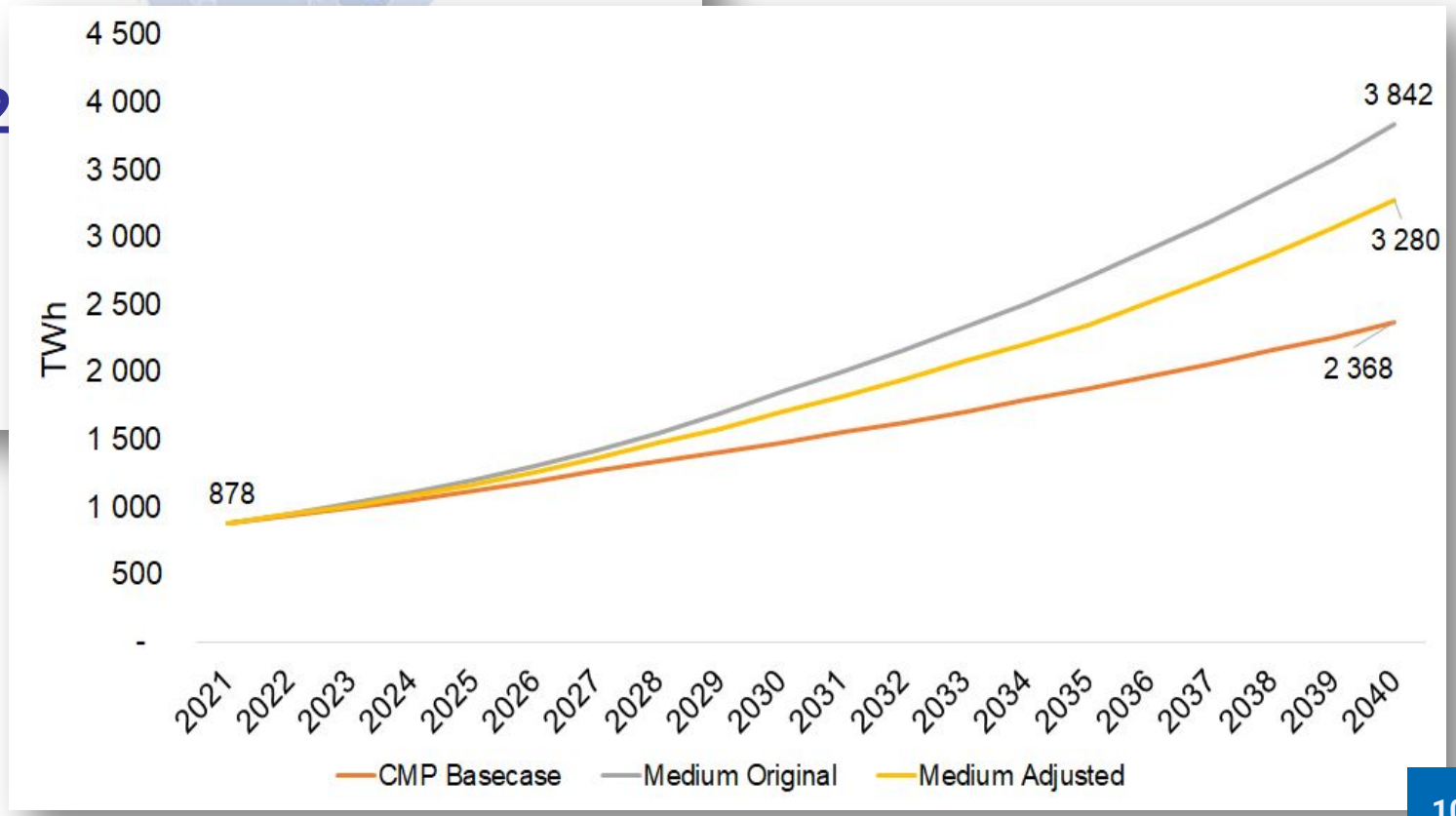
Drivers

- Need for regional integration to facilitate the AfSEM
- Achieve universal access on a sustainable development path

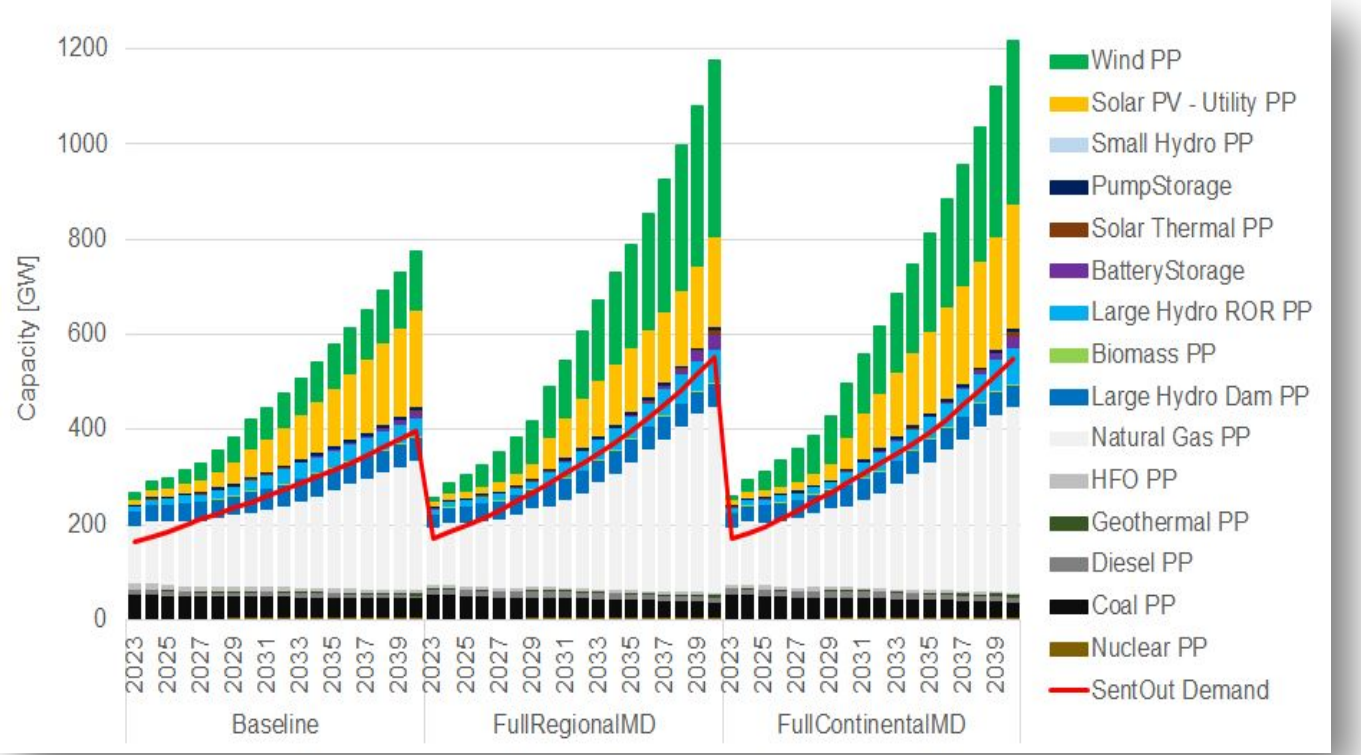
Demand - side projections	Cross-border integration levels		
	Planned regional integration	**Full regional integration**	**Full continental integration**
Reference	**Baseline I Reference**	*	*
Low growth demand	*	*	*
Medium growth demand	*	**Regional**	**Continental**
High growth demand	*	*	*

Continental Electricity Demand Scenarios





Generation Expansion – Key results snapshots



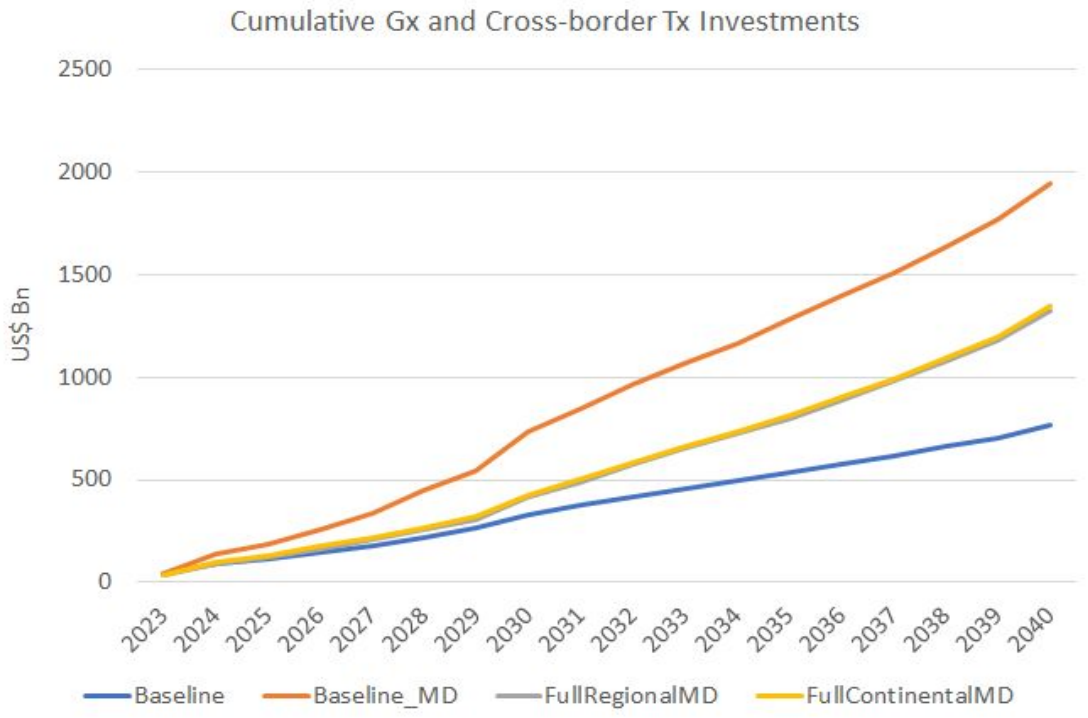
Continental totals [GW]

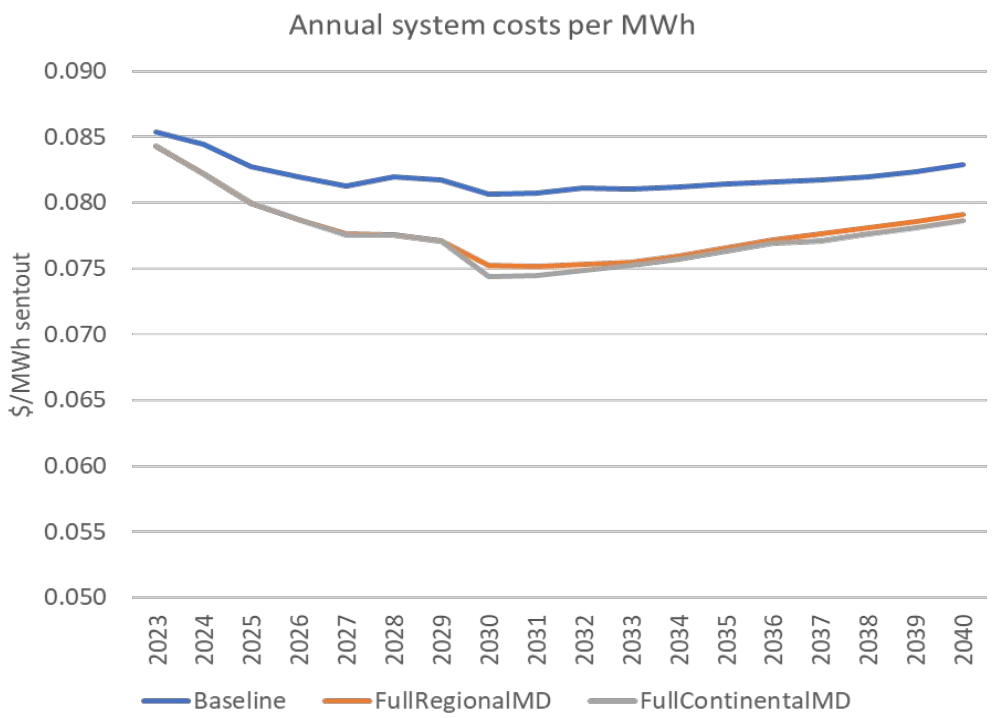
2023	Baseline	Regional	Continental
263	777	1 199	1 213

Projected trend

- Hydro, VRE (solar and wind) complemented by storage increasingly prominent
- Natural gas continues to play key role as a transition fuel
- Coal diminishing but still prominent, geothermal and nuclear role projected to increase but at a lower scale
- Increased trade to Middle East and Europe in full integration scenarios

Investments and Total Costs

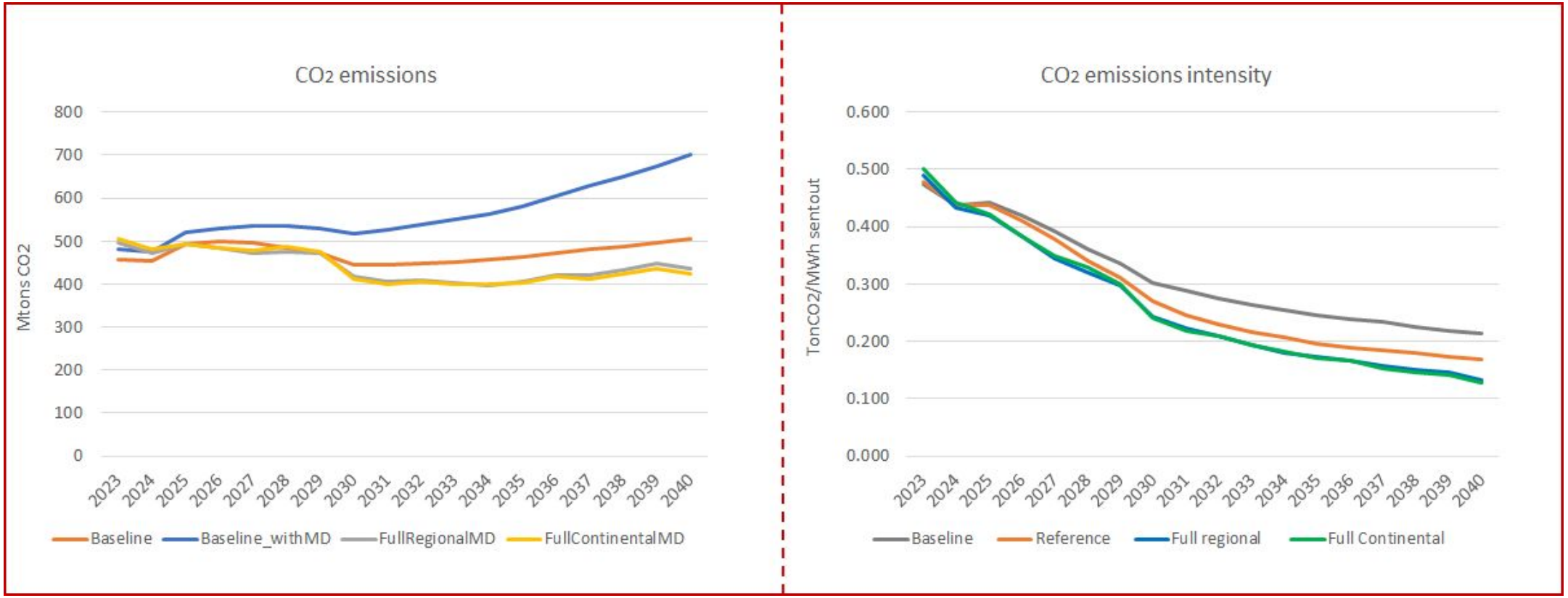




CMP scenario	Investment Cost (US$)	System costs (US$/kWh)
Baseline	777 Billion	0.084
Full Regional	1.31 Trillion	0.079
Full Continental	1.32 Trillion	0.078
Baseline with MD	1.94 Trillion	

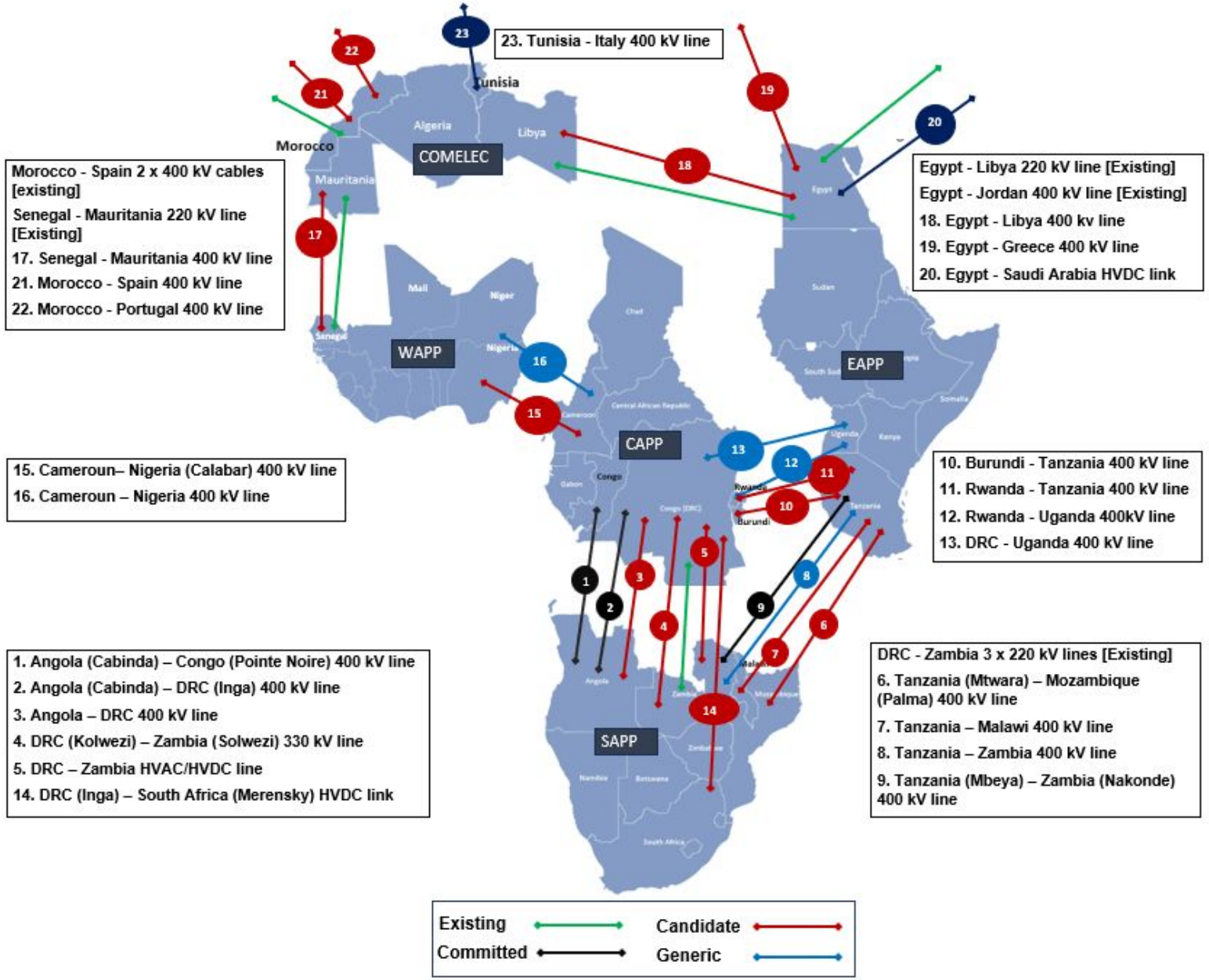
- Unit system costs lower under full integration scenarios (0.084 vs 0.078 US$/MWh)
- Significantly higher investments (US$ 620 Bn more compared to the integration scenarios) projected if medium demand is to be met via the baseline scenario

CO_2 emissions



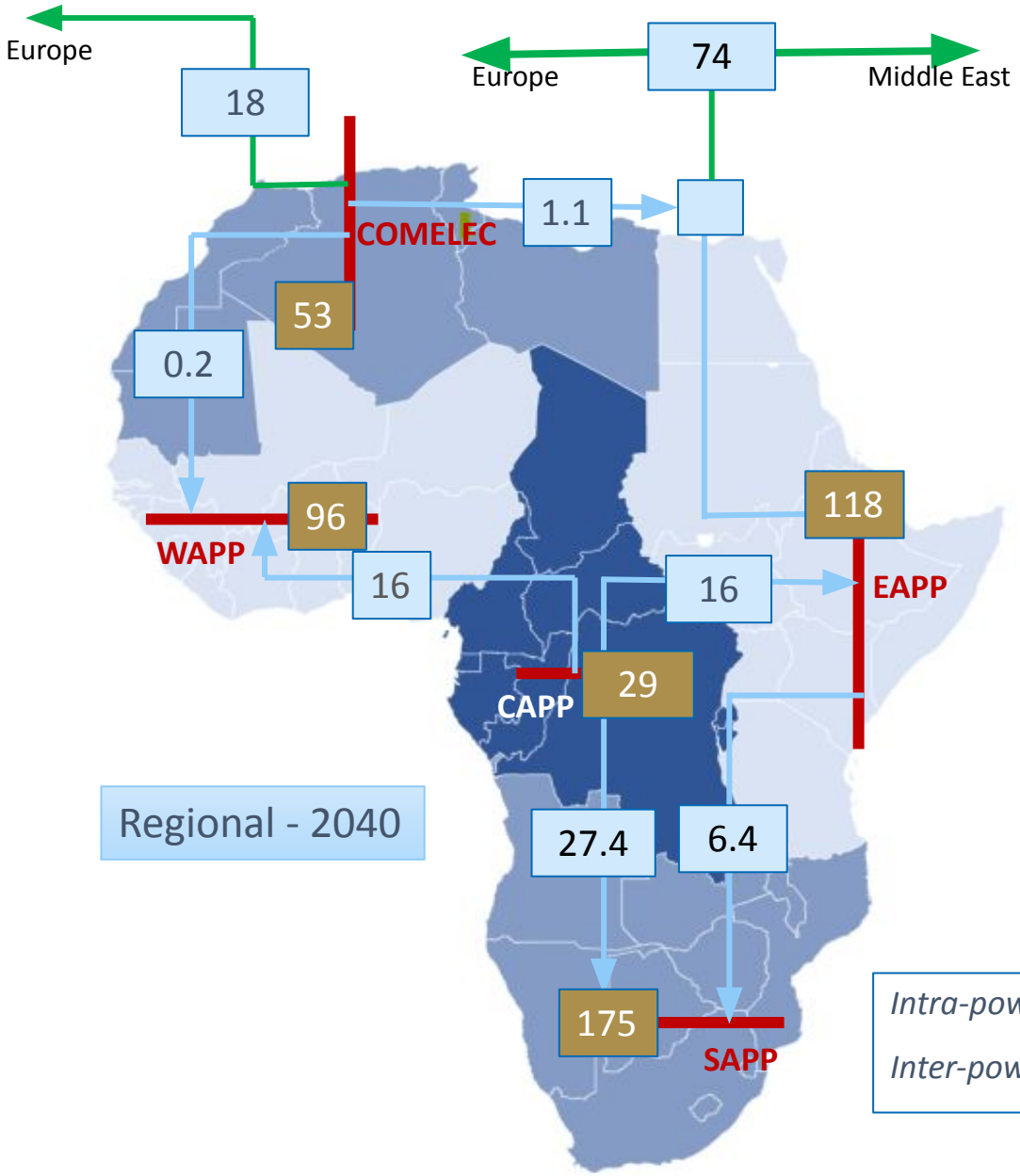
- Less CO_2 emissions in the Full Regional and Full Continental due to large RE
- Lower CO_2 emissions intensity in all scenarios due to gradual reduction in fossil generation contribution

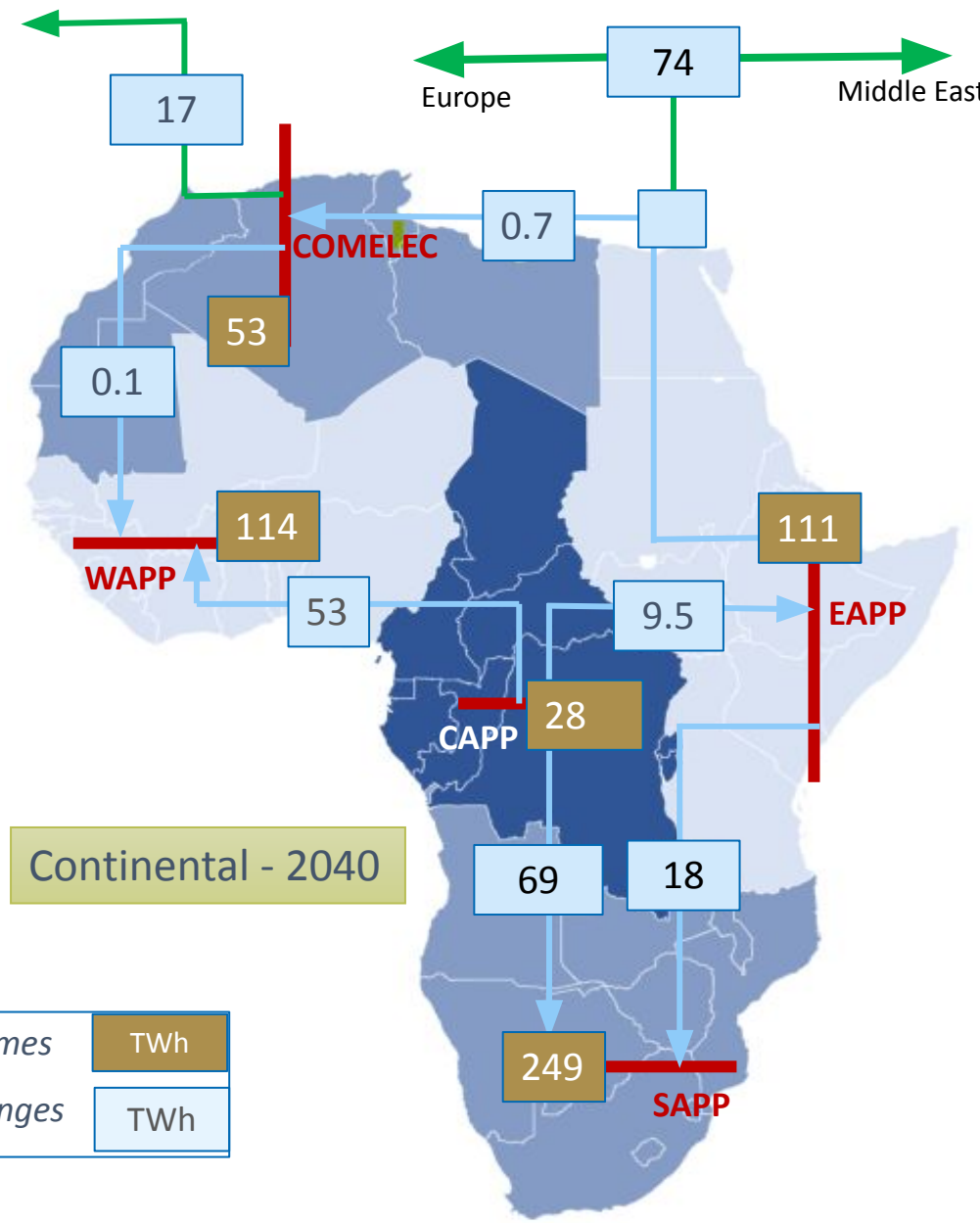
Existing and future inter-regional interconnectors



Derived from the SPLAT-Africa Model [Continental scenario]

Intra and inter-regional annual trade volumes - 2040



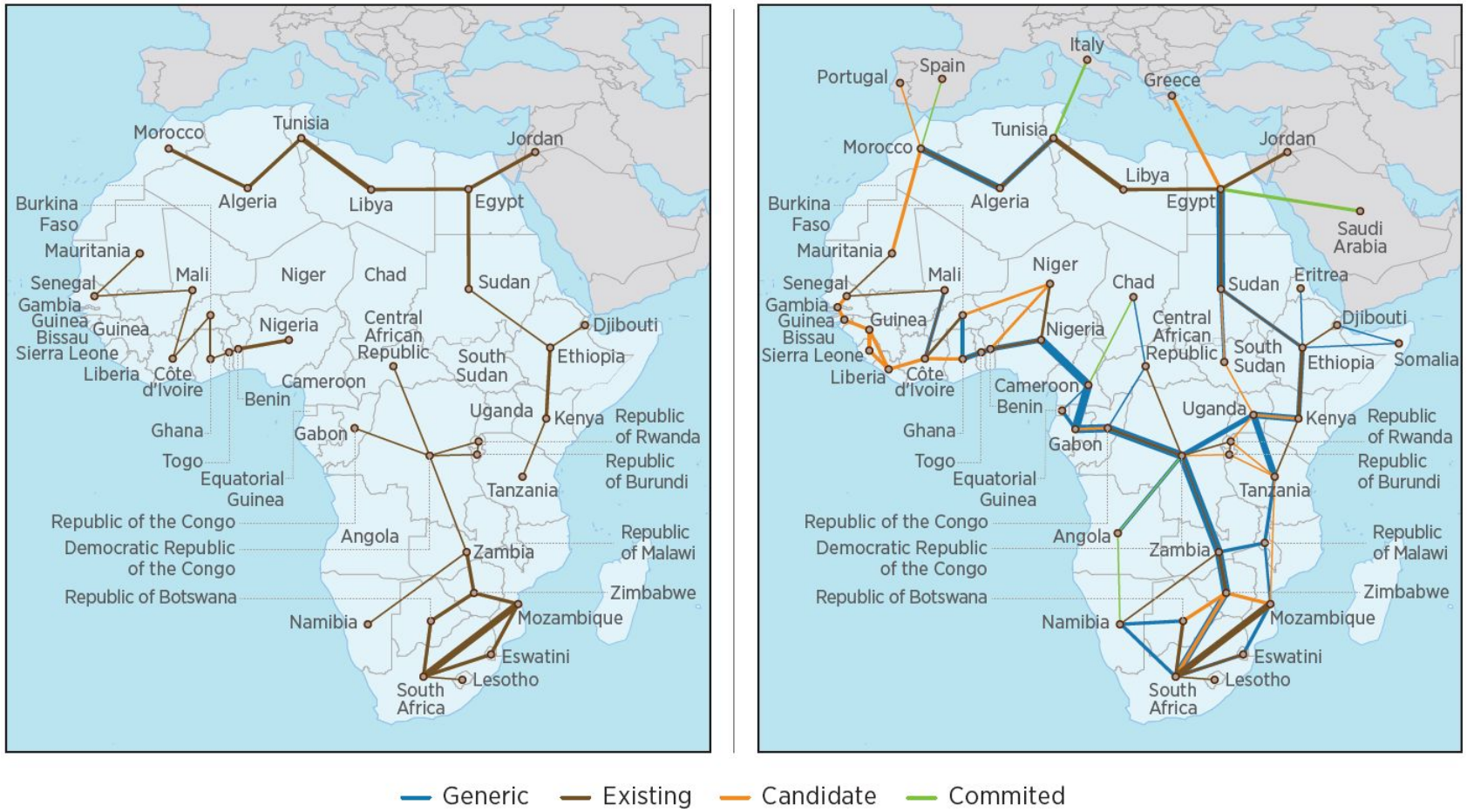


Intra-power pool trade volumes TWh

Inter-power trade net exchanges TWh

Transmission network studies – Key results snapshot

CMP cross-border interconnectors 2023 to 2040



Source: IRENA

Identified HVDC corridors – linked to Grand Inga Hydro

HVDC corridors selected for lines longer than 1000 km and carrying excess of 1000 MW

Interconnector Name	Countries involved	Regions / Power Pools	Investment Date
DRC (Inga) – Nigeria (Calabar) 600kV HVDC	DRC, Nigeria	CAPP, WAPP	2033
DRC(Inga) - DRC (East) HVDC link	DRC	CAPP, EAPP	2033
DRC (Inga)-South Africa (Merensky) Grand Inga HVDC Phase 1	DRC, South Africa	CAPP, SAPP	2032
DRC (Inga)-Zambia (Luano) Grand Inga HVDC Phase 1	DRC, Zambia	CAPP, SAPP	2032

https://nepad.org/continental-master-pla

Takeaways

- Energy needs in number of developing countries are increasing rapidely
- Difficulties in providing energy services in some regions/countries are enormous, reflecting lack of timely decision making supported by an appropriate planning process
- All energy supply and demand options must be considered, especially in the light of increasing treats from adverse climate change impacts
- Regional cooperation brings benefits to all parties concerned – there is no alternative to collaboration
- IAEA offers analytical tools, capacity building and support for energy systems assessments and elaboration of regional and national energy strategies, plans and actions

Thank you!

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