Building the Renewable Energy Sector in Saudi Arabia
تنشأ مدينة علمية تسمى مدينة الملك عبد الله للطاقة الذرية والمتجددة.

الأمر الملكي رقم أ/35 في 3 جمادى الأولى 1431هـ

"...there shall be established a scientific city to be called, King Abdullah City for Atomic and Renewable Energy" Royal Order No. A/35 3/5/1431 A.H.
Target Capacity by 2032

Optimizing Energy Generation with Alternative Energy Economic Sector Development

- **Nuclear**: 17 GW
- **Renewable**: 54 GW
Sustainable energy outlook for Saudi Arabia

<table>
<thead>
<tr>
<th>Year</th>
<th>Wind/Other Ren</th>
<th>Solar PV</th>
<th>Solar CST</th>
<th>Nuclear</th>
<th>New Required Fossil</th>
<th>New Committed</th>
<th>Existing Diesel</th>
<th>Existing HFO</th>
<th>Existing Crude</th>
<th>Existing Gas</th>
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Renewable Energy Development Targets
Target Renewable Capacity by 2032

- **Solar PV**: 16 GW
- **Solar CSP**: 25 GW
- **Wind**: 9 GW
- **Waste-to-energy**: 3 GW
- **Geothermal**: 1 GW
Gradual Deployment of Alternative Energy

* Load factor: PV = 0.2, CSP = 0.34, Wind = 0.2, Geothermal = 0.9, Waste-to-energy = 0.85
Role of Alternative Energy in Reducing Fossil Fuel Consumption

Fossil Fuel Savings*

Fossil Fuel Consumption

* Load factor: PV = 0.2, CSP = 0.34, Wind = 0.2, Geothermal = 0.9, Waste-to-energy = 0.85
The Case for Alternative Energy
Energy Consumption Patterns

Total of 193,472 GWH

- Industrial: 17.9%
- Agricultural: 2.6%
- Commercial: 12.2%
- Governmental: 15.1%
- Residential: 52.2%
- Building: 79.5%

70% consumed by HVAC

Source: Saudi Electricity Company (SEC) 2009
Creating Tremendous Capacity Gap

Gap between peak demand and existing + planned capacity

- Peak Demand
- New Committed
- Existing Diesel
- Existing HFO
- Existing Crude
- Existing Gas

60 GW (Approx.)
Business As Usual: KSA’s Petroleum Demand Expected to Nearly Triple by 2032

Could impact ability to meet international oil demand

*Total local consumption (transportation, industry, electricity, etc.)

Source: Saudi Aramco 2010
Maximizing Return

Oil Saved

Economic Sector

Sustainability

How Much **Can** We Do?
- Demand Growth
- Demand Pattern
- Technology Characteristics

How Much **Should** We Do?
- Economics
- Sustainability
- Technology maturity
Summary of Saudi Arabia’s Alternative Energy Program

- **CONTRIBUTES** to a sustainable future for Saudi Arabia
- **PRESERVES** non-renewable fossil fuel resources
- **SAFEGUARDS** Saudi Arabia’s international energy leadership
- **ENSURES** greater long-term global energy market stability
- **TRANSFORMS** KSA into the Kingdom of Sustainable Energy
K·A·CARE Mandate
Selecting the Optimum Energy Mix
Parameters Affecting Energy Mix Development

- Value chain development
- Economics of hydrocarbons saved
- Electricity and desalination demand patterns
- Technology choices
- Regulatory and physical infrastructure requirements
- Human capacity development
Annual Electricity Demand Pattern in KSA

Seasonal change in peak load exceeds 40%
Day-Night Load Variation for Saudi Arabia

Uniform day-to-night variation year round
Forecasted Daily Electricity Demand Pattern 2032

Daily load during a work day in August 2032

Daily load during a holiday in January 2032
Capacity Identification Using Technology – Load Matching Approach

Start with known hydrocarbon capacity in target year $X$:

- Nuclear
- Waste-to-energy
- Geothermal

$121 - 60.5 = 60.5 \text{ GW}$
Capacity Identification Using Technology – Load Matching Approach

Start with known hydrocarbon capacity in target year 2032:

- **Base Load**: 17 GW
- **Load Following**: 3 GW
- **1st Group**: 16 GW
  - **2nd Group**: 25 GW
- **2nd Group**: 9 GW
- **3rd Group**: 17 GW
  - **4th Group**: 3 GW
  - **5th Group**: 1 GW

\[ 121 - 60.5 = 60.5 \text{ GW} \]
Proposed Energy Mix

- **Solar PV**: 16 GW
- **Solar CSP**: 25 GW
- **Hydrocarbons**: 21 GW
- **Nuclear + Geothermal + Waste-to-Energy**: Total capacity
Renewable Energy Value Chain Development
Manufacturing, EPC and O&M split

% total capex and opex throughout the plant lifetime
## Potential RE Value Chain Components

<table>
<thead>
<tr>
<th>Technology</th>
<th>Elements</th>
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<tbody>
<tr>
<td>1 Trough</td>
<td>Collector, Mirror, Absorber, EPC &amp; O&amp;M, Molten Salts, HTF, Steam turbine and generator, Storage Tank, Other power block elements, Minor elements</td>
</tr>
<tr>
<td>2 Tower</td>
<td>Heliostat, Mirror, EPC &amp; O&amp;M, Receiver, Molten Salts, Steam turbine and generator, Storage tank, Other power block elements, Minor elements</td>
</tr>
<tr>
<td>3 Thin Film</td>
<td>Integrated Module Factory, EPC &amp; O&amp;M, Inverter, Rest of balance of system</td>
</tr>
<tr>
<td>4 HCPV</td>
<td>Integrated Module Factory, Tracking System, EPC &amp; O&amp;M, Inverter, Rest of balance of system</td>
</tr>
<tr>
<td>5 Silicon</td>
<td>EPC &amp; O&amp;M, Poly Silicon manufacturing, Inverter, Wafer, Cell, Module, Rest of balance of system</td>
</tr>
<tr>
<td>6 Wind</td>
<td>Blades, Towers, EPC &amp; O&amp;M, Gearbox, Generator, Power converter, Nacelle housing and assembly, Bearings, Minor elements</td>
</tr>
<tr>
<td>7 Waste-to-Energy</td>
<td>EPC &amp; O&amp;M, Steam Turbine, Boiler, Grate, Other power block elements, Minor elements</td>
</tr>
<tr>
<td>8 Geothermal</td>
<td>EPC and O&amp;M, Steam Turbine, Heat exchanger, Condenser, Minor elements</td>
</tr>
</tbody>
</table>
Value Chain Development

Building a World-Class Solar Energy Sector:

- Industrial investment
- Research, development and innovation
- Technology development
- Education and training
- Human capacity development
Value Chain Development: Beyond the Solar Cell and the Mirror

- Electricity Generation
- Industrial Energy Applications
- Seawater Desalination & Water Management Applications
- District & Solar Cooling
Value Chain Activation Plan

Value chain enablers

1. Value chain organization capacity building
2. Independent quality assurance authority
3. Industrial readiness program (cost, quality, delivery)
4. SME development program
5. FDI attractiveness and promotion
6. Stakeholder engagement and communication
7. Global vendor engagement & qualification
8. Alignment with current and planned national initiatives

Value chain interfaces

9. Value Chain Opportunities

1. Capability gap assessment
2. Identification & prioritization of preferred local suppliers
3. Readiness action plan
4. Action plan evaluation and validation
5. Assist in JV/ partner selection
6. Monitor implementation
7. Certification process assistance
8. Regulatory environment
9. Development of R&D centers and programs
10. Development of local human capabilities
11. Leveraged procurement
12. Feed-in tariff / PPA
13. Bid preparation
14. Program and project structure
15. Value chain organization capacity building
16. Independent quality assurance authority
17. Industrial readiness program (cost, quality, delivery)
18. SME development program
19. FDI attractiveness and promotion
20. Stakeholder engagement and communication
21. Global vendor engagement & qualification
22. Alignment with current and planned national initiatives

Value chain activation
Socioeconomic, Environmental and Indirect Economic Impact
## Potential Socioeconomic and Other Tangible Returns

<table>
<thead>
<tr>
<th>Additional Returns from Alternative Energy Economic Sector Development</th>
<th>KPIs</th>
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<tbody>
<tr>
<td><strong>Direct employment opportunities in alternative energy generation</strong></td>
<td>137,000 jobs</td>
</tr>
<tr>
<td><strong>GDP contribution from Alternative Energy employment opportunities for Saudis</strong></td>
<td>USD 51 billion</td>
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<tr>
<td><strong>Contribution to economy from export of Alternative Energy products and services</strong></td>
<td>USD 40-60 billion</td>
</tr>
<tr>
<td>Reduction in $CO_2$ emissions from power plants</td>
<td>60%</td>
</tr>
<tr>
<td>Reduction in $NO_x$ emissions from power plants</td>
<td>75%</td>
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<tr>
<td>Reduction in $SO_2$ emissions from power plants</td>
<td>70%</td>
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<tr>
<td>Potential cross-border and intercontinental energy export (renewables)* during off-peak season</td>
<td>10-30 GW</td>
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* DESERTEC Industrial Initiative (DII)
The Road to Successful Implementation
Alternative Energy Deployment Roadmap

**Atomic Energy**
- Site and technology selection
- 1st Concrete pouring
- 1st reactor connected to grid 9.6 GW
- 7 reactors connected to grid 17.6 GW
- 12 reactors connected to grid

**Renewable Energy**
- 1st RE Project
- 2.35 GW
- 1.05 GW
- 17.35 GW
- 6.5 GW
- 28.4 GW
- 10.8 GW
- 41.1 GW
- 13 GW
The Kingdom of Sustainable Energy
Thank You