King Abdullah University of Science and Technology

KAUST

The Impact of Climate Negotiations on the Saudi Arabian Energy System

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Outline

- The balance between climate goal and others goals in Saudi Arabian policies
- The presentation of measures decided in Saudi Arabia to fight climate change
- What is realistic about COP 21 in December 2015 in Paris? And What are the enabling conditions?
- Research initiatives by KAUST to support Saudi Arabia transition into a low carbon economy

Components of Energy Systems

Resources	**Coal**	**Oil**	**Natural Gas**	**Sun Light**	**Uranium**	**Wind**	**Biomass**	**What Nature Provides**
Extraction/ Treatment	Oil Rig	Gasification	Liquefaction	Separation	Cleaning			
Conversion Technologies	**Oil Refinery**	**Thermal Power Plants**	**Hydro Station**	**Nuclear Plant**	**PV Cell**	**Wind Converter**		**Energy Sector**
Currencies (Fuels)	**Electricity**	**Gasoline**	**Methanol**	**Methane**	**Hydrogen**	**Heat**		
Distribution	Electricity Grid	Gas Grid	Truck	Dewear	Railway	District Heat Grid		
Service Technologies								
Services	**Transport Communication**	**Keeping Warm/Cold**	**Food**	**Health Care**	**Portable Water**			**What People Want**

- IAEA Publication, *Brazil: a Country Profile on Sustainable Development*, 2006.Austria

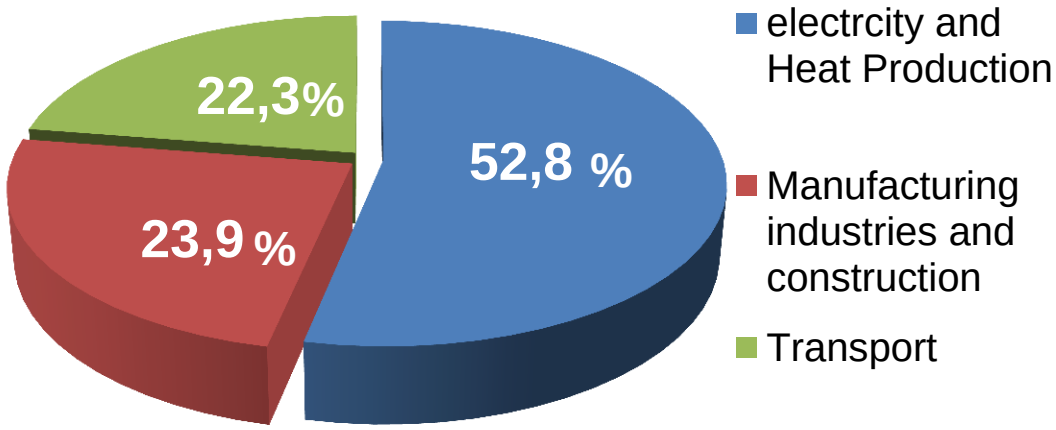
CO_2 emissions Profile in Saudi Arabia

Key Facts:

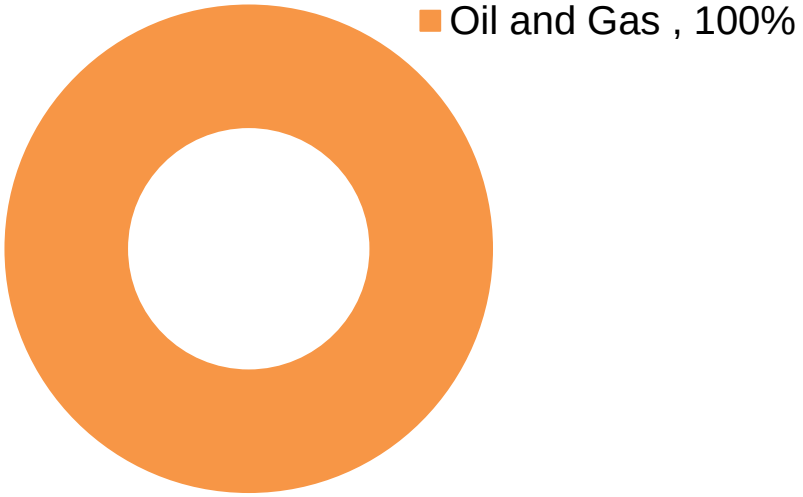
- SA is the 11th largest emitter of CO_2
- Rising energy demand in SA would mean CO_2 emissions could sharply increase to constitute a significant share of global energy demand

Source: EIA (2013) World Bank (2010)

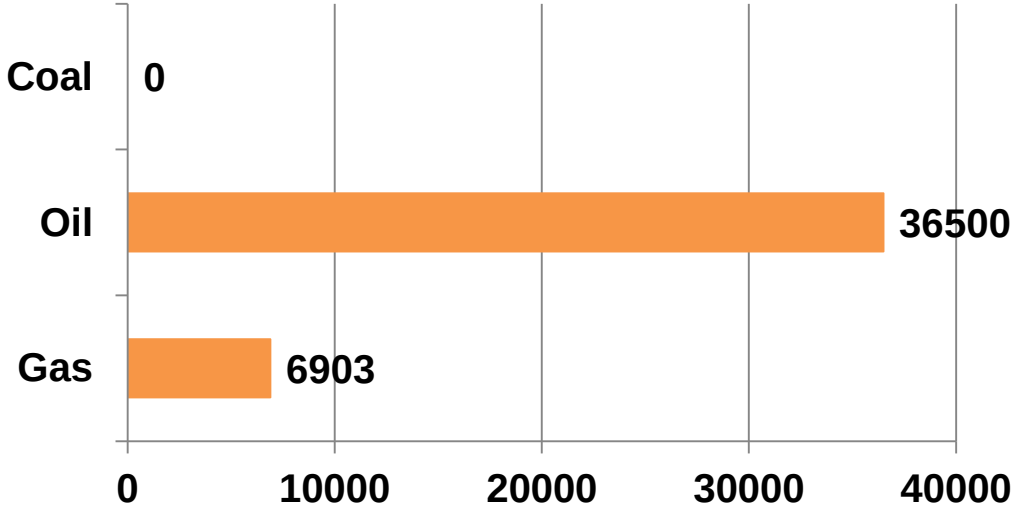
Total CO_2 emissions (Tons)= 241,330,000



Diversity of Electricity Generation, 2014

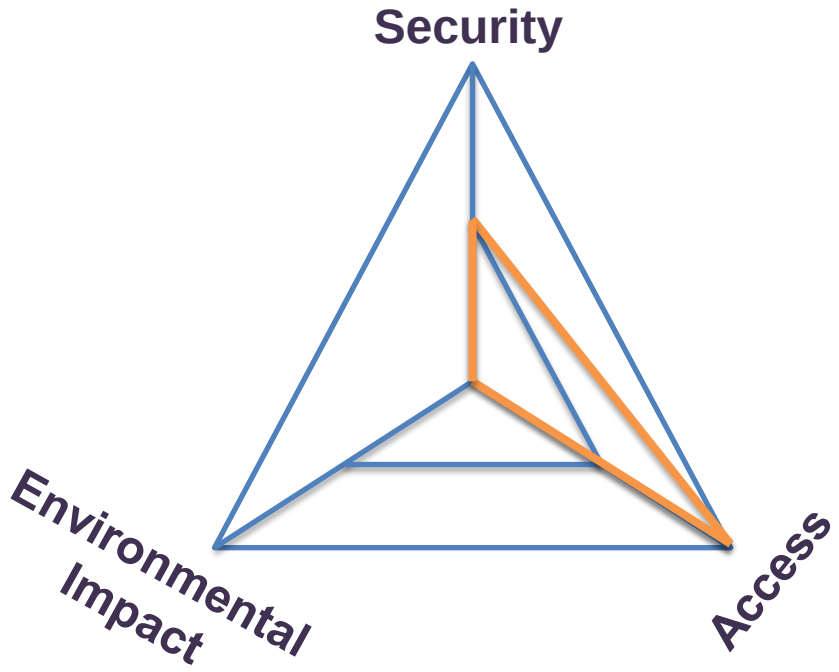


Fossil Fuel Reserves (IN MTOE)



Source:

WEC Assessment of Saudi Arabia Energy Index



Index Ranking and Balance Score	2012	2013	2014	Trend	Score
Energy Performance	**57**	**57**	**67**	↓	
Energy Security	38	45	68	↓	**B**
Energy Equity	14	12	7	↑	**A**
Environmental Sustainability	124	124	125	→	**D**
Contextual Performance	42	47	64	↓	
Political Strength	70	79	67	→	
Societal Strength	55	55	51	↑	
Economic Strength	15	14	84	↓	
Overall rank and balance score	**49**	**51**	**68**	↓	**ABD**

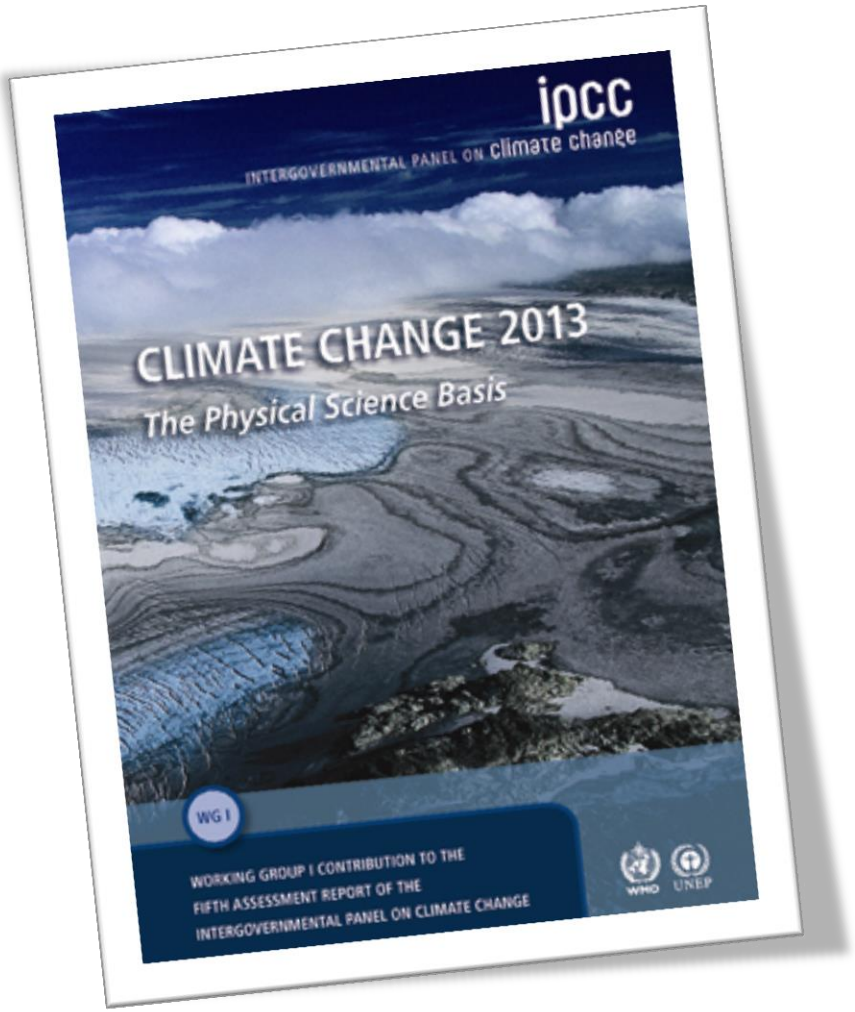
- Saudi Arabia's energy trilemma is balanced in a fashion that is typical of that country grouping, with good performance on energy security and high levels of energy equity, and a not high environmental sustainability performance.

Source: WEC (2014)

The balance between climate goal and others goals in Saudi Arabian policies

- According to the report of the Intergovernmental Panel on Climate Change, climate change effects and the response procedures will slow down economic growth, make poverty eradication more difficult and further erode food security

- From that standpoint, the Kingdom stresses the importance of setting climate Polices that encourage both mitigation and adaptation without affecting economic growth, and national prosperity of developing countries



Measures taken by the Kingdom to mitigate climate change

- Saudi Arabia joined many international initiatives including;
  - The Global Methane Initiative (GMI)
  - The Carbon Sequestration Leadership Forum (CSLF)
  - The Initiative on Building Efficiency and Reduction of Associated CO_2 Emissions under the umbrella of the Major Economies Forum
  - The Four Kingdoms, alongside the UK, Norway, the Netherlands and Saudi Arabia. The four countries have programs and effectively cooperate to develop CO_2 capture and storage technologies or utilize it in industrial and commercial uses, including enhanced oil field production
- Saudi Arabia has also established a National Committee for Clean Development Mechanism to manage and implement Clean Development Mechanism (CDM) project
- A permanent national centre was established to rationalize energy around Kingdom to improve efficient energy production and consumption

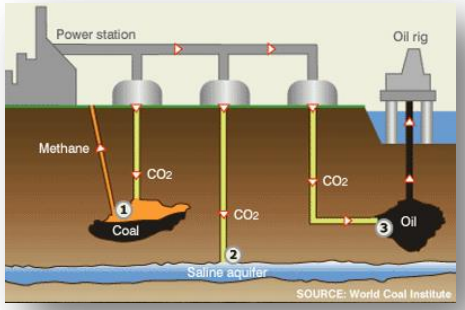
carbon sequestration leadership forum

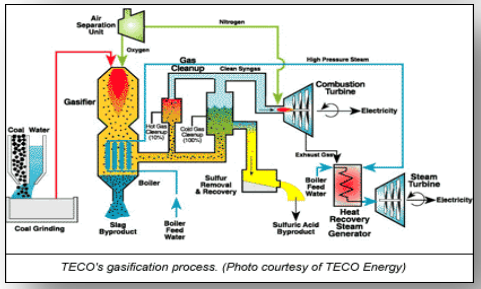
Global Methane Initiative

MAJOR ECONOMIES FORUM ON ENERGY AND CLIMATE

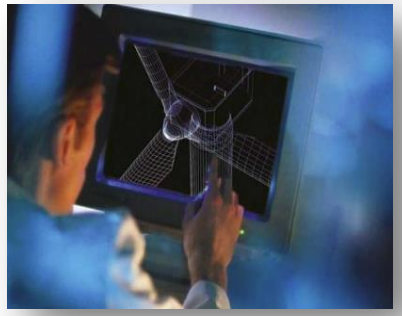
Measures taken by the Kingdom to mitigate climate change

- Saudi Arabia has taken several practical steps towards economic adaptation and diversification, necessary to achieve sustainable developments, with the aim of achieving the objectives of the Convention beyond 2020. Such efforts include **energy efficiency**, the use of **solar and wind energy**, a **carbon capture and storage** program, **gasification processes**, as well as **clean energy R&D**.





TECO's gasification process. (Photo courtesy of TECO Energy)



Source: *Speech by Minister of Petroleum and Mineral Resources Ali I. Al-Naimi at UN Climate Summit, 2014*

An Example of Clean Tech: Downhole Gasification of Hydrocarbons with CCS

Processing Consideration

- **Pressure;**

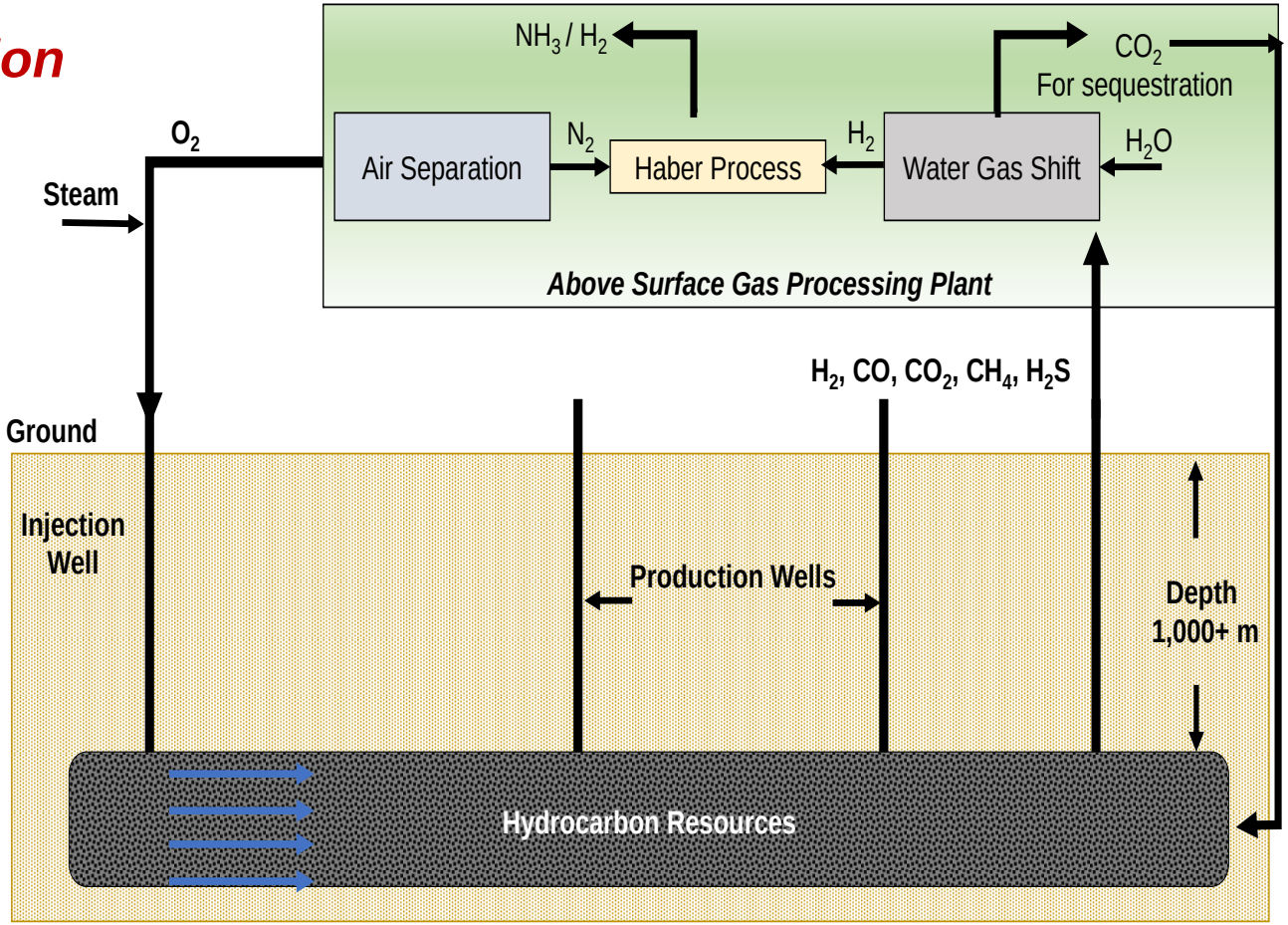
Hydrostatic Pressure

- **Temperature;**

Steam/Oxygen or geothermal temperature

- **Catalyst Placement;**

Water Soluble, Dispersed nanoparticles



Alshammari, Y.M., & Hellgardt, K. 2012. Thermodynamic Analysis of Hydrogen Production Via Hydrothermal Gasification of Hexadecane, *International Journal of Hydrogen Energy*, 37, 5656-5664.

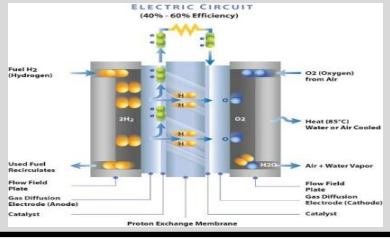
Other Examples of Clean Technologies

Fuel Cells[1]

- Converts the chemical energy of a fuel directly to electrical energy
- Offers a higher conversion efficiency compared with thermo-mechanical cycles
- Efficiency varies with type

➢ *Solid oxide (SOFC): ceramic as stabilised zirconia and doped perovskite, 600–1000°C: natural gas or propane, O_2/Air, 45–60%*

➢ *Proton-exchange membrane (PEMFC) polymer, proton exchange membrane, 50–80°C, less pure hydrogen from hydrocarbons or methanol, O_2/Air, 40–50%*



Generation IV Nuclear Reactors[2]

- Enhanced nuclear safety
- Improved non-proliferation resistance and protection
- Improved economics
- Minimising waste and optimised use of natural resources

➢ *Very high temperature reactor >1000 °C*

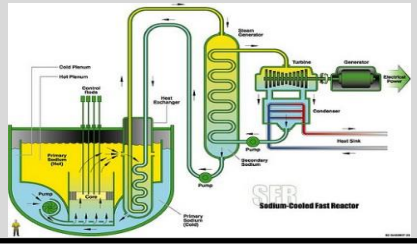
➢ *Supercritical water reactor 550 °C*

➢ *Molten salt reactor 700 °C*

➢ *Gas cooled fast reactor GFR 850 °C*

➢ *Sodium cooled fast reactor SFR 550 °C*

➢ *Lead cooled fast reactor LFR 550 up to 800 °C*



Renewables

- Intermittency can be dealt with by storage and diversity of supply
- Technical and economic barriers remain a challenge to unleashed its large-scale potential
- Various forms may be integrated into the grid depending on national resources

Types include: PV Cells, Concentrated Solar Power, Geothermal, Wind turbines, Tidal, Biomass, Hydropower

1. Elder R., Allen, R., (2009). Nuclear Heat for Hydrogen Production: Coupling Very High/High Temperature Reactors to a Hydrogen Production Plant, *Progress in Nuclear Energy*, 51, 500–525
2. Boudghene Stambouli, A., Traversa, E., (2002). Solid oxide fuel cells (SOFCs): a review of an environmentally clean and efficient source of energy, *Renewable and Sustainable Energy Reviews* 6, 433–455

Measures taken by the Kingdom to mitigate climate change: the CCS-EOR Project

- Saudi Arabia is currently implementing a pilot project to reduce carbon emissions in conjunction with "CO_2-Enhanced Oil Recovery" project aiming to reduce CO_2 emissions by 800,000 tons per year.
- Another initiative from the private sector was ma… r materials of e… sions by 500,0…

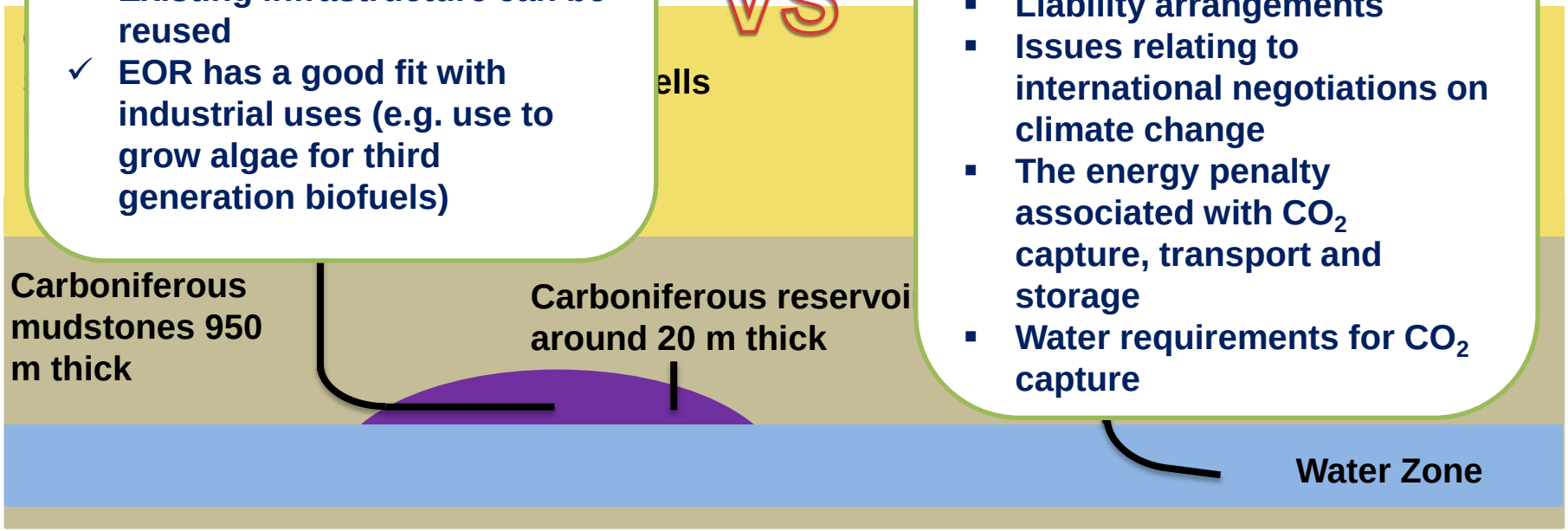
Benefits

- ✓ **Only technology suitable to achieving large scale emissions reductions**
- ✓ **Existing infrastructure can be reused**
- ✓ **EOR has a good fit with industrial uses (e.g. use to grow algae for third generation biofuels)**

VS

Challenges

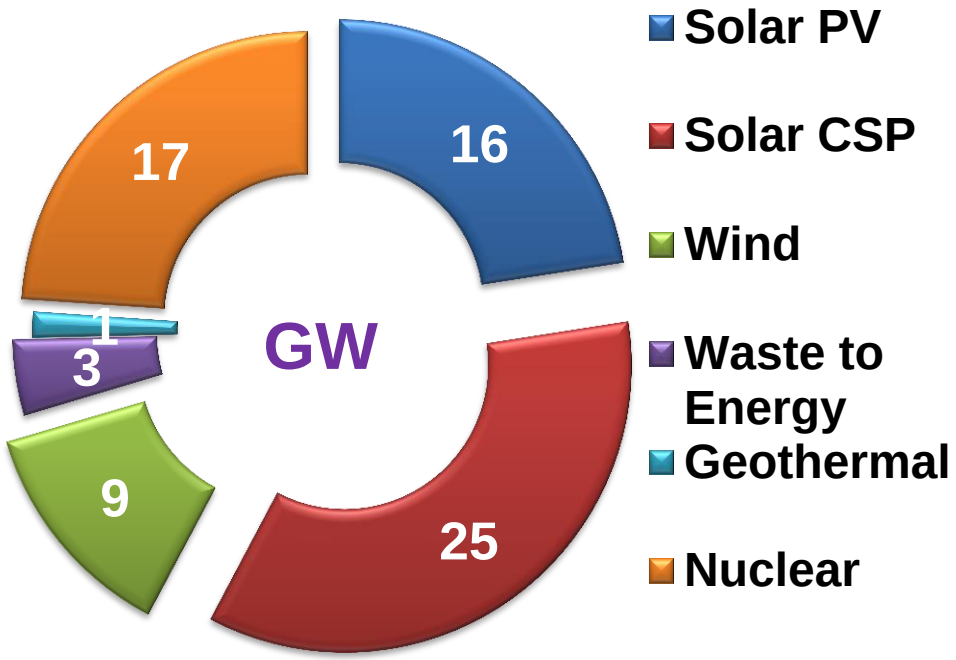
- **High cost of the technology**
- **Environmental concerns regarding safety of stored CO_2**
- **Liability arrangements**
- **Issues relating to international negotiations on climate change**
- **The energy penalty associated with CO_2 capture, transport and storage**
- **Water requirements for CO_2 capture**



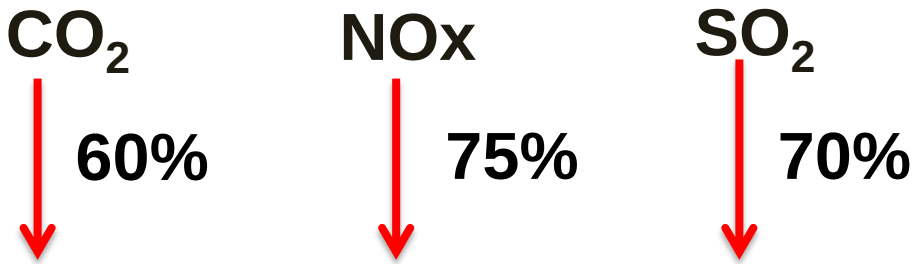
W. Heidug, *Joint IEA-OPEC workshop on CO_2-enhanced oil recovery with CCS*, Kuwait, 2012

Energy Supply and Demand

- Saudi Arabia is looking to diversify its national energy mix to include renewable energy and nuclear and recently announced plans to invest US$109 billion over the next 20 years in solar energy.
- King Abdullah City for Atomic and Renewable Energy (K.A.CARE) was established with the aim of building a sustainable future for the Kingdom by introducing renewable energy sources.
- Saudi Arabia is also looking for 1) maintaining the Kingdom's spare capacity and global position as a secure supplier of energy; 2) diversifying the economy which currently depends mainly on hydrocarbons; 3) educating the public about the importance of energy



Target Renewable & Nuclear Energy Capacity (GW) by 2032
Source: KA.CARE

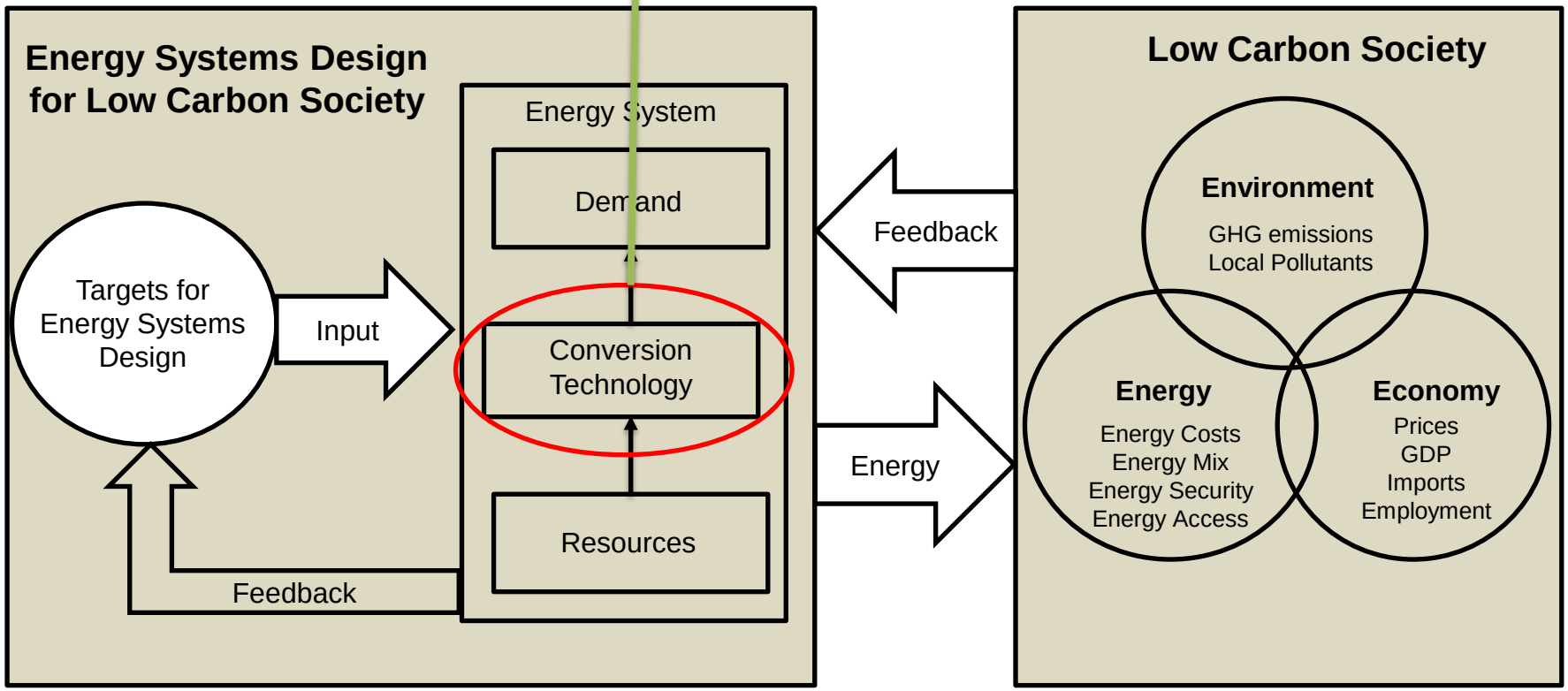


Source: KA.CARE, Saudi Arabia's Renewable Energy Strategy and Solar Energy Deployment Roadmap

Measures taken by the Kingdom to mitigate climate change: KAUST Research

Membrane Technology | Solar Engineering | Red Sea | Water Desalination & Reuse | Catalysis | Clean Combustion | Desert Agriculture

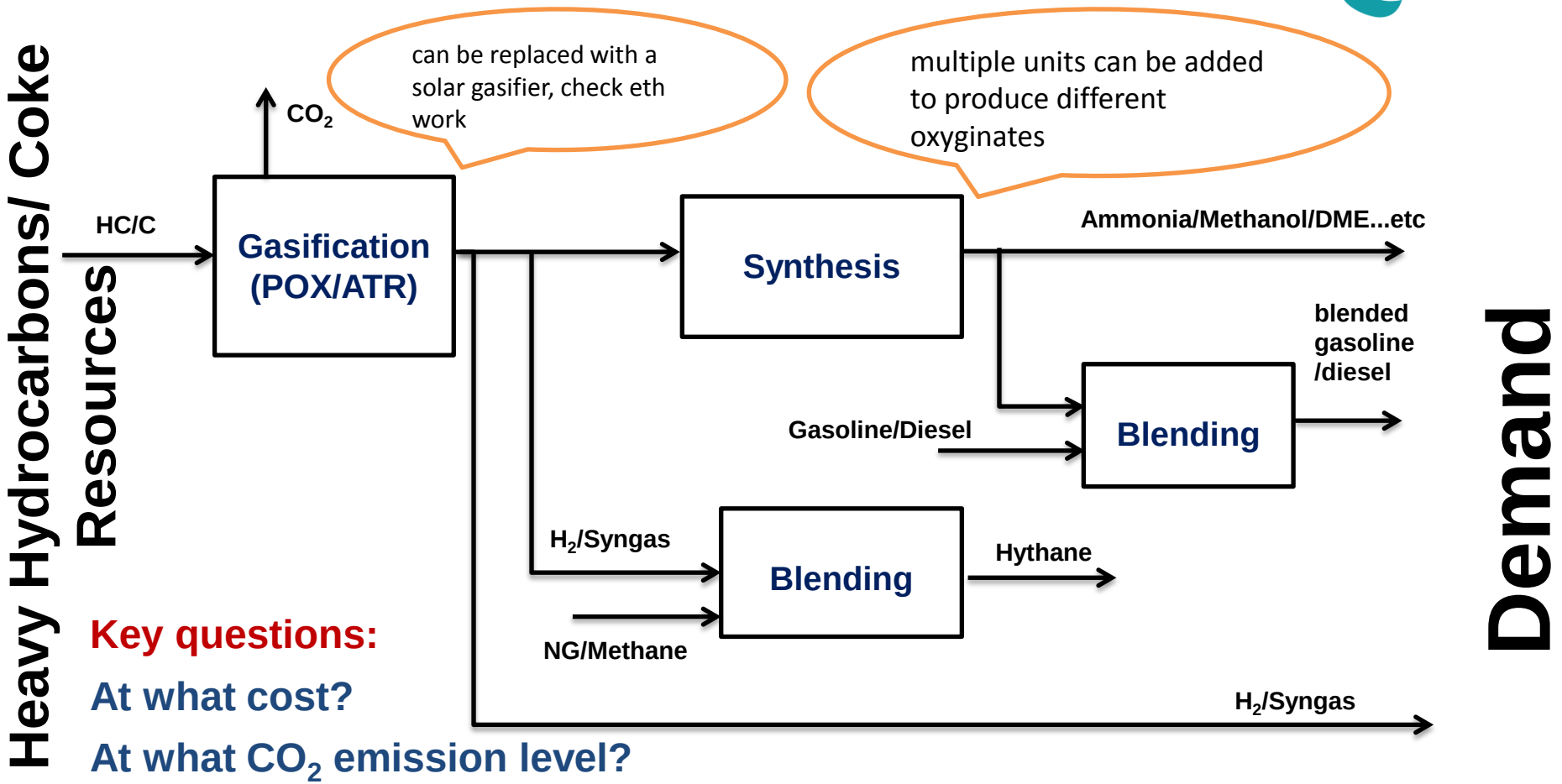
- Energy input to society and feedback from society is important feature for a sustainable design of an energy system. Mitigation of GHG emissions options can be achieved through varying technological, economic, political measures.



Energy System Design for a Low Carbon Society

*Nakata *et al*, (2011) Application of Energy Systems in Designing a Low Carbon Society , *Progress in Energy and Combustion Sciences*, 37, 462-502

KAUST Future Fuel Initiative



Key questions:

At what cost?

At what CO_2 emission level?

At what resource capacity?

At what demand?

Ultimately assessing the impact on systematic configuration of existing refineries in order to meet future fuel demand and specifications at the lowest possible cost

What is Realistic in December 2015 in Paris?

- Saudi Arabia believes that the reduction of greenhouse gas emissions must be achieved without undermining the economic growth, or negatively affecting the social development, or destabilizing the global energy market

- The proposed mechanisms to reduce emissions through the imposition of taxes or "carbon pricing" will undermine the principle of justice and equity.
- The new convention must extend beyond 2020 and be motivational, voluntary and binding on the national levels, and particularly for developing countries.
- We must bear in mind that developed countries need to take the lead in this area based on their potential and historic responsibility.

Source: *Speech by Minister of Petroleum and Mineral Resources Ali I. Al-Naimi at UN Climate Summit, 2014*

Global Collaboration Opportunities

- Joint action will be undermined as soon as there are policies and measures that distort the market to enhance the commercial and economic benefits of certain countries at the expense of other countries under UNFCCC.

- It is important to unify the efforts for better action under UNFCCC in a manner consistent with our goals and approach to sustainable development.

- Collaboration is particularly needed in the given aspects:

A. Climate change needs to be integrated into national sustainable development agenda.
B. Recognition of efforts made by countries
C. Support for countries with defined the efforts that lie beyond their capabilities and work with the international community to enhance global efforts.

Concluding Remarks

- Saudi Arabia stresses the importance of developing the adaptation efforts under the framework of the Convention, according to the Doha Decisions related to GCC economic diversification, taking into account the importance of mitigation efforts as a co-benefit.
- National circumstances and capacities of each country must be taken into account, to achieve rigorous climate goals, in line with the different stages of economic development
- The importance of partnership and collaboration between the public and private sector in climate activities and international initiatives that help states and private sectors to achieve climate objectives in a comprehensive and balanced manner.
- R&D will be at forefront of supporting the Kingdom's national development and transition into a low carbon economy

Special Acknowledgment for the "Conseil Français De l'Énergie" for invitation to speak at this forum

CONSEIL FRANÇAIS DE L'ÉNERGIE
WORLD ENERGY COUNCIL

Merci Beaucoup

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