The Benefits of a Pan-Arab Regional Electricity Market

Based on World Bank's report: *The Value of Trade and Regional Investments (VOTRI)*

Dr. Mohamed Zakaria Kamh

WORLD BANK GROUP

CAIRO WORKSHOP
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Agenda

1. Background
2. Key barriers to trade in existing infrastructure
3. Unexploited benefits of trade in existing infrastructure
4. Priority Interconnection expansions
5. Quantifying the Benefits:
    - Power system cost savings
    - Economic and commercial
    - Environmental and climate
6. Integration beyond MENA and Take-aways

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Benefits of Regional Trade

Many jurisdictions have, or are moving to, expanded regional integration including the European Union (EU), Central America (SIEPAC), West African power Pool (WAPP), Southern Africa Power Pool (SAPP), etc.

Drivers of regional integration vary, but generally relate to the following:

- **Reduced supply costs** owing to:
  - generation dispatch over a broader region resulting in reduced fuel costs
  - coordinated and optimized expansion of generation and transmission assets to gain economies of scale and share reserves
- **Improved reliability** through assistance from other countries during supply shortages owing to: extreme weather (i.e., drought, heat), mechanical failures (generation/transmission outages), construction delays, etc.
- **Reduced environmental impacts**; i.e., improved access to renewable generation sources, optimized dispatch (i.e., greater use of the more efficient and cleaner generation assets), etc.

Need for Coordinated Support for Regional Trade and Market Integration

Scaling-up Trade & Infrastructure

Countries of the region need to develop and agree on a pricing approach suitable for cross-border trade on economic and commercial basis

Finance for investment in generation and transmission assets needs to be mobilized to meet forecasted demand

Deepening Integration of the PAEM Electricity Grid

New investments and Regional institutions for power trade need to be established and empowered within the PAEM governance framework, including the General Agreement and the PAEM Market Agreement

Harmonized regulations such as market rules and grid codes need to be developed for cross-border trade

The Value of Trade and Regional Investments Report (VoTRI)

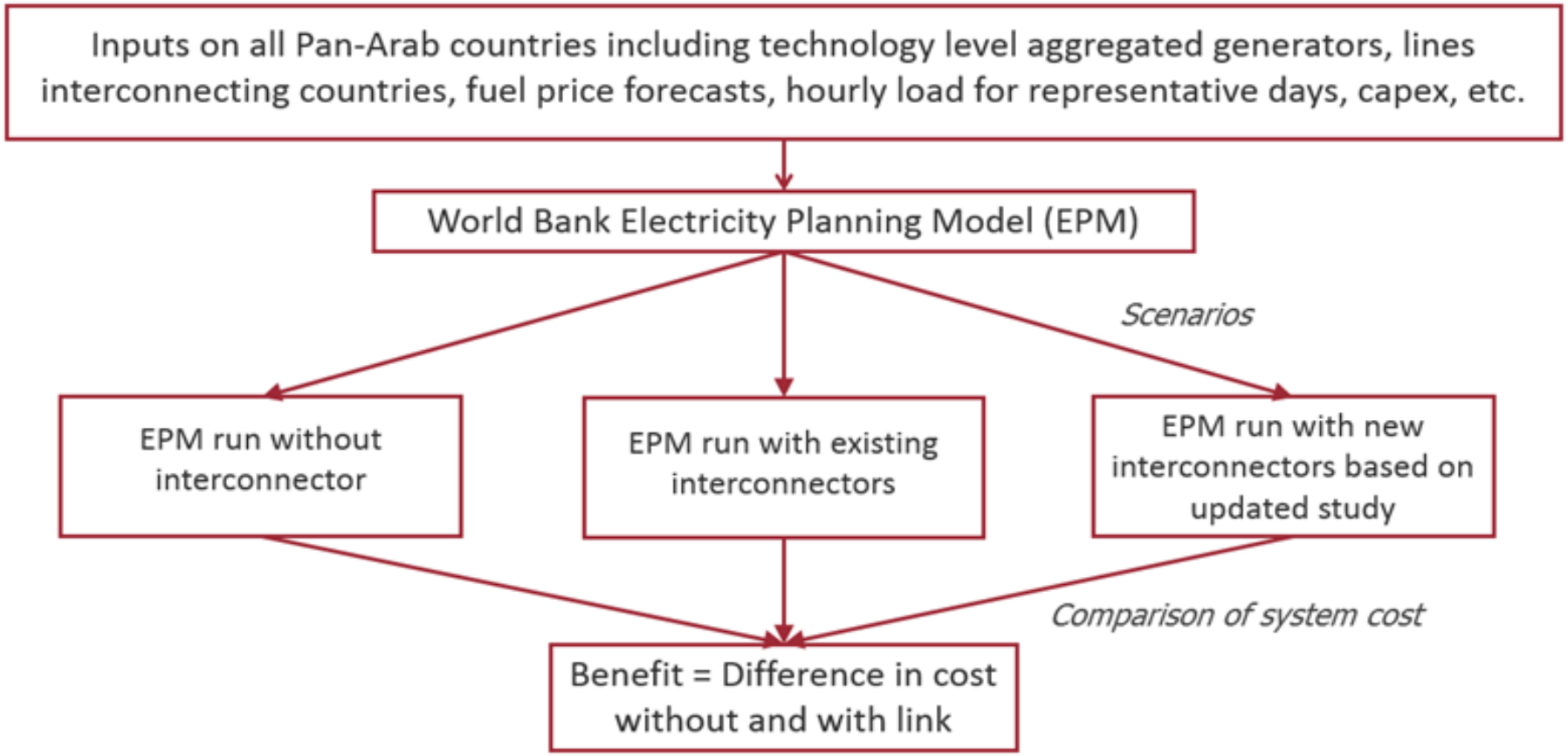
1 Sets a structured analytical methodology to assess the need and benefits of Regional Interconnection through electricity planning model.

2 Sets a baseline for a Regional Interconnection Investment Plan & Potential Financing

3 Identifies 25 regional investment projects

4 Paves the way for transition from three sub-regional integration to a Pan-Arab Electricity Grid

Analytical Framework



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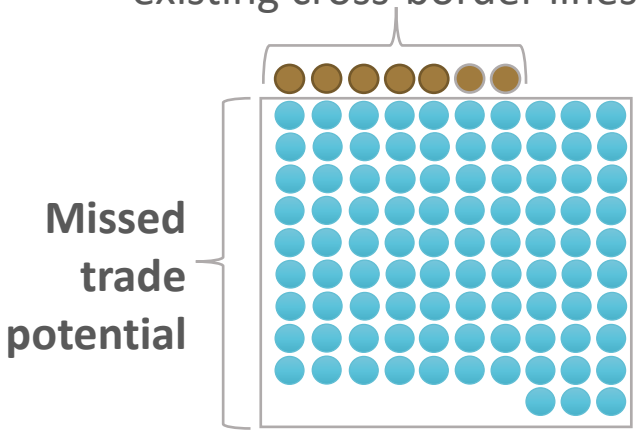
Key barriers of trade in existing MENA cross-border lines

GRID

5-7% av. annual utilization of existing cross-border lines



PRICING

Average exported gas subsidy

US$11.7 billion
annually
in 2020-2035

MARKET

Limited Market liquidity is hindering utilization of existing lines

Sellers → **Buyers** = **LIQUIDITY**

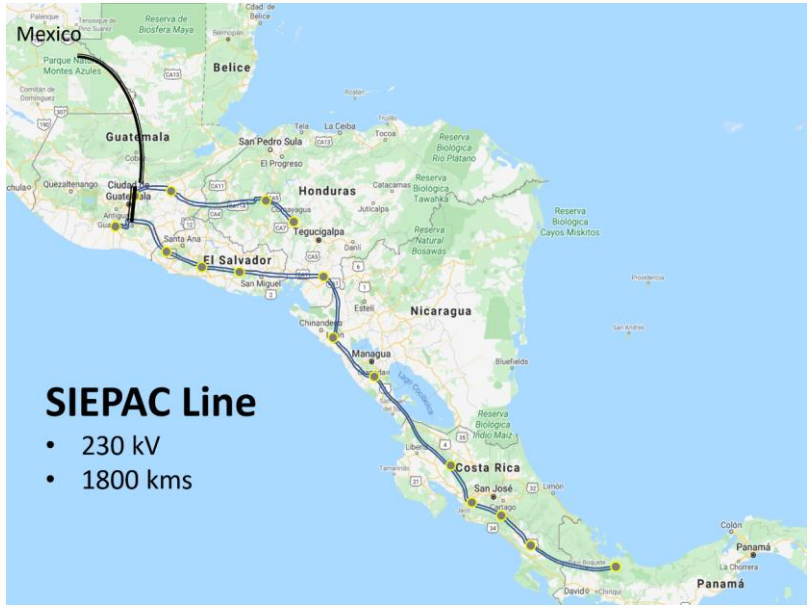
Traders

Example for a Utilized Interconnector – The case of the SIEPAC* Interconnection

9 shareholders with no shareholder controlling more than 15% of the issued and outstanding shares

A PPP SPV was formed to design, engineer, construct, and own the 1,793 km interconnector. It is owned by:

- 6 government-owned transmission companies or utilities
- 1 private company
- 2 regional government-owned transmission companies



The total trading benefits just in 2017 exceeded the $505 million initial investment

The GCC interconnector has

4x the transfer capacity of SIEPAC, but traded volume in GCCIA is

1/10 of SIEPAC trades in 2013-2017

MENA Interconnectors

- 5-7% av. annual utilization of existing cross-border lines

* SIEPAC is the acronym for the Spanish title: Sistema de Interconexión Eléctrica para los Países de América Central.

Benefits of Utilizing Existing Infrastructure

Benefits of enabling trade – on economic merits - through the existing interconnections only:

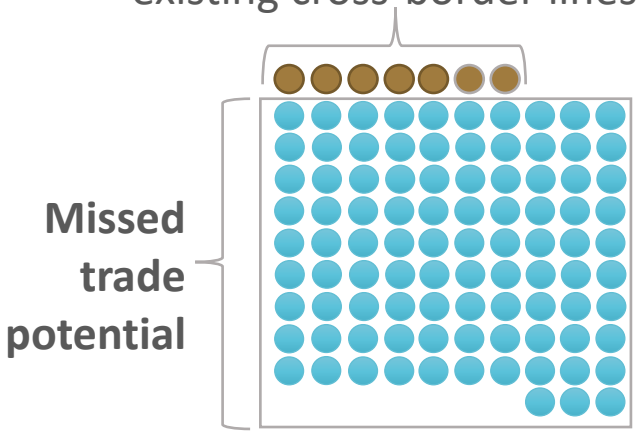
- Decreases total system costs by US$71 billion
- Increases the annual average utilization from 5–7 percent in 2018 to 36 percent in 2035
- Exhibits an estimated commercial value of trade of US$23 billion
- Improves energy security by 23 percent
- Increases the share of renewable technologies in the energy mix to 17.6% by 2035
- Requires an investment of US$86.5 billion in renewable technologies

Existing Cross-Border Interconnectors with expected utilization greater than 50% in 2035	
Algeria – Tunisia	GCCIA – Kuwait
Egypt – Libya	GCCIA – Bahrain
Egypt – Sudan	GCCIA – KSA
Egypt – Jordan	Oman – UAE
Syria – Iraq	Syria – Lebanon

Opportunities of trade in existing cross-border lines

GRID

5-7% av. annual utilization of existing cross-border lines



US$71 billion

in total system cost savings

if existing cross-border lines utilized by **36%** in 2020-2035

PRICING

Average exported gas subsidy

US$11.7 billion

annually in 2020-2035

Countries need to develop and agree on trade pricing approaches to promote "commercial trade"

MARKET

Limited Market liquidity is hindering utilization of existing lines

Sellers → **Buyers** = **LIQUIDITY**

Traders

US$23 billion

untapped value of trade opportunities in 2018-2035

Due to limited grid access

Opportunities of trade in existing cross-border lines

	Scenario	Total System Cost ($ million)	Fuel Cost[a] ($ million)	Capital Cost[b] ($ million)	Reliability[c] ($ million)	O&M Cost[d] ($ million)
Pan-Arab system	Without any cross-border interconnectors, BAU	1,317,531	850,346	180,307	120,605	166,274
	With increased utilization of existing cross-border interconnectors	1,246,055	831,426	181,558	65,751	167,320
	Benefits[e]	**71,476**	**18,920**	**-1,251**	**54,854**	**-1,047**

The table reflects the total discounted cost of operating the regional power system in the period of 2018–35, assuming discount rate of 6 percent

(a) Total cost of fuel consumed in the period of 2018–35; (b) Total annualized cost of building new generation capacity in the period 2018–30, assuming a weighted average cost of capital (WACC) of 6 percent; (c) Includes the cost of unserved energy plus the cost of unserved reserves; (d) Includes fixed and variable operation and maintenance cost; and (e) Economic benefits are estimated as the difference between the discounted cost of the power system without using cross-border interconnectors minus the discounted cost of the system using existing cross-border interconnectors.

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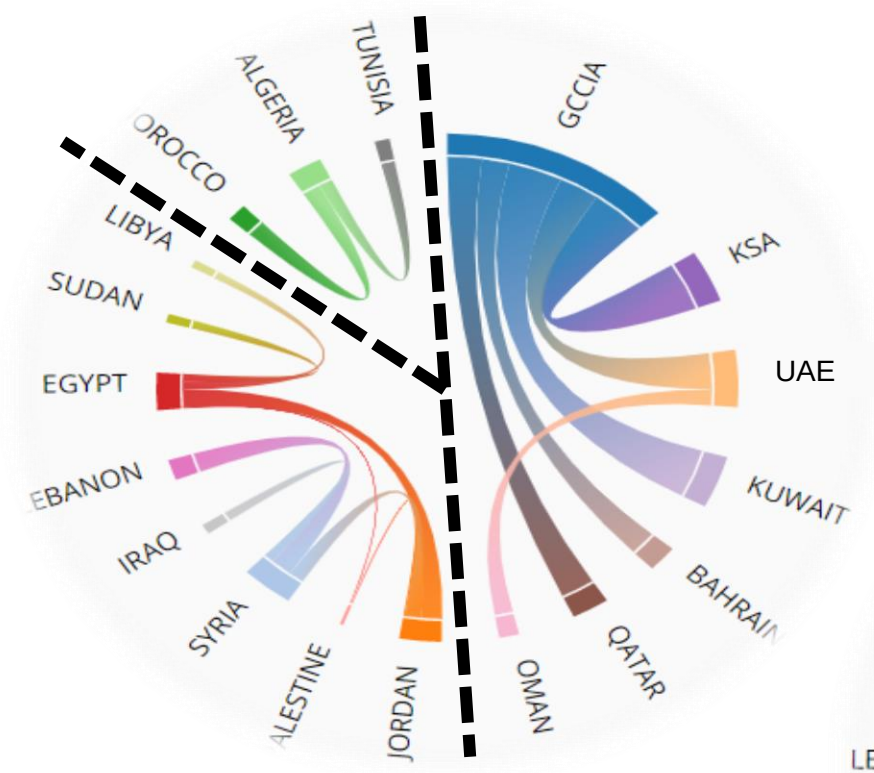
Proposed and Reinforced Cross-Border Interconnections

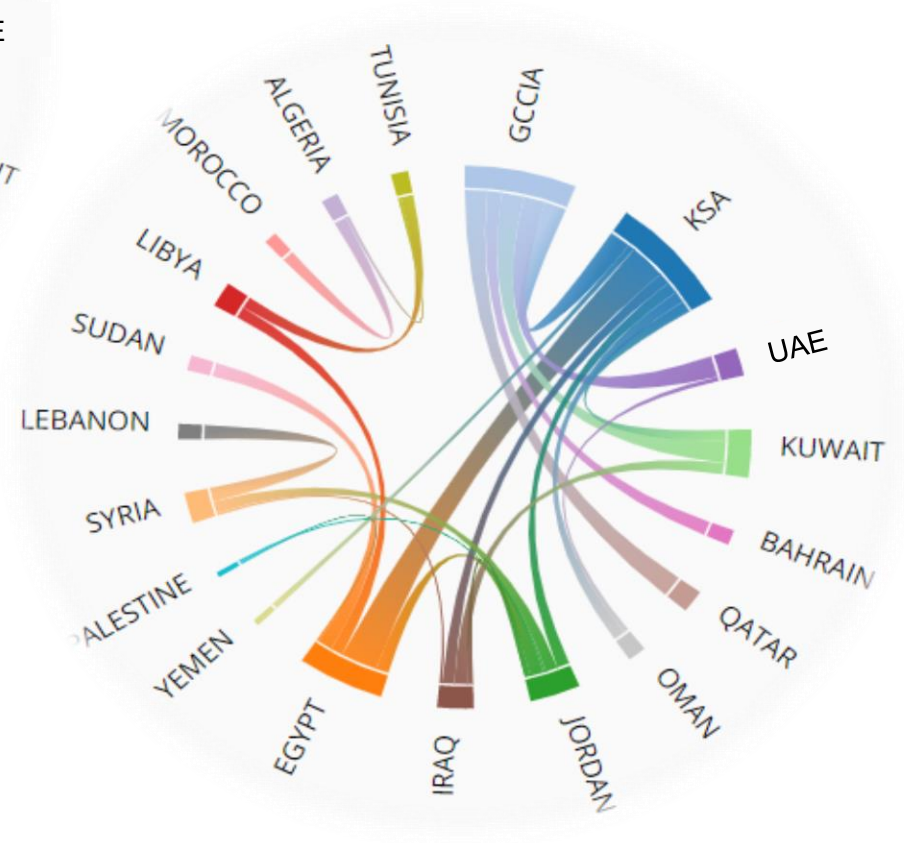
15 selected interconnection reinforcement projects require investments of about $1.6bn

10 proposed interconnection projects require almost $5.9bn

$1bn to invest in expanding regional cross-border trade saves $4.6bn in system costs



Arab countries grids, *mainly sub-regional*, in 2022



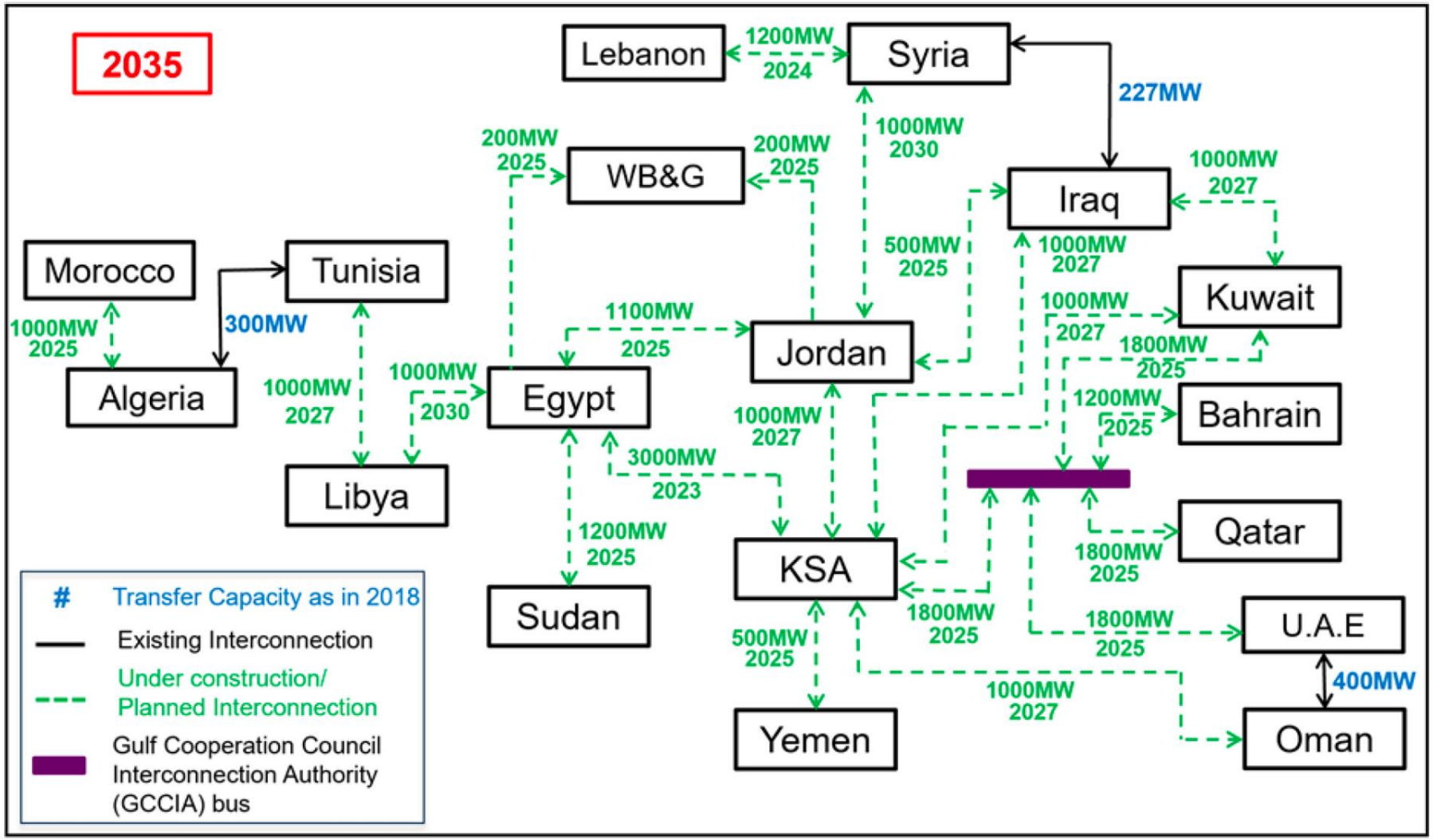
Identified projects can create a Pan Arab grid across MENA by 2035

Identified New Interconnections

New Interconnections	Total Capacity (MW)
KSA - Egypt	3000
KSA - Yemen	500
Tunisia - Libya	1000
KSA - Jordan	1000
KSA - Iraq	1000
Jordan - Iraq	500
KSA - Oman	1000
Kuwait - KSA	1000

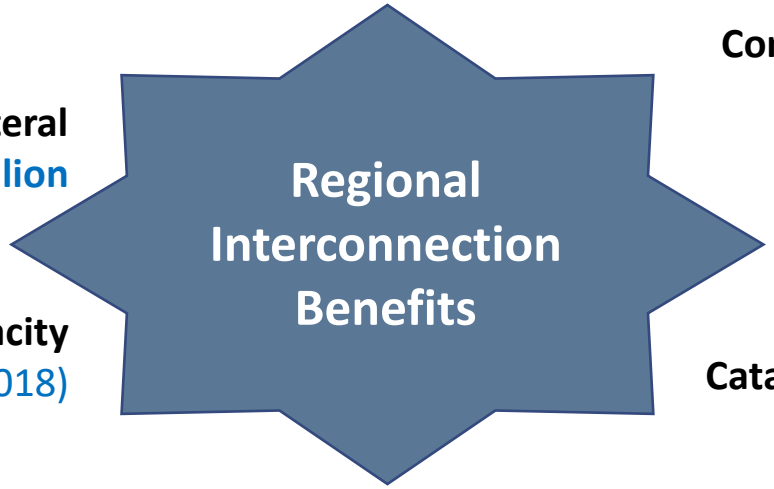
Identified Reinforcements

Identified Reinforcements	Increased Capacity (MW)
Algeria-Morocco	600
Egypt-Sudan	1000
Egypt - Jordan	650
Egypt – Gaza Strip	175
Jordan – West Bank	160
Libya - Egypt	370
Jordan – Syria	650
Lebanon – Syria	730
GCC Interconnections	600-1050



The Benefits of Integrated Pan-Arab Electricity Market

Value of Trade and Regional Investments (VOTRI) report quantifies the benefits from a fully integrated PAEM by 2035 (cumulated from the base year 2018):



Total power system cost savings: $107 - 196 billion

Commercial value of trade: $60 - 167 billion in export/import

Shared economic benefits from bilateral trade: $32 - 150 billion

Higher share of renewable energy: 16 - 28% of capacity in 2035 (vs 1.4% 2018)

Increased cross-border transmission capacity utilization: 37 - 43% (vs 5-7 % in 2018)

Catalyzed private investment in renewable energy: $64 – 305 billion

Improved energy security: Unmet reserve savings: 32% – 69% of total system cost savings

Lower cost of compliance with carbon targets: $86 billion in cost savings

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Studied Scenarios

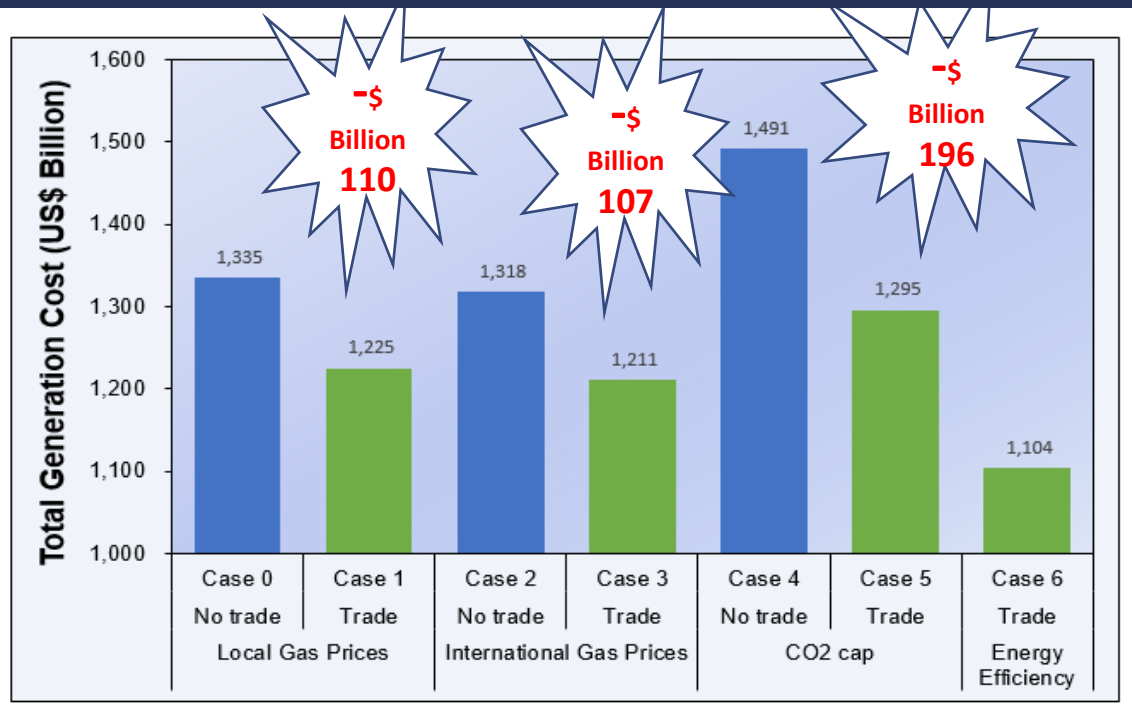
Base Case (Case 0, C0)	Natural gas—current market prices, no electricity trading
Case 1 (C1)	Natural gas—current market prices, electricity trading
Case 2 (C2)	Natural gas—international prices, no electricity trading
Case 3 (C3)	Natural gas—international prices, electricity trading
Case 4 (C4)	Natural gas—international prices, no electricity trading, CO_2 emissions limit
Case 5 (C5)	Natural gas—international prices, electricity trading, CO_2 emissions limit
Case 6 (C6)	Natural gas—international prices, electricity trading, demand-side measures

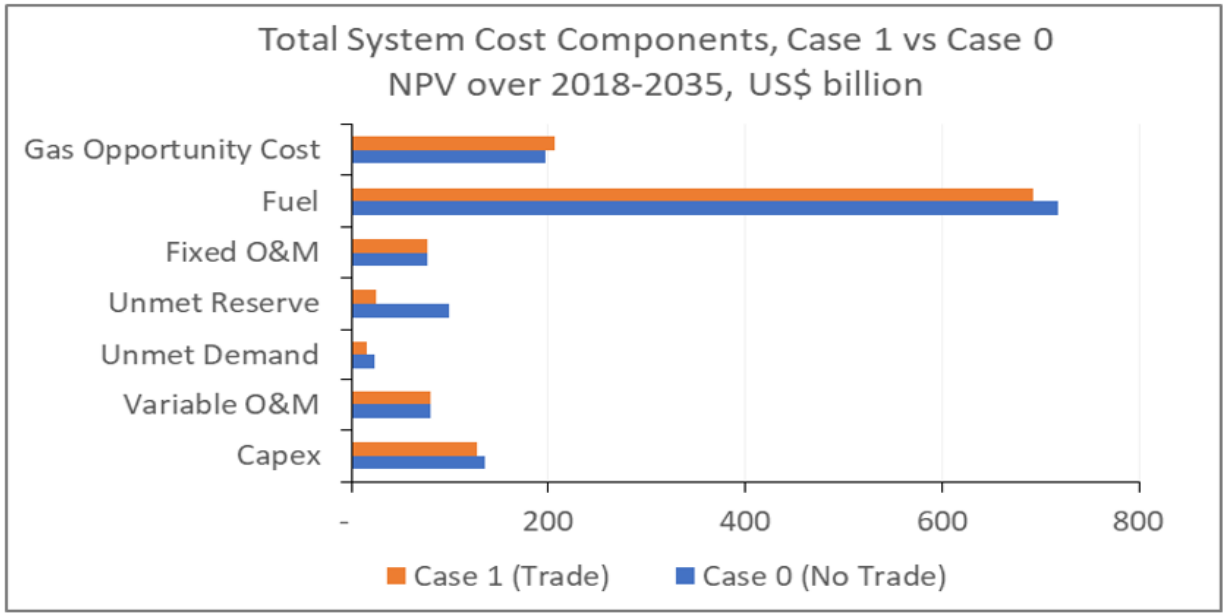
Case 0 is the most conservative baseline: assuming that gas-for-power generation remains subsidized, and there are no carbon caps

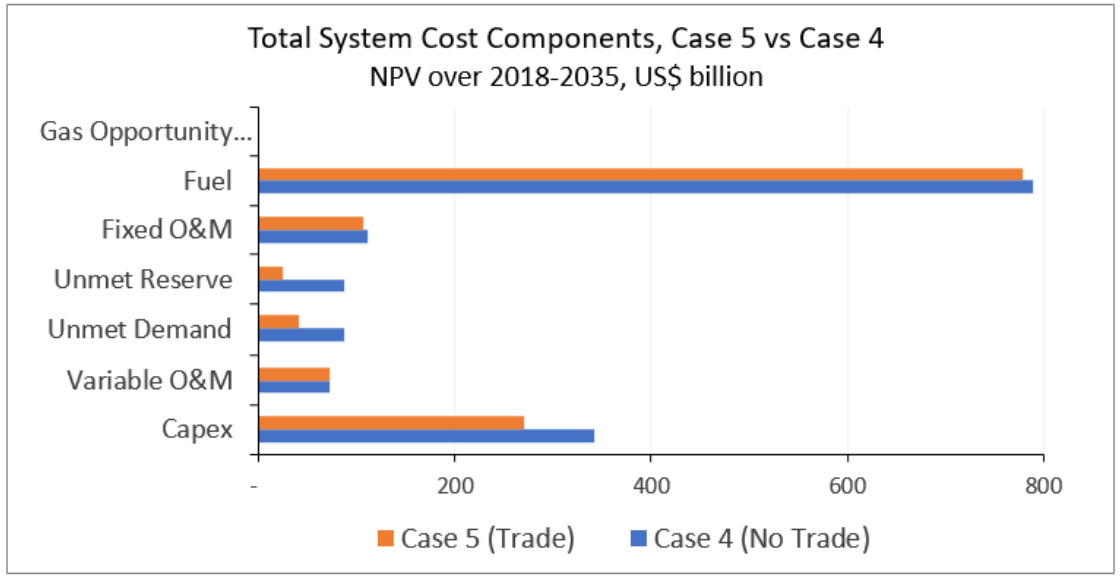
The Study investigated both the economic and the commercial (financial) benefits of trade

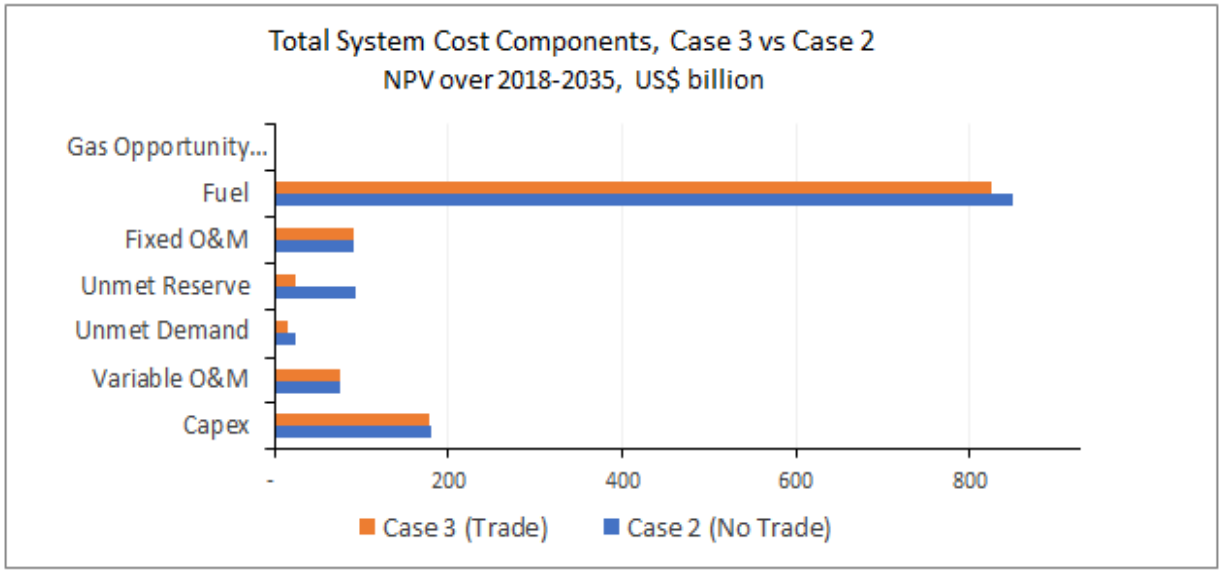
The benefits were quantified at system, subregion, and country level

Massive Savings on Power System Costs

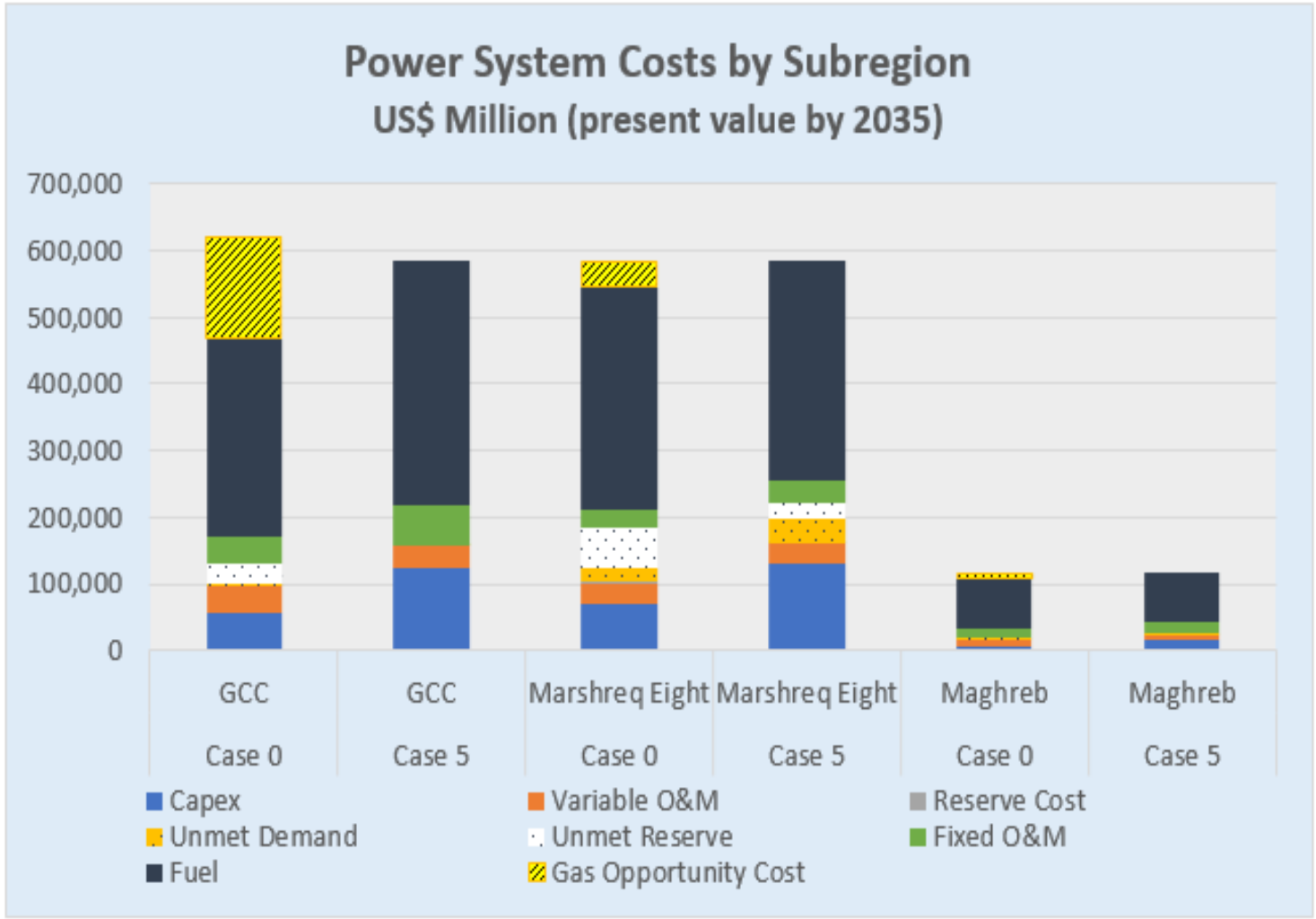


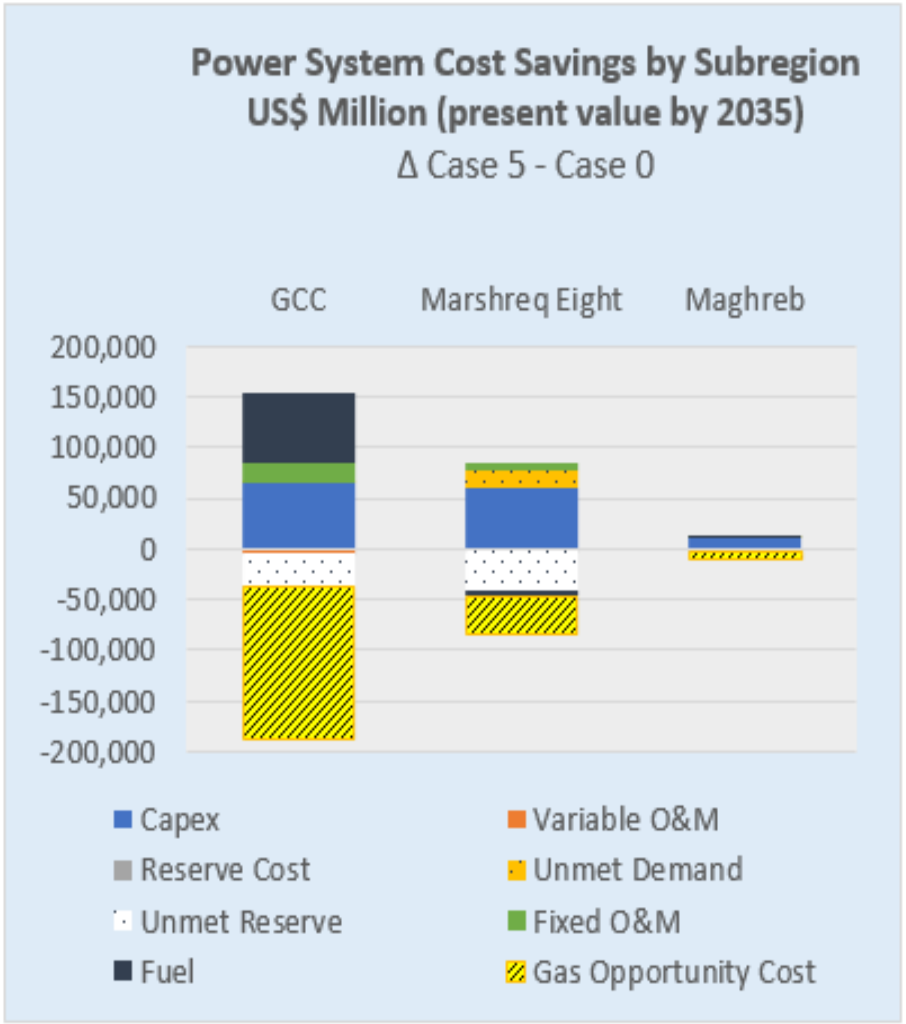






Power System Cost Savings by the Sub-region

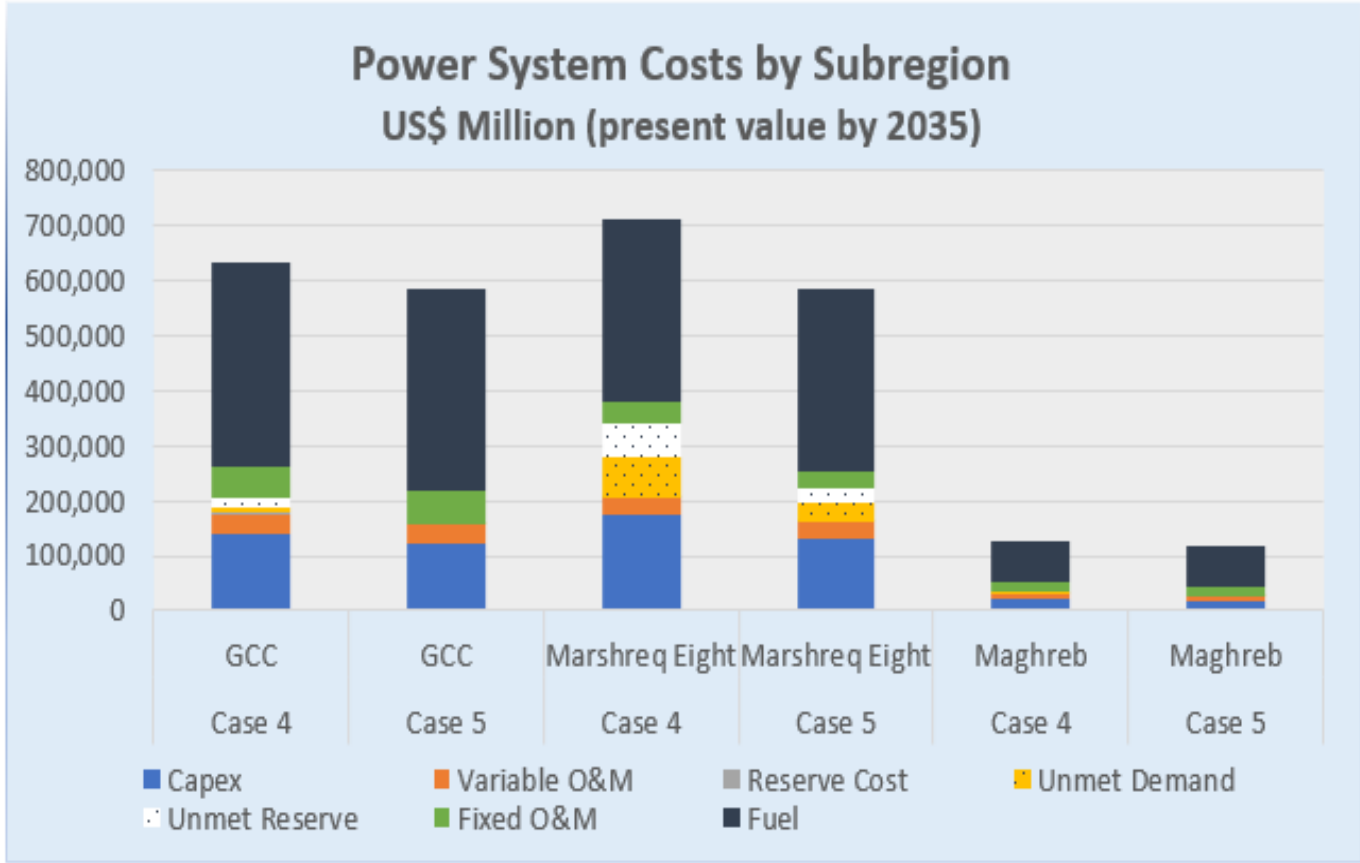


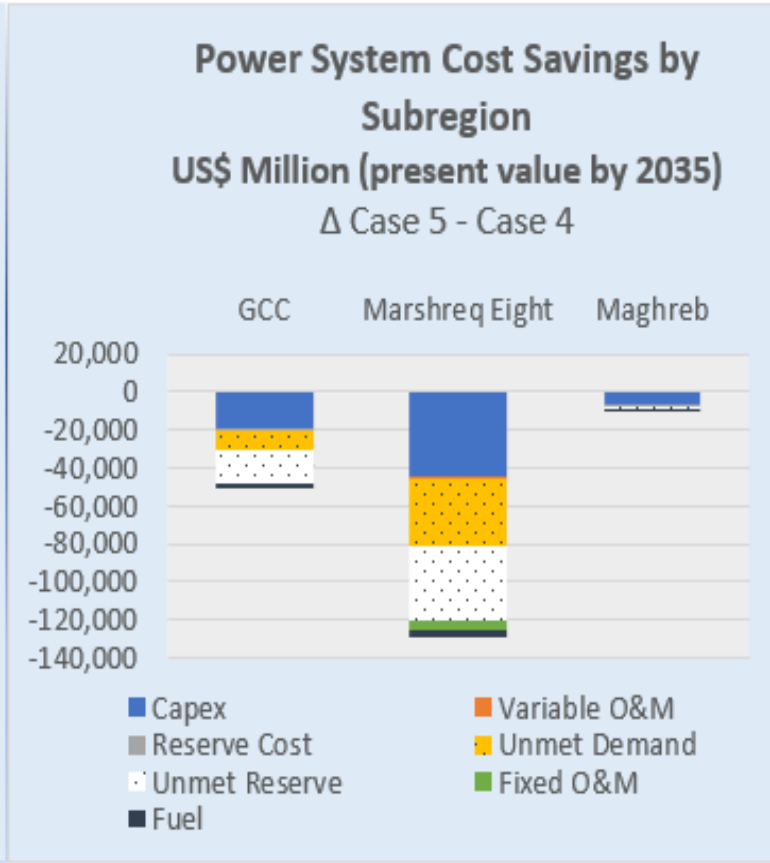


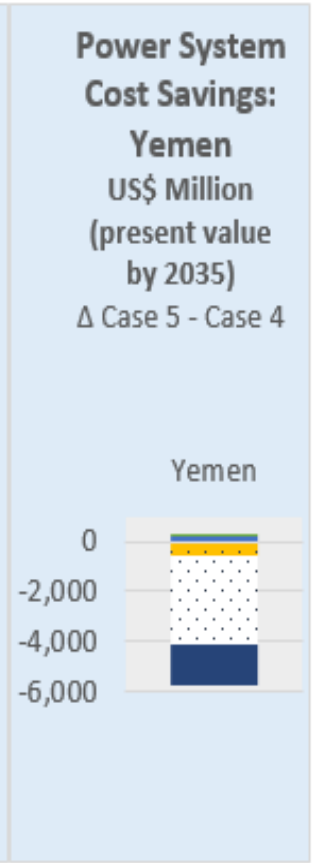
GCC = Gulf Cooperation Council countries: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and United Arab Emirates.
”Mashreq Eight” states in this study are: Egypt, Iraq, Jordan, Lebanon, Libya, West Bank and Gaza, Sudan, and Syria.
The Maghreb states are: Algeria, Morocco, and Tunisia.
Yemen is accounted separately from the three sub-regions in this study.

Power System Cost Savings by the Sub-region (cont'd)

All three Sub-regions: GCC, "Mashreq Eight", and Maghreb, as well as Yemen, will save costs from market integration under PAEM assuming the COP-21 carbon emission constraints







GCC = Gulf Cooperation Council countries: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and United Arab Emirates.

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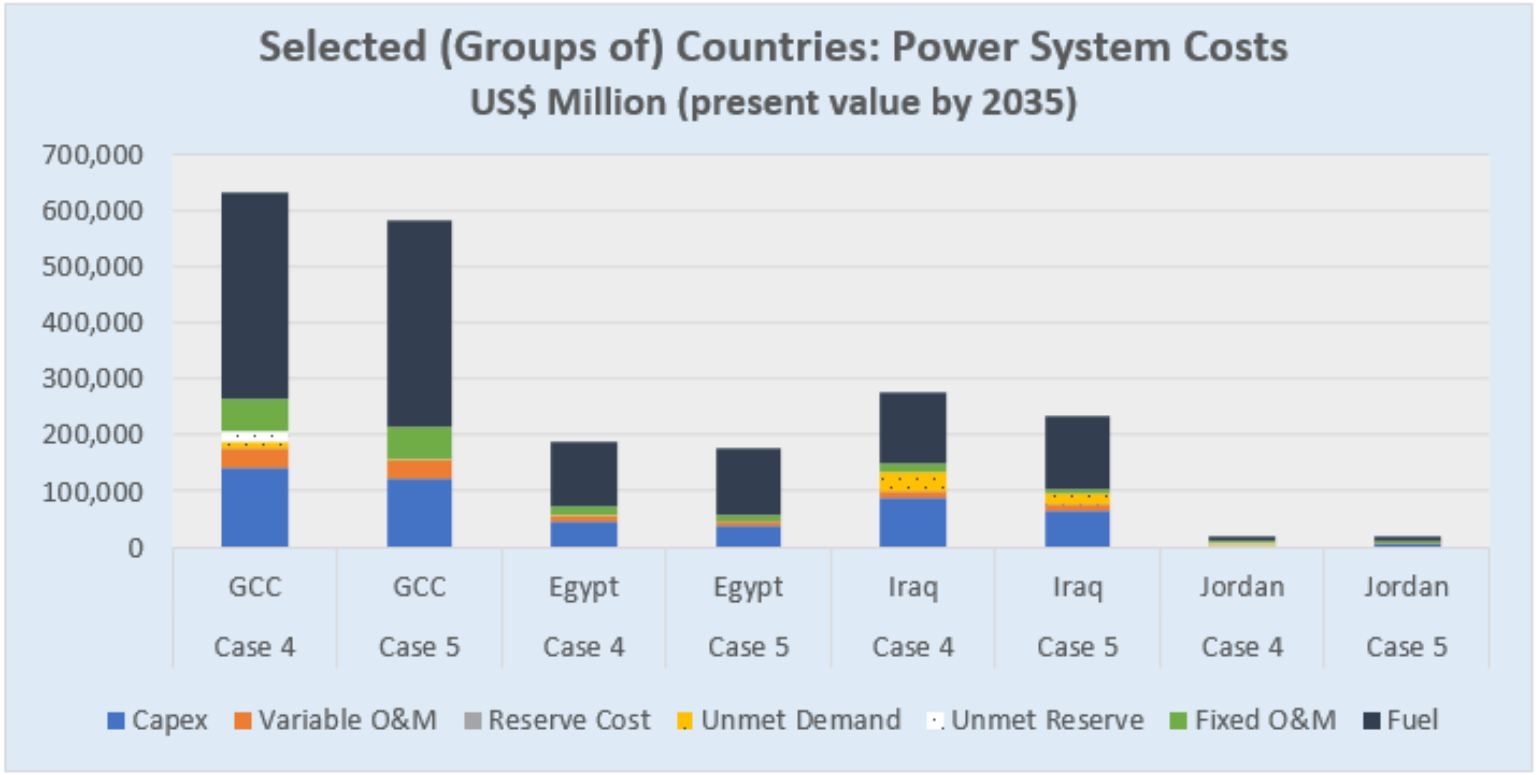
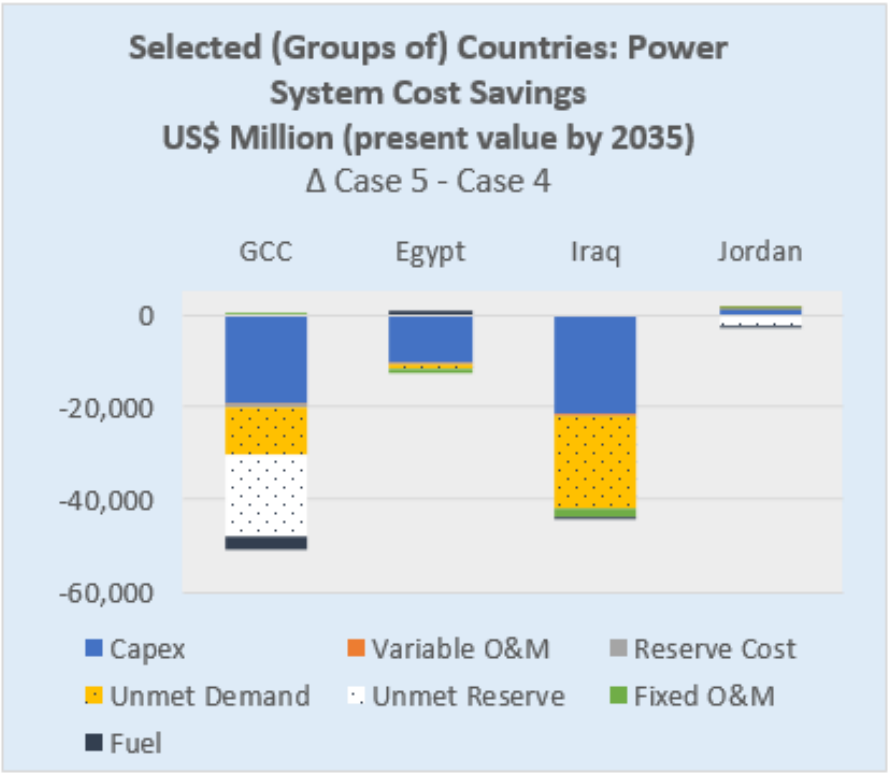
The Maghreb states are: Algeria, Morocco, and Tunisia.

Yemen is accounted separately from the three sub-regions in this study.

Power System Cost Savings by the Sub-region (cont'd)

1) GCC integrating with Egypt, Jordan, and Iraq accounts for 55% of the PAEM benefits
2) GCC integration with all Eight Mashreq countries can bring about 90% of the PAEM benefits





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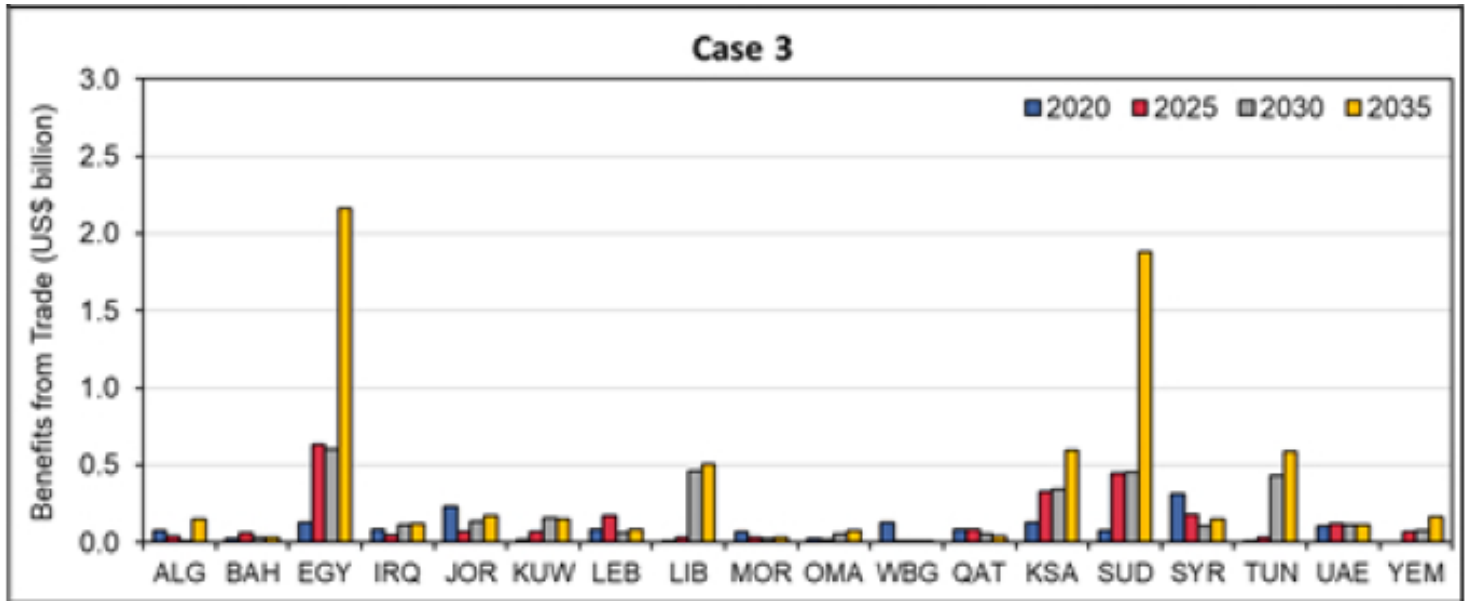
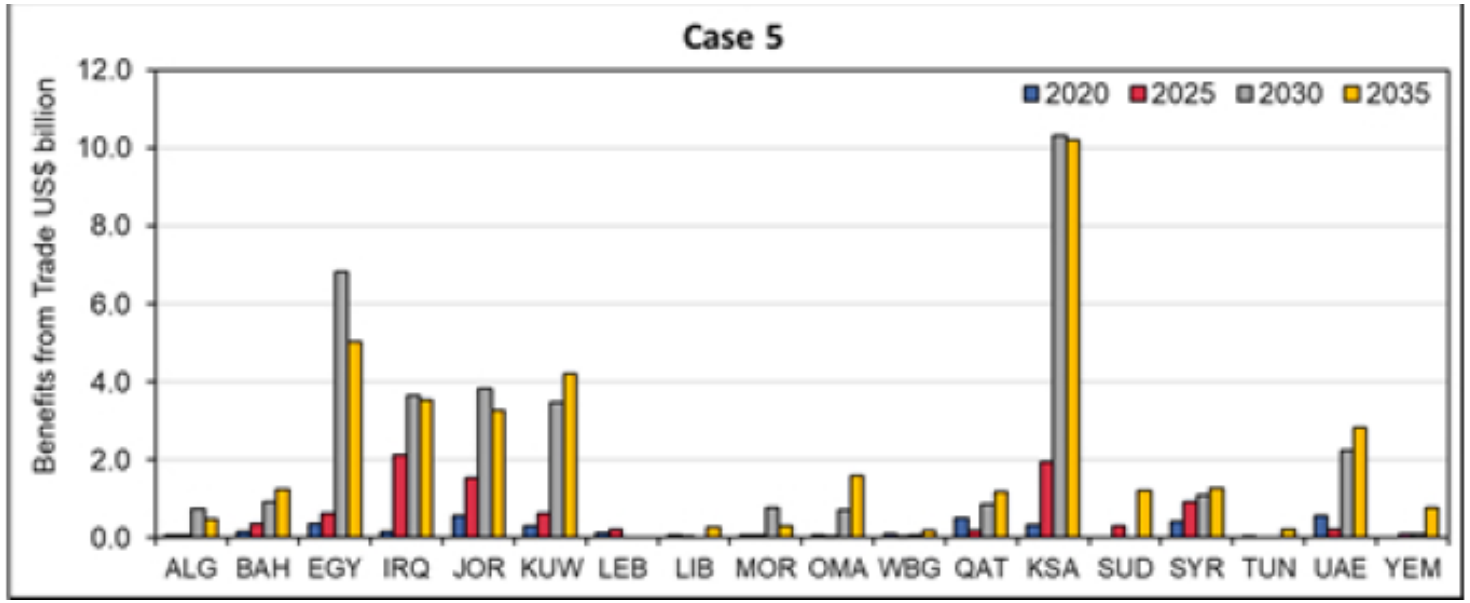
The Stakeholders Benefiting from PAEM

Country governments	Utilities	Investors and financiers	Global climate
$107 – 196bn Power system cost savings	**$32 – 150bn** Shared benefits from bilateral trade	**$60 – 167bn** Commercial value of export/import transactions	**$86bn** Savings in cost of compliance with carbon targets
Unmet reserve cost savings **32% – 69%** of total system cost savings Improved energy security is a large component of power system cost savings benefiting both countries and utilities		Access to a wider pool of consumers, thus more commercial products and services	**16 - 28%** Share of RE capacity (vs 1.4% 2018) Higher share of renewable energy

All benefits based on the Value of Trade and Regional Investments 2020-2035 (VOTRI) report completed under PA-RETP1.0

Shared Economic Benefits of Trade: $40.3-150.0 Billion



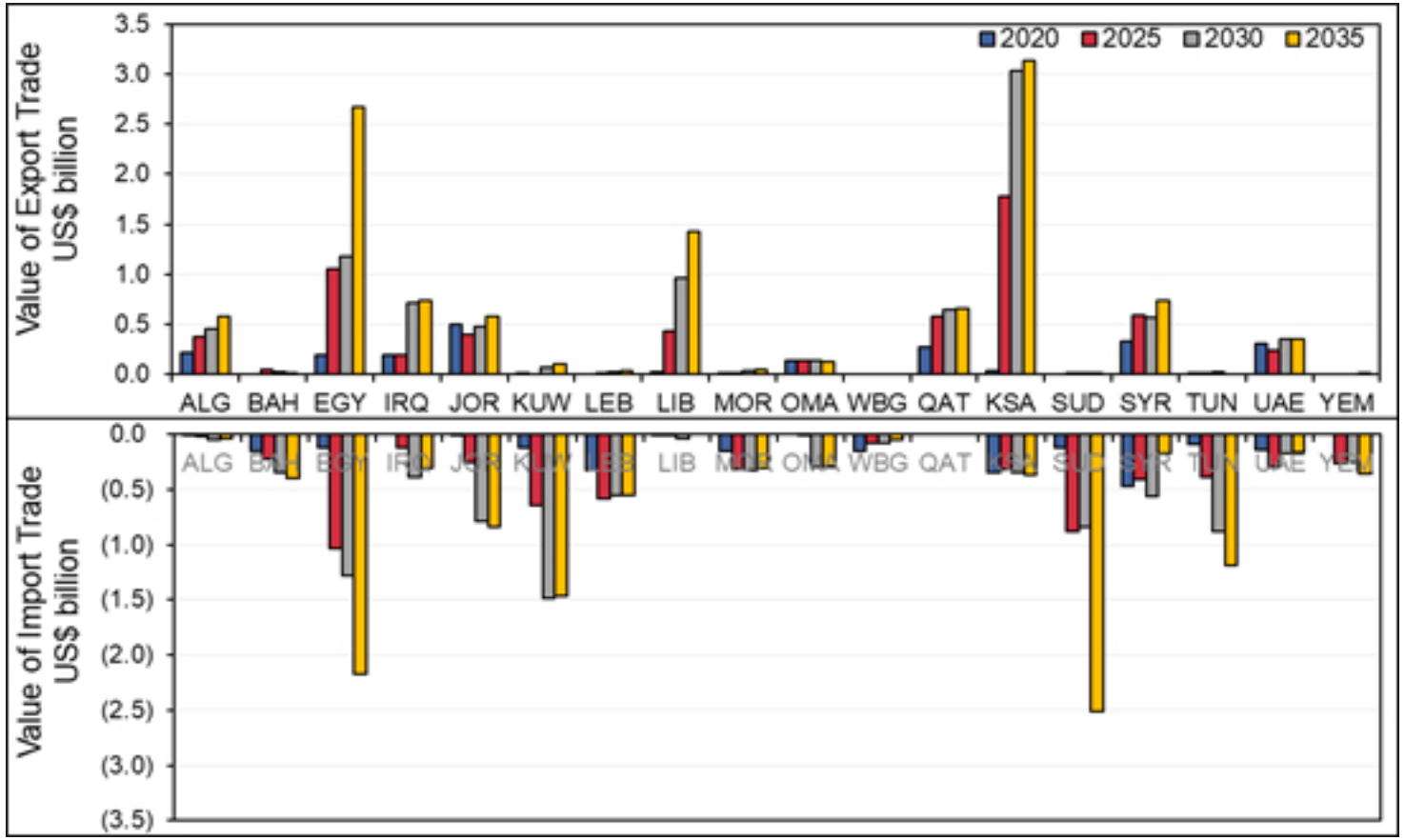


Value Definition	Shared Economic Benefits of Trade, US$ Billion
Formula (*)	$(C_i - C_e) \times Q$
Case 1: Natural gas current prices, electricity trading	40.3
Case 3: Natural gas international prices, electricity trading	32.2
Case 5: Natural gas international prices, electricity trading, CO2 emissions limit	150.0

* Note:
C_i, in $/MWh, is the marginal cost of electricity of the importing country without trading;
C_e, in $/MWh, is the marginal cost of the exporting country without electricity trading; and
Q, in Billion MWh, is the quantity (or volume) of electricity traded over a time period.

Commercial/Financial Value of Potential Trade: $60 – 167 Billion

Value of Trade per year for Case 1

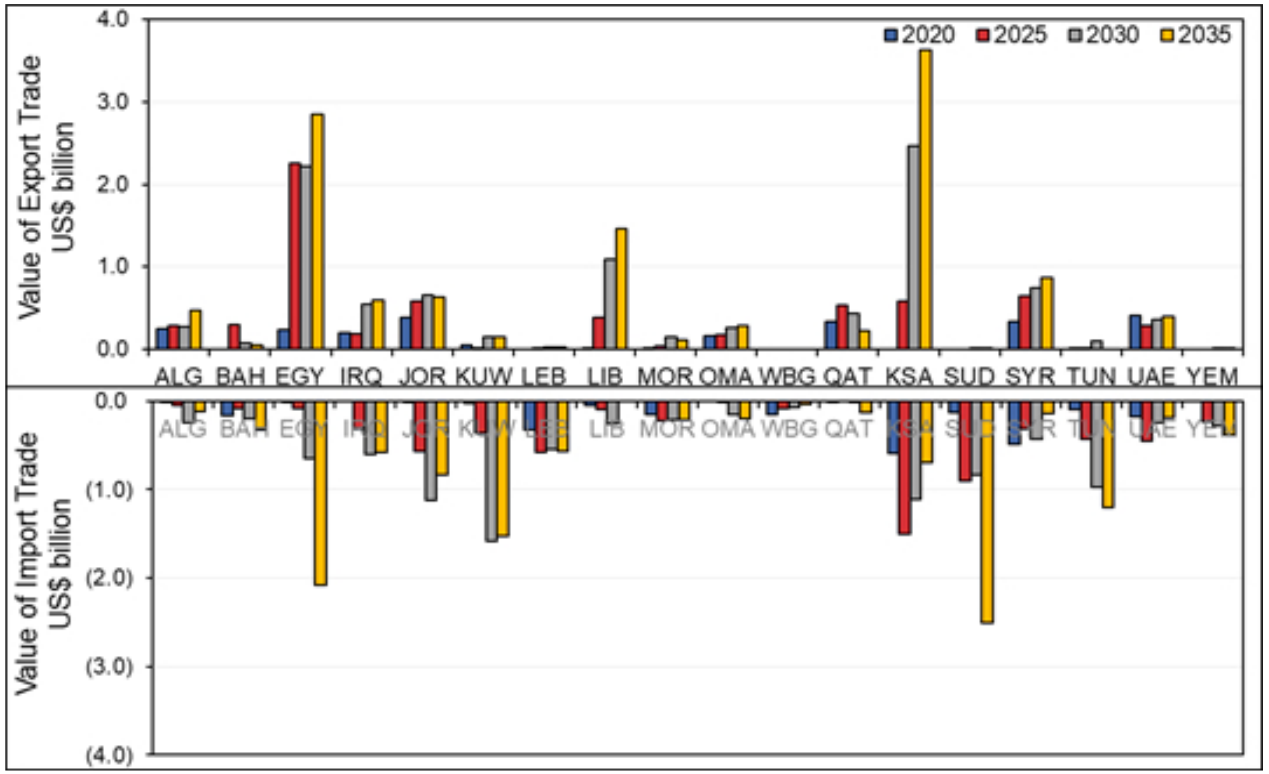


Value Definition	Commercial Value of Trade, US$ Billion
Formula (*)	$(C_i + C_e)/2 \times Q$
Case 1: Natural gas current prices, electricity trading	59.5
Case 3: Natural gas international prices, electricity trading	62.9
Case 5: Natural gas international prices, electricity trading, CO2 emissions limit	166.6

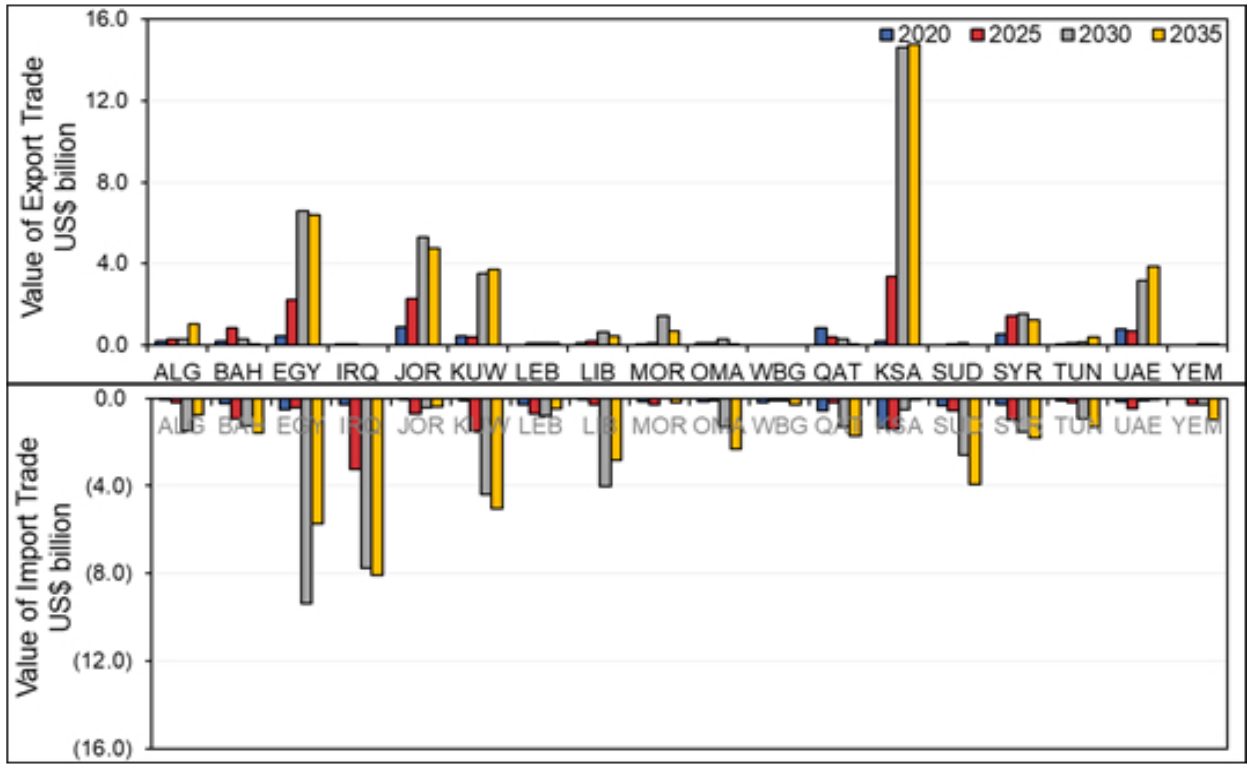
* Note:
C_i, in $/MWh, is the marginal cost of electricity of the importing country without trading;
C_e, in $/MWh, is the marginal cost of the exporting country without electricity trading; and
Q, in Billion MWh, is the quantity (or volume) of electricity traded over a time period.

Commercial/Financial Value of Potential Trade: $60 – 167 Billion

Value of Trade per year for Case 3



Value of Trade per year for Case 5



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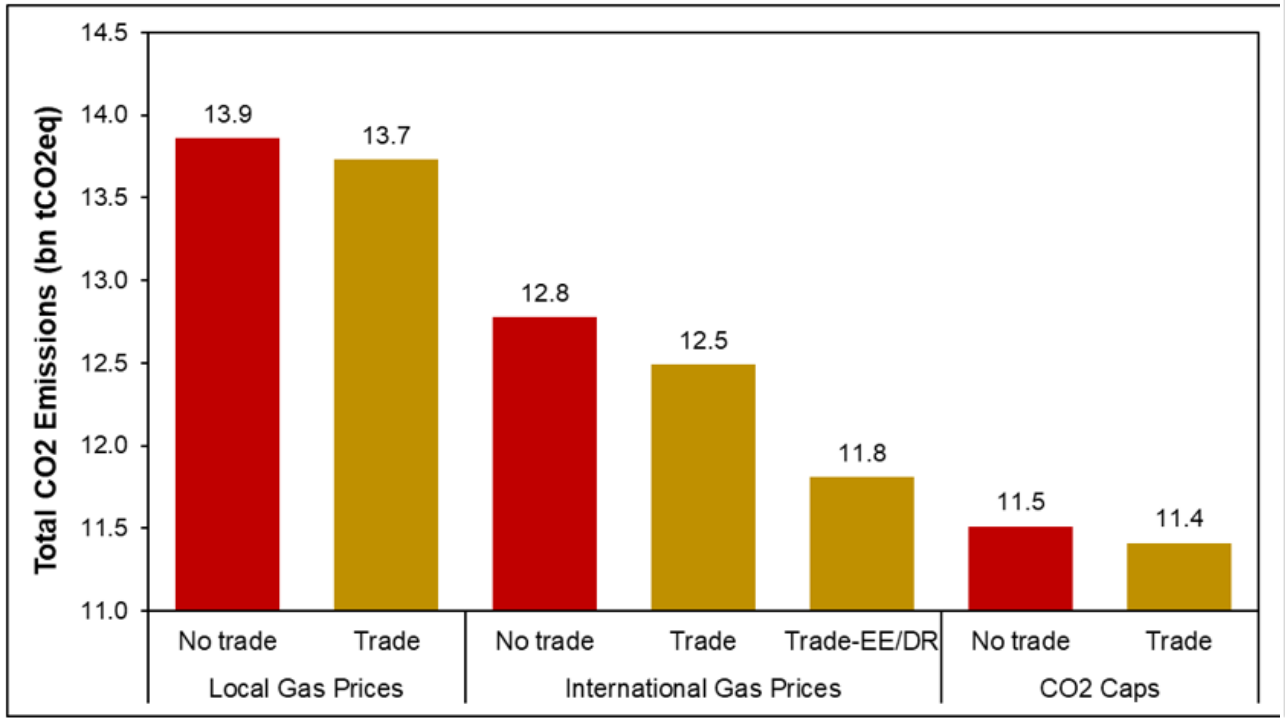
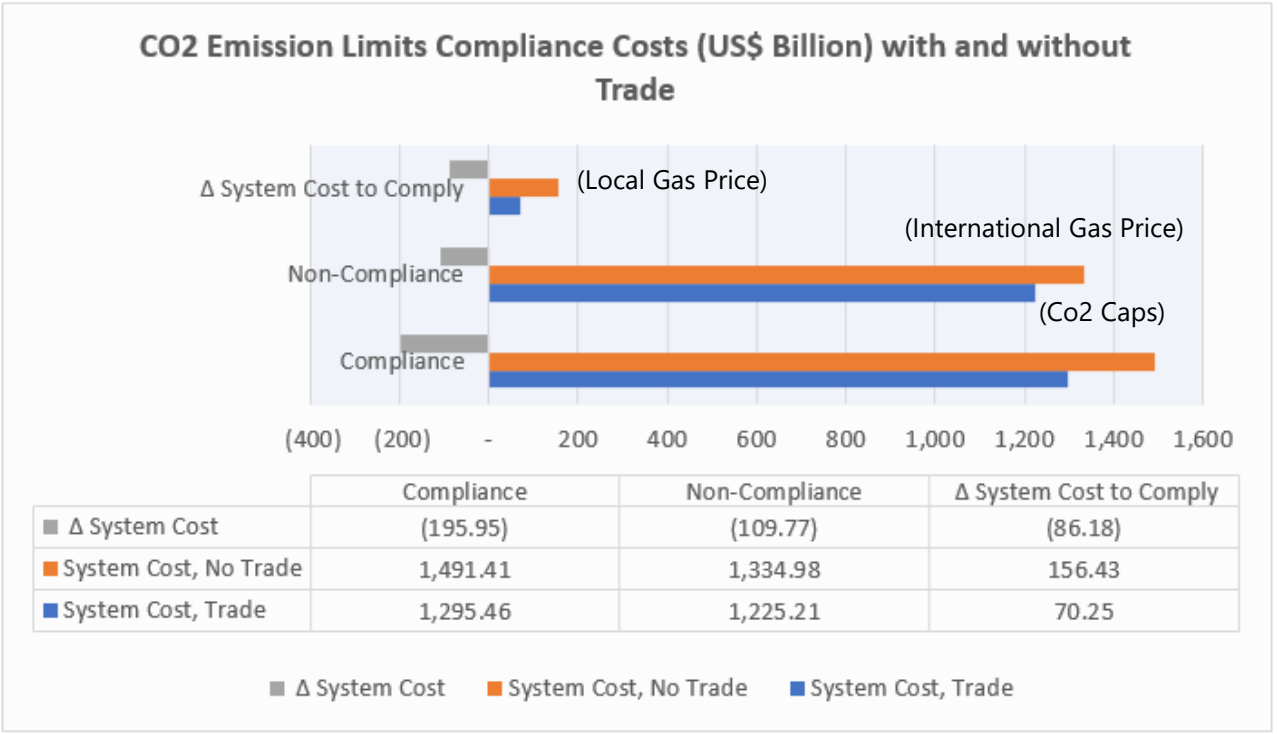
Impact of Trade on CO2 Emissions

1) Trade is <u>not</u> a substitute for essential domestic policies such as removing gas price subsidies or introducing CO2 emission caps (left-side graph, total CO2 Emissions in 2018-2035)
2) Costs of compliance with CO2 emission limits are lower by $86 billion with trade (right-side graph):

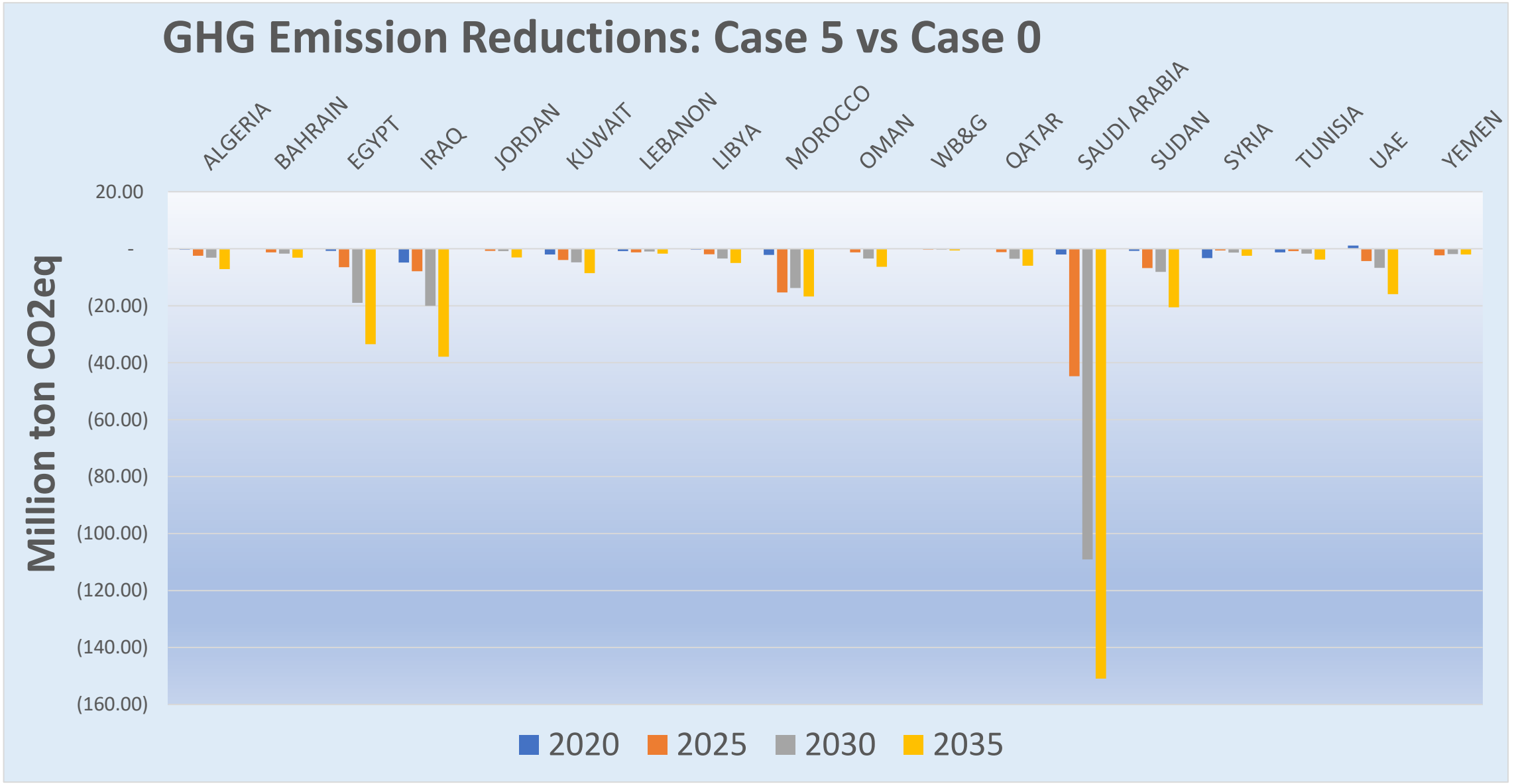




	Compliance	Non-Compliance	Δ System Cost to Comply
Δ System Cost	(195.95)	(109.77)	(86.18)
System Cost, No Trade	1,491.41	1,334.98	156.43
System Cost, Trade	1,295.46	1,225.21	70.25

EE = energy efficiency; DR = demand response

Impact of Trade on CO2 Emissions (by country)

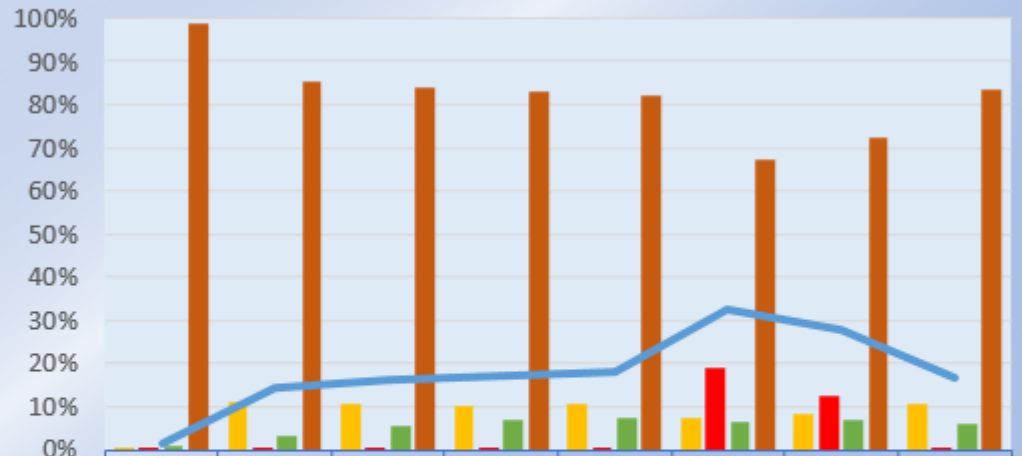


Reductions are negative values below X-axis

Renewable Energy Development Scenarios

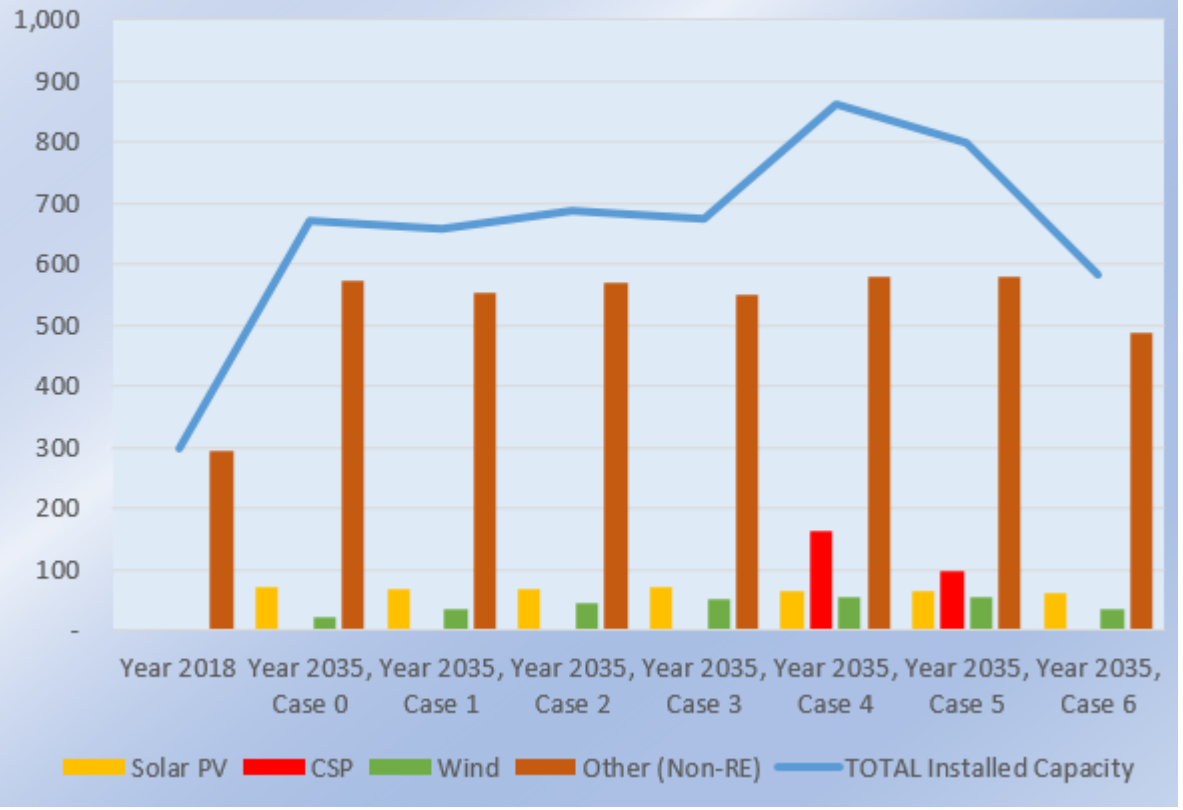
1) Electricity generation mix by 2035 will see a greater share of renewable energy
2) The scenarios with carbon emission limits (Cases 4 and 5) have the highest shares of renewable energy but also the highest total capacity requirements

Region-level (PAEM) Renewable Energy Share in Installed Capacity
Percent Share in 2018 and in 2035 under Different Scenarios/Cases



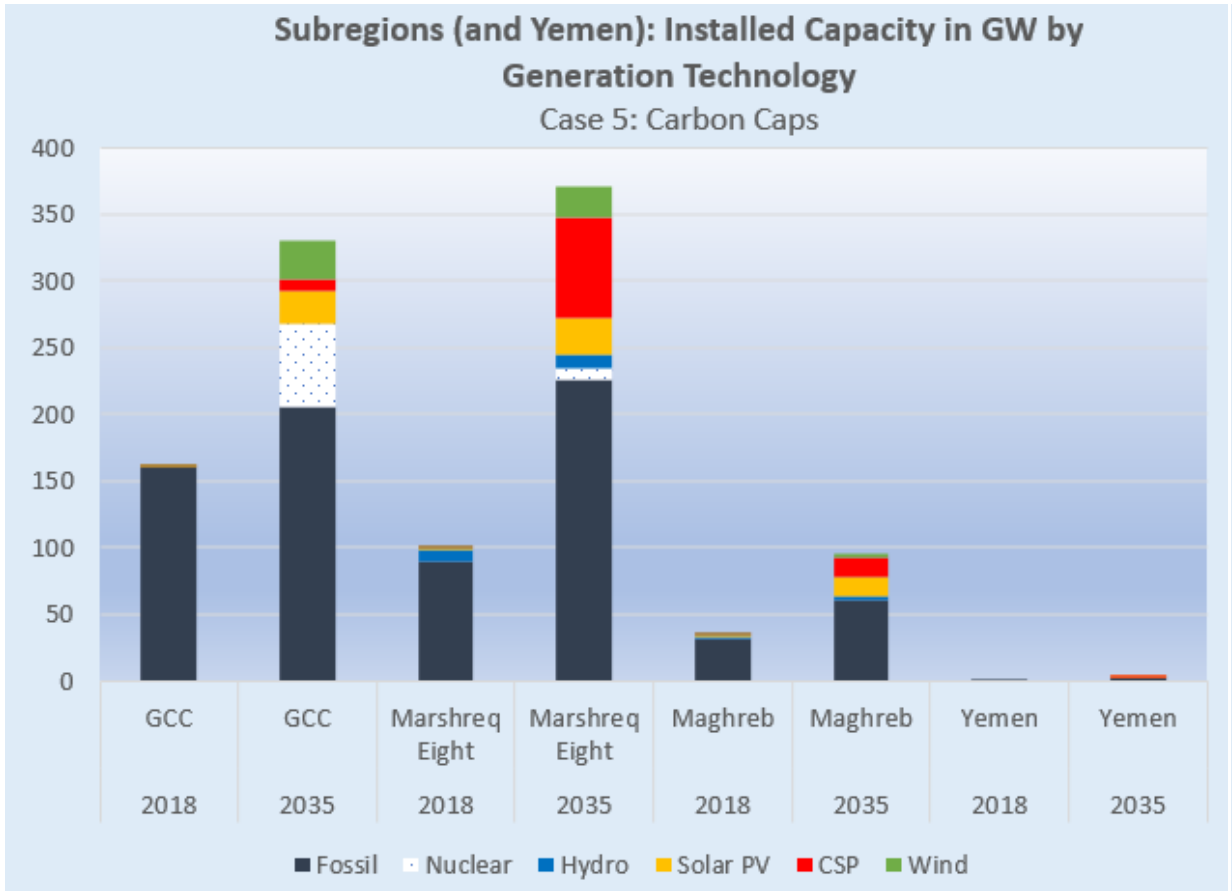
	Year 2018	Year 2035, Case 0	Year 2035, Case 1	Year 2035, Case 2	Year 2035, Case 3	Year 2035, Case 4	Year 2035, Case 5	Year 2035, Case 6
Solar PV	0.5%	10.8%	10.5%	10.0%	10.5%	7.5%	8.2%	10.4%
CSP	0.2%	0.3%	0.2%	0.3%	0.2%	18.8%	12.3%	0.2%
Wind	0.8%	3.3%	5.3%	6.7%	7.4%	6.4%	7.0%	6.0%
Other (Non-RE)	98.6%	85.5%	84.0%	82.9%	81.9%	67.3%	72.4%	83.5%
RE Total	1.4%	14.5%	16.0%	17.1%	18.1%	32.7%	27.6%	16.5%

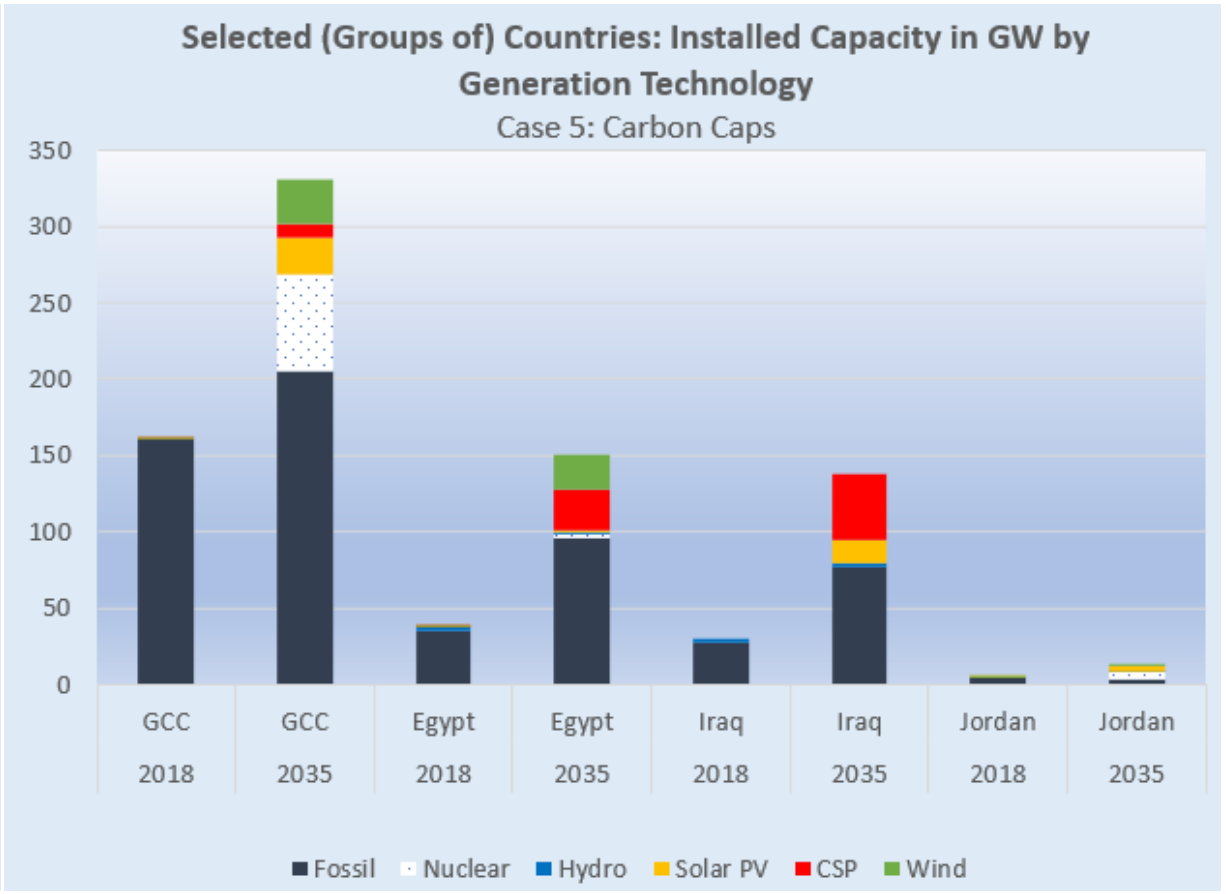
Region-level (PAEM) Renewable Energy Capacity in GW
2018 and 2035 under Different Scenarios/Cases



Transition Paths to Low-Carbon Energy (Sub-regions)

1) Electricity generation mix by 2035 will see a gradual transition from fossil fuels to carbon-free technologies
2) GCC integrating grids with Mashreq countries (Egypt, Iraq, and Jordan) is critical to enable the transition





Summary of Potential Benefits from Regional Trade

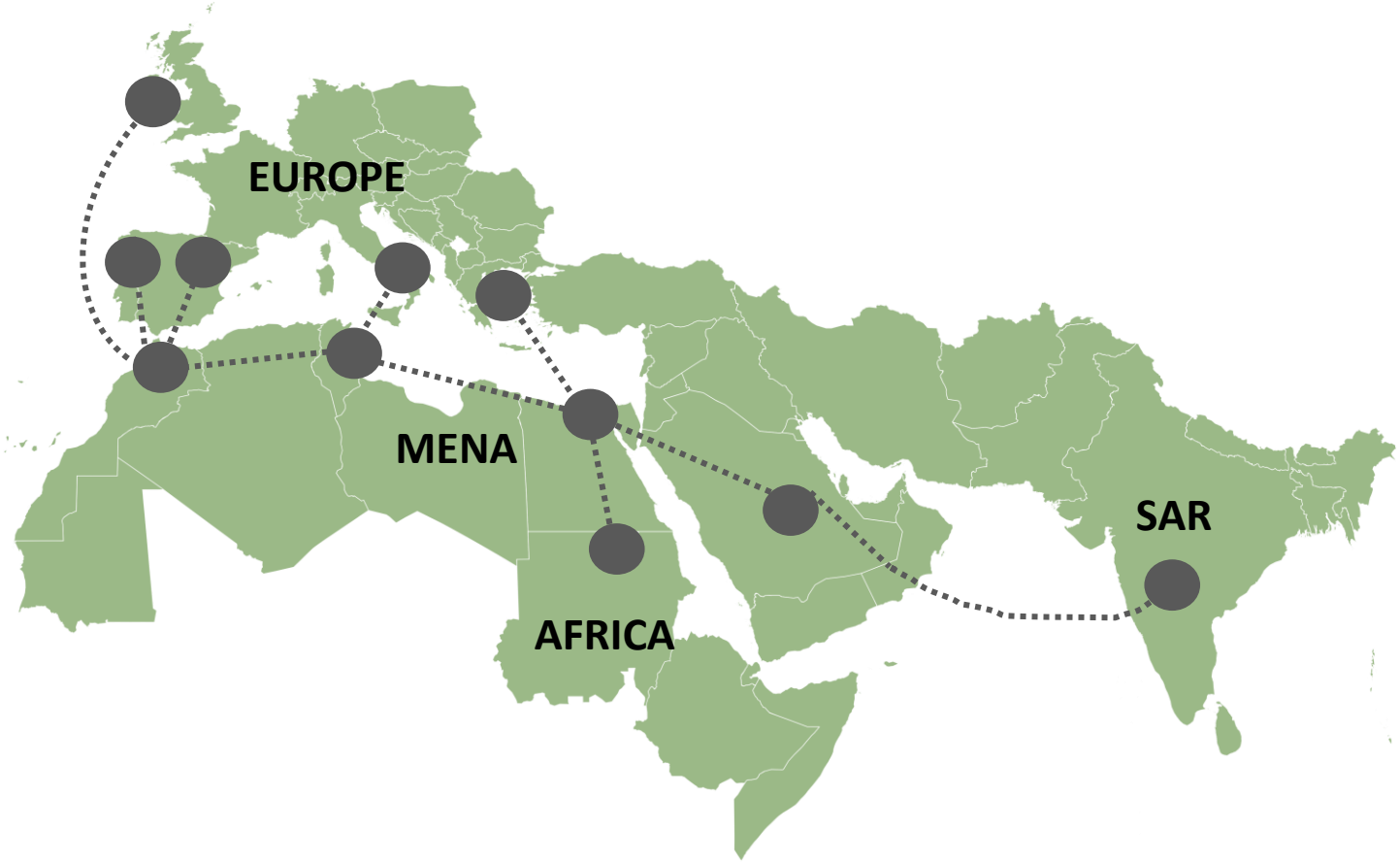
Trade Case	Total System Cost Savings (US$ billion)	Shared Economic Benefits (US$ billion)	Commercial Value of Trade (US$ billion)	Average Transmission Utilization in 2035	Energy Security Improvement	Cost Savings for CO_2 Emissions Compliance US$ billion	Share of Renewable Capacity Installed	Investment in Renewable Technologies (US$ billion)
Case 1	$110	$109	$60	41%	38%	N/A	16%	$64
Case 3	$107	$32	$62	37%	38%	N/A	18%	$88
Case 5	$196	$150	$167	43%	53%	$86	28%	$305
Case 6	$213	$25	$60	37%	63%	N/A	17%	$68

Agenda

1. Background
2. Key barriers to trade in existing infrastructure
3. Unexploited benefits of trade in existing infrastructure
4. Priority Interconnection expansions
5. Quantifying the Benefits:
    - Power system cost savings
    - Economic and commercial
    - Environmental and climate
6. **Integration beyond MENA and Take-aways**

Integration Beyond MENA

By 2035 the Pan-Arab Grid can be at the center of a future super-highway transmission lines connecting SAR-MENA-AFRICA-EUROPE



Inter-regional Projects:

- Italy-Tunisia
- Egypt-Sudan
- Egypt-Greece
- Morocco-UK
- Morocco-Portugal
- Morocco-Spain
- India-Oman-KSA

*Indicative regional map

Take Home Message:
The Do's & Don'ts in Regional Electricity Markets

Do's

- Economic Assessments
- Investigate Alternatives, Value Based Planning
- Private Sector Partnership (merchant lines)
- Compliance, Self Reporting, Auditing
- Firm Market Rules
- Clear Roles (TSO, MO, Regulator)
- Harmonization, Transparency
- Progressive Regulations
- ***INTEGRATE, Build Interconnectors, and TRADE !!!***

Don'ts

- Over subsidize
- Uncertainty
- ***Stop if you started!!!***

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Thank You