The Future of Energy Challenges and Opportunities

IEF Seminar
20/02/2020
Contents

1. Renewable and Gas; wholly embraced in KSA?
2. Renewable Energy, a cost competitive value proposition
3. Gas and LNG Competitiveness.
4. Where is this transition headed?
5. Fossil Fuels – What is the Future?
6. Why we at ACWA Power are convinced?
1. Clean Energy in KSA fully embraced

Clear Target to deploy 58.7GW of Renewable Energy by 2030, in a system which by then is expected to have a capacity of 125GW

Decommission Oil fired power plants (currently 45% of the energy mix in power generation) by 2030

First two utility scale plants in construction. 300MW PV + 400MW wind

2000MW PV due to go into construction in the next month

2500 +MW of capacity in tender

Kingdom is intent of capturing industrialization opportunities on the back of this scale of RE procurement
2.1 Load Profile in KSA on a Typical Summer & a Winter Day

- For this segment of load, during a summer day or winter day, one needs to keep a power plant and run it only for these few hours.

Source: ECRA annual report 2013
2.2 Cost of Electricity will Depend on Duration of Dispatch

**Plant Capacity Factor**

- **Total 100 units**
  - Finance 13 units
  - Opex 12 units
  - Fuel 30 units
  - Capex 45 units
  - Plant Producing Electricity 100% of the time

- **Total 128 units**
  - Finance 13 units
  - Opex 10 units
  - Fuel 15 units
  - Capex 90 units
  - Plant Producing Electricity 50% of the time

- The same amount of funding over the same period
- The saving on wear and tear of parts
- Plant will use only half the amount of fuel
- The Capital cost need to be recovered at twice the rate
2.3 Levelized Cost of Electricity (LCOE) from Renewables today

<table>
<thead>
<tr>
<th>CAPACITY FACTOR</th>
<th>PV</th>
<th>CSP</th>
<th>WIND</th>
<th>WTE</th>
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<tbody>
<tr>
<td>20%</td>
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<tr>
<td>30%</td>
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<td>40%</td>
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<tr>
<td>50%</td>
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<td>60%</td>
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<td>70%</td>
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<tr>
<td>80%</td>
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<tr>
<td>BASE LOAD</td>
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</table>

- **PV**: $< 3.5 \$/kWh
- **CSP**: $< 8 \$/kWh
- **WIND**: $3.5 \$/kWh, $3.0 \$/kWh, $2.5 \$/kWh, $2.0 \$/kWh
- **WTE**: $10^* \$/kWh

* Assumed 30$ tipping fee per metric Ton

Source: ACWA Power

www.ACWAPOWER.com
2.4 Renewable Energy; Cost Competitive

Real numbers from recent contracts in the MENA region

Jordan Wind Power – US$ Cents 2.41/kWh

Dubai CSP 750MW CSP 24 hours per day; 7 days a week – US$ Cents 7.3/kWh

Egypt PV – US$ Cents 2.75/kWh

Ethiopia – US$ Cents 2.54/kWh

KSA (PV – US$ Cents 2.34/kWh and Wind US$ Cents 1.99/kWh

DUBAI PV 900 MW – US$ Cents 1.69/kWh
3.1 Competitiveness of LNG/Gas LCOE vs. alternatives

- LCOE for renewables is becoming more attractive and as a consequence LNG/Gas prices have to be competitive.
- In particular, gas companies have to adjust their operations and profit margins expectations accordingly to be able to compete against other source of energy.

* Sources: Lazard; IRENA, ACWA Power, Strategy& analysis
## 3.2 Gas Vs Coal

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Advanced Gas based CCGT</th>
<th>Ultra-Supercritical Bituminous Coal based Power Plant.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thermal Efficiency</strong></td>
<td>65 % CCGT</td>
<td>44 %</td>
</tr>
<tr>
<td><strong>EPC cost (On gross MW basis)</strong></td>
<td>0.5 to 0.6 Million USD/MW</td>
<td>1 to 1.5 Million USD/MW</td>
</tr>
<tr>
<td><strong>Estimated CO2 Emission from 3.6 GW power plant Annually @ 94 % Availability.</strong></td>
<td>9.48 Million Tons</td>
<td>25 Million tons.</td>
</tr>
<tr>
<td><strong>Maintenance Requirement</strong></td>
<td>Boiler require less maintenance compared to Coal based</td>
<td>More maintenance will be required.</td>
</tr>
<tr>
<td><strong>Auxiliary consumption.</strong></td>
<td>The Auxiliary consumption of CCGT plant is around 2.5 %</td>
<td>The Auxiliary consumption of Coal based Power plant range between 7 to 9 %</td>
</tr>
<tr>
<td><strong>Land required</strong></td>
<td>Less land required based on per MW basis. Around 100 Hector Land will be required to put a 3.6 GW CCGT plant.</td>
<td>More Land required in Coal fired Power plant. Around 160 Hector Land will required to put a 3.6 GW Supercritical Coal based Power plant.</td>
</tr>
<tr>
<td><strong>Transmission line cost.</strong></td>
<td>Gas Plant can be build close to demand center</td>
<td>It is difficult to build coal plant to demand center.</td>
</tr>
<tr>
<td><strong>Carbon Tax</strong></td>
<td>As Emission of Carbon dioxide is 3 time less than that Coal fired Power plant so future risk of carbon Tax will have less impact.</td>
<td>As Emission of Carbon dioxide is 3 times more than CCGT plant so future risk of Carbon tax is there, which ultimately raised the tariff.</td>
</tr>
<tr>
<td><strong>Cost of lending</strong></td>
<td>World Banks and international Banks still supporting CCGT high efficient Technology of Power Generation.</td>
<td>World Bank and international banks are not willing or less inclined to support Coal based Power generation.</td>
</tr>
<tr>
<td><strong>Calorific Value</strong></td>
<td>Gas has very high Calorific value compared to Coal. The Calorific value of Gas is around 46 MJ/Kg.</td>
<td>Coal of good quality (Bituminous) has calorific value in the range of 20 MJ/Kg.</td>
</tr>
</tbody>
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## 3.3 Gas vs Coal

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<td>Thermal Pollution to Sea or River</td>
<td>Less water requirement to condense the steam in the condenser, hence less thermal pollution to the sea which result in to comparatively better marine life. Around 120,000 m³/h of Sea water will be required for 3.6 GW</td>
<td>Huge amount of Sea water is required for steam condensation in the condenser which will ultimately increase the sea water temperature when out fall water mixed in the Sea. Around 360,000 m³/h of Sea water will be required FOR 3.6 GW.</td>
</tr>
<tr>
<td>Sulphur dioxide emission.</td>
<td>Due to very low or negligible Sulphur in gas and high efficiency of Power Cycle Emission of Sulphur dioxide is very low</td>
<td>The emission of Sulphur dioxide in environment is high even with the use of high efficient FGD.</td>
</tr>
<tr>
<td>Emission of NOX in the environment</td>
<td>Very low NOX emission in environment</td>
<td>High emission of NOX in the environment even with the use of SCR or SNCR.</td>
</tr>
<tr>
<td>Particulate Emission</td>
<td>The gas contain negligible amount of dust so there is almost no particulate emission from CCGT plant</td>
<td>Coal contain high amount of dust so emission of particulate are very high. Even after use of Electrostatic precipitator the dust in the environment remains with higher % compare to Gas. Particulate emission contribute to lungs problems in human being of nearby locality.</td>
</tr>
</tbody>
</table>
4.1 What Does this Mean for Power Generation NOW?

Source: pres. KACARE 2012 & ACWA Power analysis of cost
4.2 Where is this Transition Headed (2050 Horizon)?

1. Roof Top Generation both in Rural and urban setting with small batteries reducing levels of central generation

2. Central Generation with increasing levels of renewable energy and Gas in the mix

3. Long Distance HVDC improving efficiency of asset utilization

4. Smart Grids integrating multiple sources of generation and storage including household level generation + batteries including EV batteries + demand management with time of use adjustments

5.
4.3 Where is the transition Headed?

- Increasing use of electricity which in turn will be utilized more efficiently also optimizing time of use.
- Greater use of renewables; reducing carbon content in power generation.
- Cost of electricity will come down due to increasing content of the lower cost renewable energy in the mix.
- More of the cost of that electricity getting fixed; reduction in cost volatility due to reduction in fossil fuel content in the “fuel” mix.
4.4 Example of Cost Reduction due to RE in the mix - Jordan

- 2012 Negligible RE; average cost of generated electricity – US Cents 23/kWh
- 2018 16% RE in the mix; average cost of generated electricity – US Cents 15.6/kWh
5. Fossil Fuels – What is the Future?

- Gas will be the transitional fuel for base load power generation for many decades to come.
- At least as far as SAUDI ARAMCO is concerned “Chemicals is the fastest growing crude oil demand sector. It is also the fastest growing segment of our business. So we are working hard to develop new, more efficient ways to convert crude oil into chemicals” from ARAMCO Website.
- The target is to convert 70% to 80% of each barrel of Crude Oil to Chemicals.
- All major oil companies are committed to reducing carbon emission in their own operations and to find ways to reduce carbon emissions in the use of their products.
- Considerable faith is being placed on carbon capture and sequestration. Still to be convinced.
ACWA Power reliably delivers electricity and desalinated water at a low cost, contributing to the social and economic development of the communities and countries it invests in and serves.

At A Glance

We are a leading global developer, investor and operator of a portfolio of power generation and desalinated water production plants.

DEVELOP
We win bids as lead developer, by partnering with the best and focusing on cost leadership.

INVEST
While taking significant, long-term stakes in all our plants

OPERATE
We operate and maintain our plants to the highest global standards

ACWA Power has invested in projects across the world, with a portfolio of power generation and desalinated water production plants.

**Portfolio in Renewable Energy based on Share of project cost**

- **54** Assets*
- **30** GW Power*
- **5.3** Million day Desalinated Water*
- **13** Countries
- **$45+bn** USD of Assets*
- **$**
- **3,500+** Employees
- **30+** Nationalities
- **~60%** Local Employment in projects

* Figures inclusive of advanced development projects

**Timeline of Investments**

- **2004** Saudi Arabia
- **2008 – 2010** Oman
- **2010 – 2014** Jordan
- **2012 – 2014** Morocco
- **2017** South Africa
- **2015 – 2017** Turkey
- **2015 – 2017** UAE
- **2016** Egypt
- **2016 – 2018** Vietnam
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Portfolio in Renewable Energy based on Share of project cost
By leading CSP Tariff Reduction, ACWA Power has made this versatile solution viable; to in turn accelerate the Energy Transition.

Please note that methods of calculation of tariffs compared differs, as some tariffs are year 1 not escalated and others are LCOE basis. However, it indicates a trends of reductions. Please note that DEWA CSP is indicated on LCOE basis.
By leading PV Tariff Reduction, ACWA Power is accelerating the Energy Transition

- Shuaa (UAE)
- DEWA Phase 3 (UAE)
- Kom Ombo (EGY)
- Ethiopia pV (ETH)
- Sakaka (KSA)
- Dubai 900 MW

Please note that methods of calculation of tariffs compared differs, as some tariffs are year 1 not escalated and others are LCOE basis.
ACWA Power in Renewable Energy Today - 5000 MW in Construction & Operation

Diverse Renewables Asset Base

- **Morocco**: 510 MW, 120 MW, 135 MW
- **Bulgaria**: 60 MW
- **South Africa**: 150 MW
- **Jordon**: 100 MW
- **Bahrain**: 125 MW
- **Oman**: 575 MW
- **UAE**: 750 MW, 400 MW
- **Saudi Arabia**: 2300 MW

Total Investment Costs of renewable portfolio: US$ 11.5 billion
<table>
<thead>
<tr>
<th>Country</th>
<th>Address</th>
<th>Phone/email informations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saudi Arabia</td>
<td>Building 1, Ground Floor, Business Gate Office Complex, Airport Road P.O. Box 22616 Riyadh 11416 T: +966 1 2835555 F: +966 1 2835500</td>
<td>Saudi Arabia Building 1, Branch Rd, Ash Shoji, Jeddah, 23613 T: +966 12 618 9000</td>
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<tr>
<td>Egypt</td>
<td>Plot 176, Second Sector, City Center Giza Systems Building, New Cairo, Cairo T: +202 23 225 500</td>
<td>Egypt The One Tower, 41st Floor, Barsha Heights, P.O. Box 30582 Dubai T: +971 4 2480800 F: +971 4 3889623</td>
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<td>China</td>
<td>2101 Tower B, Ping An International Financial Center, No. 1 3, Xin Yuan Nan Lu, Chao Yang District, P.O. Box 10027, Beijing T: +86 10 8438 1078 F: +86 10 8438 1075</td>
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