KACST R&D Efforts Addressing Climate Change Issues

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King Abdulaziz City for Science and Technology (KACST) is both the Saudi Arabian national science agency and its national R&D laboratories. KACST plays a key role in science and technology policy making, related data collection, funding of external research, and other related services such as scientific publishing and managing the patent office.

http://www.kacst.edu.sa
This presentation highlights how KACST has been using R&D to address selected challenges in climate change including:

- Renewable energies & energy efficiency.
- Mitigation technologies.
- Adaptation technologies.
R&D in Renewable Energy and Energy Efficiency
Solar Panel Production Line

- 100MW PV Module Assembly (Ongoing)
- Project Benefits: PV industry localization
100MW PV Manufacturing Production Line

**Panorama View**
100MW Module Assembly Line

**PV Module Assembly Line**
- 100MW annual Capacity
- Fully Automated
- 60 & 72 Cell Module Capability
- High Quality Standards
- ISO 9001:2014 certification
- Production Start October 2016

Stringer & Lay-up
- Fully Automated

Trimming & Framing
- Fully Automated

5 Stage Laminator
- With In/Out Buffer

4BB Module Manufactured in this Assembly Line
100MW PV Cell Backend Manufacturing Line

- **Inspection Station**
- **Sorter 48 Bins**
- **Print Head**
- **Cell Test Station**
Solar Panel Installation in Various Places in the Kingdom

- Solar Panel in KACST Solar Village
Solar Energy was implemented in the roofs of several Public buildings

- **Solar System Installation Program** (Ongoing)
- Deploying solar systems for large public buildings, technology Demonstration - PV industry localization - Industry collaboration
- Achieving **30-40%** of energy cost saving
Water Desalination Plant Powered by PV Solar in Alkhafji (Ongoing)

- Project Benefits: Implement of KACST solar and membrane R&D, and reduce cost production of water
- Performance Metrics: Build a 60,000 m3/a day of RO desalination plant powered by 20 MW of PV Solar
Sand Storm in 2005 captured by satellite image

Arid Environment
After Sand Storm, in KACST Solar Village, Al-Ainah
Solar Cells Reliability Laboratories

Sand Spray Chamber

Diagram:
- **Desert Shore**
  - UV
  - Sand Storm
  - Salt Mist
  - Mechanical Load
- **Desert Life**
  - UV
  - Sand Storm
  - Desert TC
  - Mechanical Load
- **Desert Farm**
  - UV
  - Sand Storm
  - Ammonia
  - Mechanical Load
Development of Dust Repellent Surfaces (KACST-Fraunhofer Collaboration)

– Coating materials containing SiO₂ particles (5-20 nm)
– Tested at 6 different sites and weather conditions around the Kingdom for over 1 year at vertical and tilt directions sites
– 10% better transmittance compared to uncoated glass, and large savings in cleaning costs

Uncoated glass

Coated with primary particles

Coated with larger particles

Images after 1 year outdoor exposure (Al Ahsa site)
Nano-Coatings for Energy Efficient Glass

This project is focusing on the development of new glass coating nanomaterials applied by Atmospheric Pressure Chemical Vapor Deposition processes (AP-CVD). The nanomaterials exhibit certain optical properties (UV-blocking, VIS-transparency, (N)IR-blocking), allowing to tailor glazing being suitable for Saudi-Arabian climate conditions. As a result a composition of at least two nanomaterial thin films, consisting of zinc oxide (ZnO) and antimony doped tin oxide (ATO) such as Sb$_2$O$_3$.SnO$_2$ was developed and patented. Furthermore a lab coating device was designed, built up, and installed in KACST perimeter.

**Project description**

Improved properties of glazing, enhanced by coating and nanostructuring:
- UV – blocking
- VIS – transparent
- IR – blocking

Energy distribution of solar radiation
- UV range (1 – 360 nm) → 5%
- visible range (380 - 780 nm) → 51%
- IR-range → 44%

Saving energy by controlling wavelength of transmitted solar radiation
Quick Overview of the R&D efforts related to climate technology
Using metal organic frameworks (MOFs) to selectively seek and separate carbon dioxide.

This is the first demonstration that carbon dioxide can be separated by a solid material in the presence of water.

The use of solid MOF in this application saves over 90% of energy usually required to separate carbon dioxide using the traditional amine solutions.
Organic Strut + Inorganic Zn₄O Joint → MOF-5

Easy to make from readily available materials, ultrahigh surface area (10,000 m²/g), the organic and inorganic can be varied.

Simple synthesis and environmentally safe manufacturing

Flue gas → CO₂ trapped in the pores → No CO₂ → Fuels and/or Chemicals
**New Technology to Produce Hydrogen from Heavy Oil for Fuel Cell** (Ongoing): Joint project between KACST and the University of Oxford.

- **Project Benefits:** Development of a specific process for the production of hydrogen through the cracking of crude oil, heavy oil or heavy hydrocarbons, using microwave technology.
The aim of this project is to develop catalyst, electromagnetic process for thermal pyrolysis and catalytic cracking and scaling-up pilot plant for conversion of crude oil (wax) into hydrogen for the fuel cell.

- Wax is the major product of the low temperature Fischer-Tropsch synthesis process from any carbon-containing resources.
- Our catalytic technology assisted by microwave irradiation can instantly generate high purity hydrogen (80-95%) free of carbon oxides (CO+CO₂).
- A base metal catalyst can be regenerated and reused to generate continuously high purity hydrogen.
- Residual carbon can be gasified to further generation of hydrogen and/or fuel hydrocarbons by FT synthesis.
Depending on starting fuel, the cell can work as electrolysis (pure hydrogen) or Co-electrolysis (hydrogen + carbon dioxide) to give water and carbon monoxide.
Influence of Heterogeneities on CO₂ Sequestration in Potential Saline Formations

This work presents three saline formations investigated as potential candidates for CCS. The three formations show relatively low sequestration efficiency attributed to rock heterogeneity controlling the displacement efficiency as indicated by saturation distribution profiles determined from the tomography scanner images. Scattered plug to plug heterogeneity and structured heterogeneity in form of layering with upward dip influence negatively the storage efficiency of the first two formations. Structured heterogeneity in form of layering with zero dip parallel to flow direction seems to have the least effect on storage capacity as seen for the third formation.
Experimental Investigation of Low Salinity Water and Carbon dioxide Miscible Flooding in Sandstone Reservoirs

Low salinity waterflood (LSW) was combined with miscible CO2 in a water alternating gas (WAG) scheme to elucidate our understanding on the interrelationships of these enhanced oil recovery methodologies. Seven runs were conducted with various schemes of LSW and high salinity waterflood (HSW) in secondary mode with CO2-WAG in tertiary mode at WAG parameters of 1:1 WAG ratio and 0.2 pore volumes slug size. LSW miscible tertiary CO2-WAG was not very efficient. Negligible clay content and less CO2 availability for interaction with the residual oil due to an increased solubility of CO2 in the low salinity brine were the believed reasons of such observation. High salinity miscible tertiary CO2-WAG was effective and reduced CO2 solubility in higher salinity brine was effective in making more CO2 available to interact with and mobilize residual oil.


Selected recent inventions in KACST related to mitigation and adaptation to Climate Change
Method and Apparatus for Carbon Capture and Utilization Using Nano Slurry Medium

\[ Fe^0 + 2CO_2(g) + 2H_2O \rightarrow Fe^{2+} + 2HCO_3^- + \uparrow H_2(g) \]

\[ Fe^{2+} + 2HCO_3^- \rightarrow \downarrow FeCO_3(s) + \uparrow CO_2(g) + H_2O \]

\[ Fe^0 + 2CO_2(g) + 2H_2O \rightarrow \downarrow FeCO_3(s) + \uparrow H_2(g) \]

Brief:
The invention is a method and apparatus to capture and utilize carbon dioxide (CO2) through using a medium containing nano slurry. The apparatus enables carbon dioxide gases to get in contact with the nano slurry solution (e.g., nano zero valent iron particles which are dispersed in deoxygenated ultra pure water in 10g/L) and provide a longer time for reaction through circulating the carbon dioxide gases. Iron carbonates are generated after the reaction and deposited on the surfaces of nano iron particles. Nano zero valent iron particles are covered with a layer of iron carbonates.
Destructive Device for Sand Dunes

The invention is a device to remove the sand dunes. The device is designed to be fixed on top of the sand dune. One device for each sand dune. The size of the device might be adjusted based on the sand dune size. This device utilizes from the phenomenon of wind shear to destruct the sand dunes.

The working mechanism of the device and the parts of the device are presented in the attached the figures. This device is fixed manually on the top of the sand dune.

The device consisted [as in Figure 1 3D] of (1) solid copper stick with tapered lower side and a piece of circular metal to enable the hammering of the device (3). Pear body of copper (2) smooth and curvy contain a valve (4) to fill the empty space (5) inside the device.

The working mechanism of the device is illustrated in Figure 2 (3D) depending on utilizing the wind shear phenomenon. Where, the prevalent wind (1) hits (2) the curvy-pear body, some of the wind disrupted (3) and some others (4) go through the curvy-smooth body of copper and dig beneath the body (5) in the direction opposite to the prevalent wind direction (1). Over time, the digging would increase and the sand dune would be lowered gradually until completely demolished. The speed of the process is heavily dependent on the wind speed and the sand size, the sand dune size, and the type of sand.
An Automatic System to Combat Desertification to Stop Sand Movement Through Controlling Groundwater Pumping Based on Wind Speed

- The invention is a system to combat desertification, stabilize sand movement, and to protect plantations in the areas at the dangers of desertification. This claimed invented system is working automatically (without human resources) to pump groundwater when the wind storm attack the region.

- The invented system can identify the storm using a wind speed tool that is able to detect the speed of wind, and this tool is connected with a sensor. The sensor yields signals to the groundwater pump at the time of storm. Groundwater is pumped at the signal and distributed into pipelines into the irrigation system above the ground. The water spray that comes from the irrigation system help to stabilize the sands from movement. The energy is generated in the system by wind-speed to operate the pump. The tool that is used to measure the speed of the wind is the same as that used to generate wind energy.
King AbdulAziz City for Science and Technology (KACST)

Riyadh, Saudi Arabia
Work Projects, LAVA, 2012

The project site of KACST is located in the north western Riyadh metropolitan area, in the vicinity of KSU.

The KACST Knowledge Campus is a network of spaces which help in know-how exchange. The Plaza and Boulevard connect the people in their daily routine of walking from a carpark to their respective research facilities, bringing together researchers from various fields to interact and communicate with each other.

Energy reduction forms a key part of any environmental strategy and this comes through careful consideration of massing, shading, environmental facade design and natural cooling strategy present in any environmentally responsive development.

The presence of different institutes within the same building has been featured as one of the Master-plan principles in order to create a very flexible programmatic solutions. With the institutional needs changing into the future, the modular build up system ensures to provide an easy way to adjust, switch or move any lab/office module in order to satisfy the next generation research facility.
Thank you