



---

# ***Israel's Role in Reducing Global Oil Dependency***

## ***Alternative Liquid Fuels***

***M. Herskowitz***

***Blechner Center of Industrial Catalysis and Process Development***

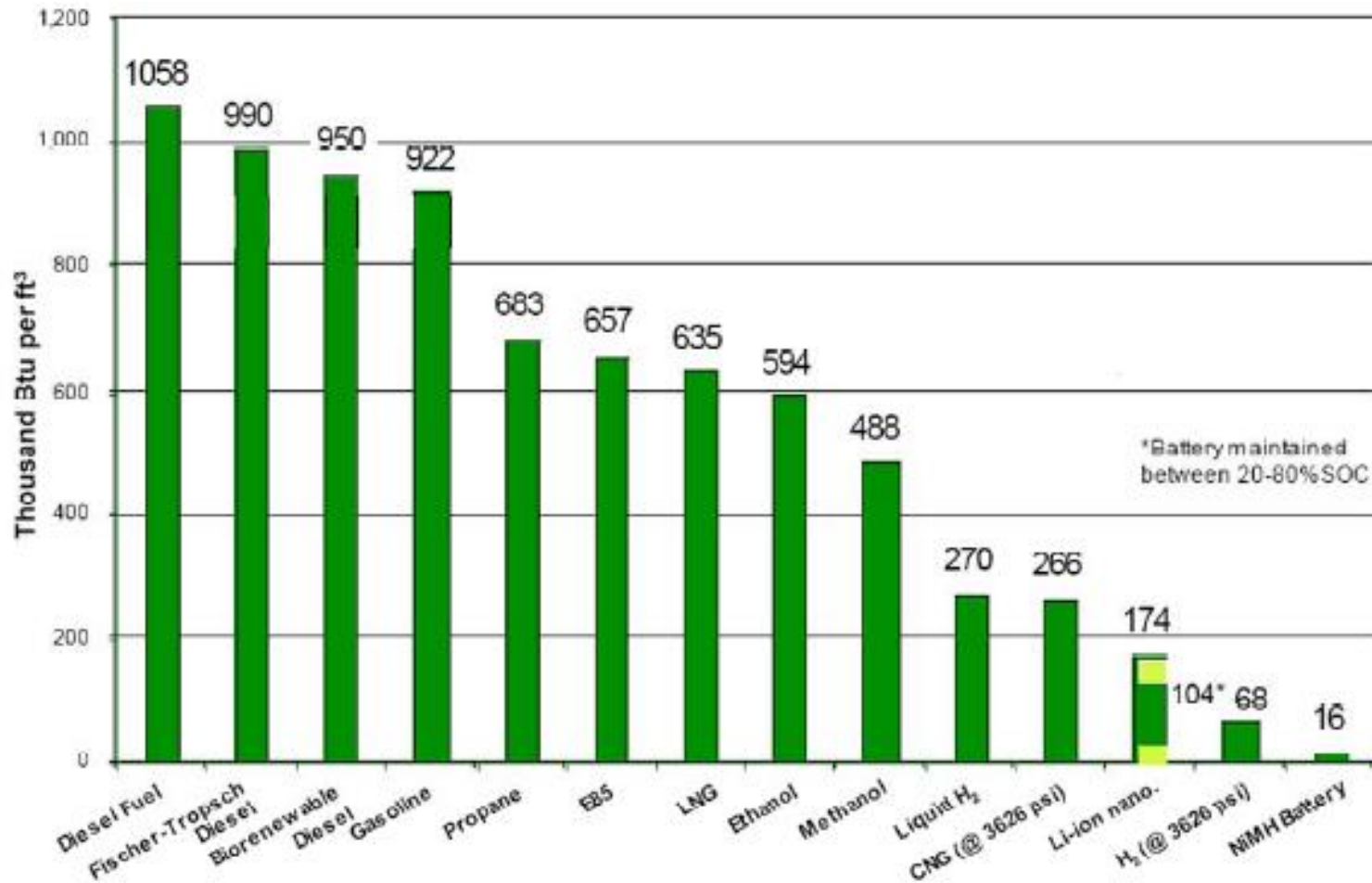
***Herzliya Conference, February 8, 2011***

# ***Remedies to oil addiction are diverse and require short- to long-term RD&D***

---

- ***Biomass is a potential sustainable source while coal and natural gas are abundant in short term***
  - ***Biomass to fuels should be examined based on availability, life cycle analysis, food vs. energy crops, transportation***
  - ***Technologies based on coal and natural gas can be deployed***
- ***CO<sub>2</sub> and water are the ultimate feedstock for fuels***
  - ***Carbon dioxide capture and decomposition to carbon monoxide***
  - ***Photo-catalytic water splitting to hydrogen***
  - ***Hydrogenation of carbon dioxide to liquid fuels***
  - ***Artificial photosynthesis***

# Liquid fuels have the highest energy density



**Solar energy**

**Artificial  
Photosynthesis**

**Carbon dioxide**

**Air**

**Biomass**

**Gasification**

**CO<sub>2</sub>  
H<sub>2</sub>**

**Carbon dioxide  
hydrogenation**

**Water splitting**

**H<sub>2</sub>**

**Carbon dioxide  
hydrogenation**

**Carbon dioxide**

**Hydro-  
de-oxygenation**

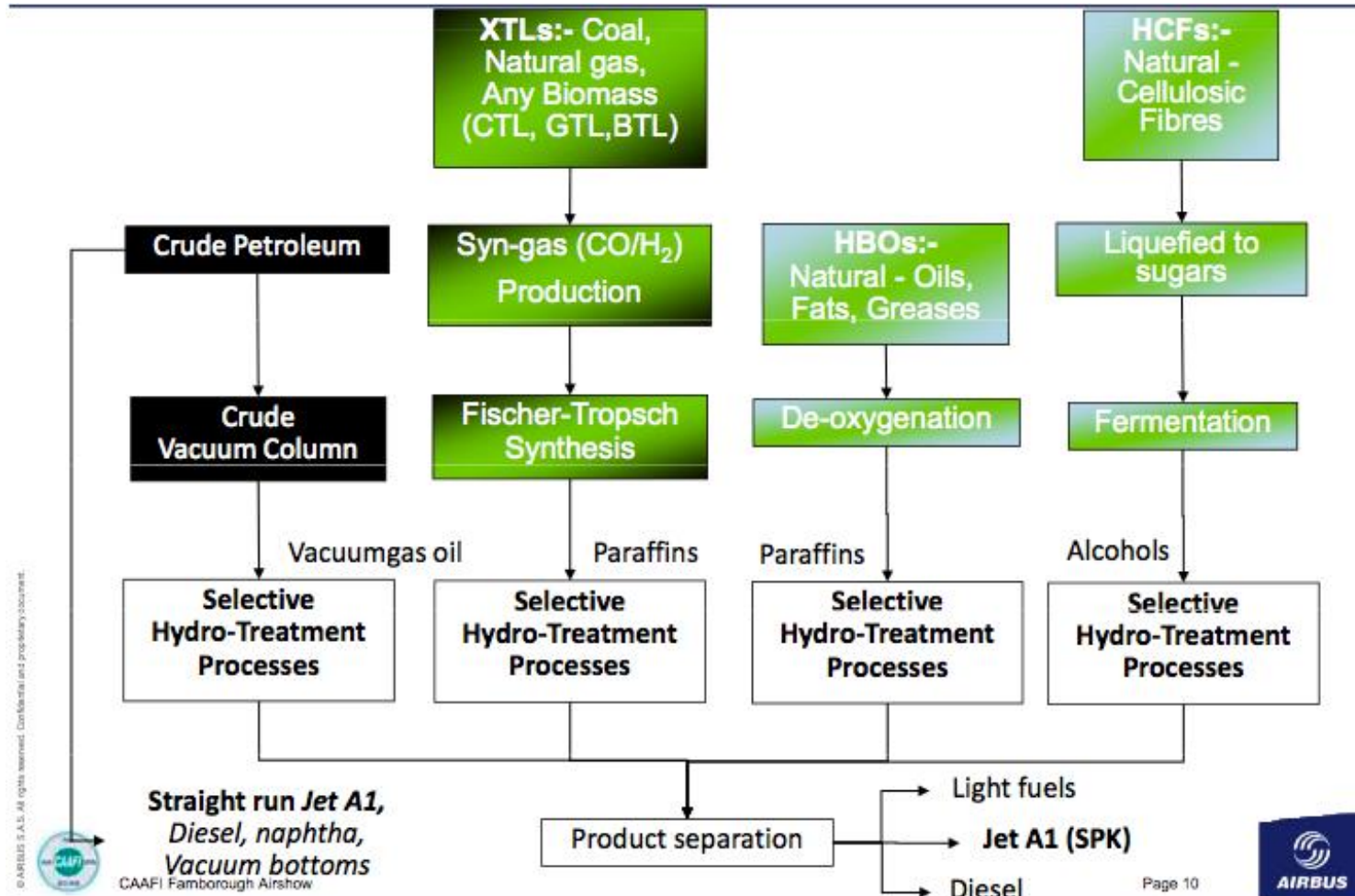
**H<sub>2</sub>**

**oils**

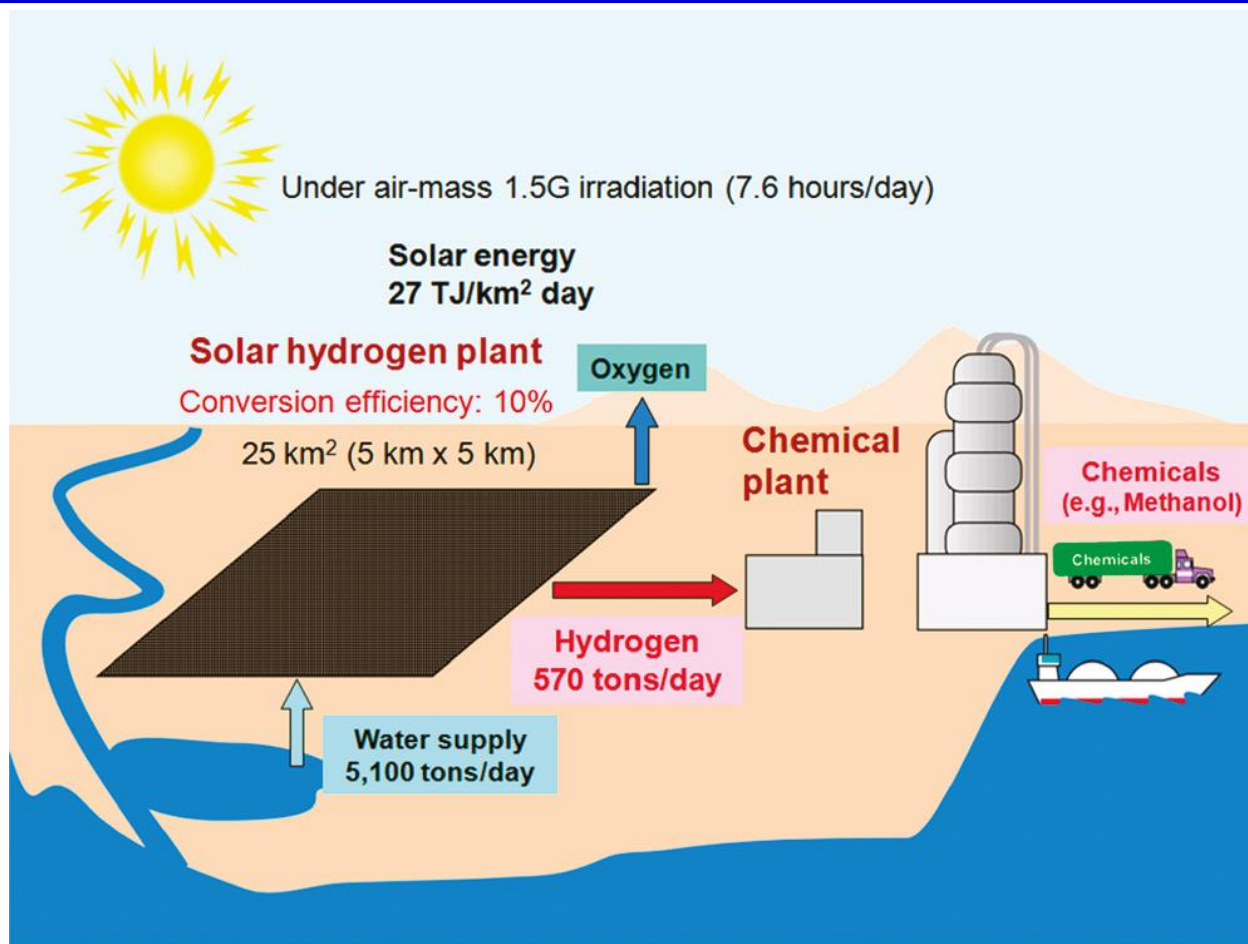
**Liquid fuels**

**Water**

# Developing materials at $10^{-9}$ m level will produce renewable fuels



# *Renewable hydrogen is a key element in production of liquid fuels*



# *A variety of fuels will be available during the transition period*

---

## ■ *First-generation renewable fuels*

- *Ethanol from sugar/starch crops and biodiesel from oils*

## ■ *2<sup>nd</sup> generation renewable fuels*

- *Ethanol, higher alcohols, methanol from cellulosic feedstock*
- *Green diesel by hydrotreatment of vegetable and animal oils*
- *Synthetic biofuels (diesel and gasoline by FT)*
- *Bio-gas*
- *Bio-DME*
- *Bio-hydrogen*

## ■ *Alternative fuels*

- *GTL from natural gas and CTL from coal*

# ***Establishment of the Israeli Center of Research Excellence (I-CORE) provides unique opportunity***

---

- ***Exploit and upgrade existing infrastructure***
- ***Promote teaching programs and advanced training of researchers, students and engineers***
- ***Provide an interface for cooperation — between senior and new researchers***



# ***Research universities in Israel will conduct R&D on biomass to liquid fuels***

---

- ***Develop plants, algae and cyanobacteria – genetically selected or engineered – for large-scale production (especially dryland growth) of energy-rich biomass as a biofuel feedstock by exploiting recent advances in metabolomics, genetics, genomics and agrotechniques***
- ***Utilizing novel microbial and enzymatic systems for the efficient hydrolysis of biomass to soluble sugars en route to biofuels, e.g., ethanol***

# ***Research universities in Israel will conduct R&D on production to renewable liquid fuels***

---

- ***Non-catalytic conversion of low-grade biomass of any type into a mixture of H<sub>2</sub> and CO<sub>2</sub> that will serve as a feedstock for liquid fuel production by a catalytic process***
- ***Efficient and cost-effective direct conversion of solar energy into liquid fuels by photoelectrolytic and photocatalytic water splitting and CO<sub>2</sub> reduction***
- ***Development of catalysts and catalytic processes for the sustainable and environmentally friendly production of liquid fuels from a variety of feedstock materials***

# The Arava group recently won a tender to operate RD&D center for renewable energy

- The Ministry of Industry, Trade and Labor of Israel and the group will each invest half of \$30 million over a five-year period



**Industry**



**Investment**



**Renewable Energy Site**



**Research University**



**Management**

# ***Isodiesel™ is a neat diesel with superior properties***

---

## ***■ Isodiesel™ is an excellent diesel product***

- High cetane number, low mono (<10wt%) and no poly-aromatics***
- Negligible sulfur***
- Excellent lubricity and high oxidation stability***
- Acceptable density and good compatibility with diesel engines***
- Engine tests demonstrated excellent (NO<sub>x</sub> and PM) emission***

## ***■ Mild operating conditions yield good performance***

- 370 - 385°C, 30 bar, LHSV = 1h<sup>-1</sup> and 550 NL/L are employed***
- Operation with crude (pretreated) vegetable and tallow oils, mixtures and pure oils***

## ***■ Isodiesel was converted to improved jet-fuel***

# *Isodiesel™ has been produced from various vegetable and animal oils*

---

