OPPORTUNITIES AND OBSTACLES IN ELECTRICITY AND GAS TRADE IN THE ARAB WORLD

Fareed Zedan
Former Electricity Regulator, Kingdom of Saudi Arabia
LONG TERM OUTLOOK OF ELECTRICAL INTERCONNECTION GRID

Countries forming Maghreb Block
- Algeria
- Morocco
- Tunisia
- Libya

Countries forming Mashreq Block
- Jordan
- Egypt
- Palestine
- Lebanon
- Syria

Countries forming GCC Block
- KSA
- Qatar
- Bahrain
- Kuwait
- U.A.E
- Oman
- Yemen

Existing Interconnection
- Under Construction/Planned Interconnection

EXISTING INTERCONNECTION
- Morocco to Tunisia: 250MW
- Tunisia to Algeria: 700MW

UNDER CONSTRUCTION/PLANNED INTERCONNECTION
- Algeria to Libya: 500MW (2020)
- Libya to Egypt: 400MW (2020)
- Egypt to Sudan: 1200MW (2025)
- Sudan to KSA: 500MW (2025)
- KSA to Lebanon: 50MW
- Lebanon to Syria: 160MW
- Syria to Palestine: 20MW
- Palestine to Jordan: 550MW
- Jordan to Iraq: 550MW
- Iraq to Kuwait: 800MW
- Kuwait to Bahrain: 200MW
- Bahrain to Qatar: 200MW
- Qatar to U.A.E: 600MW
- U.A.E to Oman: 1100MW
- Oman to Yemen: 150MW (2025)

EXPECTED YEAR OF ENTERING INTO OPERATION
- (XXXX) Means Expected Year of Entering into Operation
The PAN-ARAB Energy Trade Conference
Towards an effective regional cooperation in electricity and gas trade among the Arab countries
The Nile Ritz-Carlton, Cairo
November 6-7, 2019

THE GEOGRAPHY OF THE INTERCONNECTED NETWORK IN THE ARAB WORLD

Morocco → Algeria → Tunisia → Libya → Egypt → Jordan → KSA → Kuwait

Lebanon → Iraq → Palestine → Syria

Sudan → Yemen

Bahrain → Qatar → UAE → Oman → Djibout → Comoros

400/500 kV
220 and 132 kV
## STRENGTHS AND WEAKNESSES WHEN IT COMES TO ELECTRICAL INTERCONNECTION PROJECTS

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission Lines Exist</td>
<td>• Radial Network (No loops)</td>
</tr>
<tr>
<td>• Diversity of Fuel</td>
<td>• Some lines have limited capacity (e.g. Egypt – Libya Interconnection)</td>
</tr>
<tr>
<td>• Availability of Gas Resources (Gas Trade+</td>
<td>• Not contiguous any more (Libya, Syria)</td>
</tr>
<tr>
<td>Electrical Trade)</td>
<td></td>
</tr>
<tr>
<td>Higher Penetration of Renewable</td>
<td>Lack of Institutional Arrangements</td>
</tr>
<tr>
<td></td>
<td>Price Distortions</td>
</tr>
<tr>
<td></td>
<td>Absence of Interconnection Grid Code</td>
</tr>
<tr>
<td></td>
<td>Absence of Trade Agreements</td>
</tr>
</tbody>
</table>
THE EXPECTED OUTCOME

• Arab countries spending over $3 Billion on interconnection projects, utilization has been well below expectations,

• Period (2010-2018), electricity trading ranged between 3,000-4,000 GWH/year, less than between, Spain and Morocco,

• Most of the energy exchanges were in-kind exchanges.
• An integrated study by CESI, (2012-2014) showed that the amount of energy exchanged could reach 73 thousand GWH/year (using the existing and committed tie lines then), and up to 112 thousand GWH/year, with the additional expenditure of around $ 5.5 Billion (7 new electrical interconnection projects and 3 new gas projects).

• The present savings, during the period (2012-2030) were estimated around $ 34 Billion

Opportunities is there, what are the challenges?
The PAN-ARAB Energy Trade Conference
Towards an effective regional cooperation in electricity and gas trade among the Arab countries
The Nile Ritz-Carlton, Cairo
November 6-7, 2019

As a result of implementing Projects included in the CESI Study

Percent utilization of Tie Lines

<table>
<thead>
<tr>
<th>Year</th>
<th>2012</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utilization</td>
<td>4%</td>
<td>72%</td>
<td>74%</td>
<td>71%</td>
<td>71%</td>
</tr>
</tbody>
</table>

Capacity of Tie Lines (GW)

<table>
<thead>
<tr>
<th>Year</th>
<th>2012</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>10.2</td>
<td>11.6</td>
<td>16.5</td>
<td>17.9</td>
<td>17.9</td>
</tr>
</tbody>
</table>

Total Energy Exchange on Tie Lines (X1000 GWH)

<table>
<thead>
<tr>
<th>Year</th>
<th>2012</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exchange</td>
<td>4</td>
<td>72.6</td>
<td>107</td>
<td>111</td>
<td>112</td>
</tr>
</tbody>
</table>

What actually occurred

Possibilities identified by study
The PAN-ARAB Energy Trade Conference
Towards an effective regional cooperation in electricity and gas trade among the Arab countries
The Nile Ritz-Carlton, Cairo
November 6-7, 2019

A CLOSER LOOK
The PAN-ARAB Energy Trade Conference
Towards an effective regional cooperation in electricity and gas trade among the Arab countries
The Nile Ritz-Carlton, Cairo
November 6-7, 2019

THE ELTAM COUNTRIES (Constructed Projects)

Spain

Spain

Morocco

400 MW

400 kV

Algeria

1400 MW

220 kV

Tunisia

220 kV

240 MW

220 kV

Libya

220 kV

300 MW

400 kV

Studies Recommended Converting these connections to DC at 400 kV

Studies Recommended Constructing Pipelines (Egypt- Libya) & (Libya- Tunisia)

Electric Lines

Gas Lines
The PAN-ARAB Energy Trade Conference
Towards an effective regional cooperation in electricity and gas trade among the Arab countries
The Nile Ritz-Carlton, Cairo
November 6-7, 2019

**THE ELTAM COUNTRIES (Opportunities)**

In case of loss of the biggest power plant in Egypt (4500 MW), Egypt can import (2400+ 600+ 2000 MW) = 5,000 from European Grid

But → Need to change (Egypt- Libya) & (Libya- Interconnection) to DC instead of AC
Egypt had the lowest LCOE. It exported both electricity and gas to Jordan.

Syria-Iraq electrical interchange also limited (mostly in kind trade)

Jordan-Syria electrical interchange limited (mostly in kind trade)
Both Egypt and Jordan are investing heavily in RES
Egypt → 31% in 2030
Jordan → 29% in 2030

Egypt will have to curtail some of its wind/solar P/P starting 2025

There could be a benefit in doubling the size of the interconnection

Cyprus

Egypt

Jordan

Sudan

Lebanon

Syria
The PAN-ARAB Energy Trade Conference
Towards an effective regional cooperation in electricity and gas trade among the Arab countries
The Nile Ritz-Carlton, Cairo
November 6-7, 2019

EIJLLPST Interconnection (Opportunities)

Iraq can benefit from Availability of Surplus Energy in Egypt and Jordan

A Jordan-Iraq gas pipeline would benefit both Jordan and Iraq

Export opportunity
Reduce curtailment

Cyprus

Lebanon

Syria

Jordan

Iraq

Egypt

Libya

Sudan
The PAN-ARAB Energy Trade Conference
Towards an effective regional cooperation in electricity and gas trade among the Arab countries
The Nile Ritz-Carlton, Cairo
November 6-7, 2019

GCC Interconnection (Constructed Projects)

Most GCC Countries Have:
• Same type of Generating Units
• Same type of Load Pattern

Interconnection lines mostly used for emergencies

Very little energy trading
Percent utilization of lines around ≈ 5%
Both Iraq and the GCC Countries would benefit from connecting the Iraqi grid to the GCC grid

- Iraq can reduce its energy shortage
- GCC countries (especially KSA) can utilize some of its surplus capacity (especially during the Winter season (>10,000MW))

A gas pipeline from Iraq to Kuwait would help lower cost of production in Kuwait, and free up Kuwaiti oil for export
Connecting Jordan to KSA and Iraq would create a loop (Jordan-Iraq-Kuwait-Saudi Arabia) which would increase the reliability of the tie lines, and increase the transfer capacity on the lines.
CONCLUSIONS AND RECOMMENDATIONS

• There are economic benefits for energy exchange between the Arab countries. Signing of General Agreement and General Trade Agreement is a major step forward.

• Currently, there are good opportunities to export energy to Iraq and Sudan, who suffer from energy shortages. But, before this is accomplished, several electrical studies are needed:
### Study

<table>
<thead>
<tr>
<th>Study</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LOAD FLOW</strong></td>
<td>• Determine optimum amount of flow in above tie lines</td>
</tr>
<tr>
<td></td>
<td>• Identify possible congestion on the lines and possible re-enforcements</td>
</tr>
<tr>
<td></td>
<td>• The electrical model for Egypt, Jordan, and GCC networks has already</td>
</tr>
<tr>
<td></td>
<td>been constructed in the integrated study</td>
</tr>
<tr>
<td><strong>ECONOMIC ANALYSIS</strong></td>
<td>• Build an economic model</td>
</tr>
<tr>
<td></td>
<td>• Effect of energy flow on loading of Egyptian, Jordanian, Kuwaiti and</td>
</tr>
<tr>
<td></td>
<td>Saudi networks</td>
</tr>
<tr>
<td></td>
<td>• Could use model developed in the integrated study</td>
</tr>
<tr>
<td><strong>STABILITY</strong></td>
<td>• What will happen if one of the largest power plants in Egypt goes off</td>
</tr>
<tr>
<td></td>
<td>line (Sudden loss of 4,500 MW on the grid)</td>
</tr>
<tr>
<td></td>
<td>• Will system stay synchronized</td>
</tr>
<tr>
<td></td>
<td>• Develop a Defense Plan</td>
</tr>
<tr>
<td></td>
<td>• No integrated stability model for the Arab networks has been developed</td>
</tr>
<tr>
<td></td>
<td>yet</td>
</tr>
<tr>
<td>**CURTAILMENT</td>
<td>• Will existing and planned tie lines be adequate to prevent having to</td>
</tr>
<tr>
<td>PREVENTION</td>
<td>curtail renewable energy</td>
</tr>
<tr>
<td></td>
<td>• Can build on study financed by the Arab Fund on the Egypt-Jordan</td>
</tr>
<tr>
<td></td>
<td>interconnection, and the Morocco-Algeria-Tunisia interconnection</td>
</tr>
</tbody>
</table>
Giving the internal situation in Libya, Syria and Yemen, tie lines can bridge energy requirements, until, and even beyond, rehabilitation and upgrading of generation capacities.
Thank You!