The Future Transportation with Sustainable Energy

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Chairman ISO/TC203/WG3 Energy Systems Analysis & Statistics
Founder Chairman ISO/TC197 Hydrogen Energy Systems
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Energy supply for a growing population is facing fundamental change for three reasons:

1- The economic supply of the mineral energy resources oil and gas is ending in a few decades.

2 - Health hazards, risks and global warming caused by emissions from combustion engines.

3 - Imperative conservation of the fossil resources for the chemical and metallurgical industries.
SOLAR PV & THERMAL ENERGY DIRECT
WIND POWER
HYDRO POWER / TIDAL / WAVE POWER
OCEAN & GEOTHERMAL ENERGY
BIOMASS / BIOGAS ENERGY
AMBIENT ENERGY
MUSCLE POWER

SUSTAINABLE ENERGY SUPPLY

SITUATION 2000

INEVITABLE CLIMAX OF
MINERAL ENERGY

HAZARDOUS AND
DEPLETING ENERGY
CONSUMPTION (FOSSIL & FISSILE)

TOTAL ENERGY CONSUMPTION

RENEWABLE ENERGY CONSUMPTION

TOTAL USABLE ENERGY ON EARTH

DEPLETION OF FINITE ENERGY RESOURCES

ENERGY HISTORY & FORECAST

SOURCE: ISEO
To cope with these serious problems, benign, renewable energy systems must be multiplied to replace conventional combustion.
<table>
<thead>
<tr>
<th>Energy Option</th>
<th>Immediately Feasible</th>
<th>Theoretical Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Bio energy</td>
<td>50 PWh/year</td>
<td>78</td>
</tr>
<tr>
<td>- Hydropower</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td>- Geothermal Electricity Conventional</td>
<td>2</td>
<td>388</td>
</tr>
<tr>
<td>- Geothermal Electricity Hot Dry Rock</td>
<td>20</td>
<td>202</td>
</tr>
<tr>
<td>- Geothermal Heat</td>
<td>4</td>
<td>435</td>
</tr>
<tr>
<td>- Wind Power</td>
<td>53</td>
<td>160</td>
</tr>
<tr>
<td>- Solar Power PV</td>
<td>6</td>
<td>400</td>
</tr>
<tr>
<td>- Solar Thermal Power</td>
<td>40</td>
<td>435</td>
</tr>
<tr>
<td>- Solar Active Heat</td>
<td>20</td>
<td>435</td>
</tr>
<tr>
<td>- Solar Passive Heat</td>
<td>10</td>
<td>435</td>
</tr>
<tr>
<td>- Ocean Energy</td>
<td>15</td>
<td>202</td>
</tr>
<tr>
<td>- Heat Pumps</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>- Muscle Energy</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>- Novel Energy Technologies (R&amp;D)</td>
<td>100</td>
<td>200</td>
</tr>
</tbody>
</table>

Total RE potential 339 PWh/year 1537 PWh/year
Conclusions of the ISEO Energy Study

1. There is more affordable renewable energy available on Earth than humankind ever needs at the foreseeable population growth rate.

2. Most renewable energy systems are competitive with the depleting non-renewable sources - even more so, if the full costing "polluters-pay" principle is applied.

3. All nations are able to become energy self-sufficient with renewables, and thus can drastically reduce pollution by cleaner, more efficient power plants and transport modes.

4. The remaining mineral energy resources can and must be conserved for higher added value purposes in the chemical and metallurgical industries.
Solar Energy

- Biomasse: 30%
- Wind: 15%
- Wasser: 10%
- Erdöl: 5%

Geothermal and Ocean Energy are missing

Gas, Oil & Coal

by Greenpeace
Transportation absorbs over 1/3 of World Energy Production i.e. over 50% of World Oil Production

The bulk of energy is used for inefficient road transportation, too many trucks and underutilized cars with low-efficiency engines.
SUSTAINABLE TRANSPORTATION OF THE FUTURE
Clean Rapid Mass Transit and inter-modal freight systems are indispensable for the efficient flow of people and goods in highly populated regions, but also clean and safe individual transport is required to satisfy the needs of humans living or working in remote, scattered locations and for their leisure time.

Solutions are electric trains for goods and people, clean fuel trucks and ships for inter-modal transportation, cleaner aero-planes and efficient 2, 3 & 4-wheelers driven by clean fuels or electricity from RE sources.
Rapid Mass Transit Systems
must evolve towards combined Road-Rail Mass Transit Systems. Excellent example: the Electric Swiss Rail Network 2000 saving unproductive time of travellers, traffic fines, parking and fuel cost, pollution, reducing traffic congestion and improving social life among the passengers in transit
Example: Electric Schoolbus with Supercaps
Individual Transport

is, however, one of the basic human urges. It must be satisfied for professional and leisure purposes. I characterized the car of the future 1992 in Rio as follows:

Comfortable, Light, Zero-Pollution, Quite, Safe, Long-Life, Recyclable, Low Maintenance Cost & Modern Navigation System
Proposed Electric Vehicle Platforms

105 Inch Wheelbase (2667mm)
- Mid-Sized Pick-Up
- Mini-Van
- 2-Door Hatchback
- 2-Door Wagon

90 Inch Wheelbase (2286mm)
- 4-Door Sedan
- 2-Passenger Coupe

EV Concept

Solar Car
Weight (kg)

Comparison of 15 kWh Batteries by Weight

Future Electric Cars - Long Range & Long Life

- Pb-battery: 420 kg
- Ni-Cd-battery: 330 kg
- Ni-MH-battery: 214 kg
- Li-Ion-battery: 150 kg
- NOVEL batteries: 75 kg

Future Electric Cars - Long Range & Long Life
### COMPARISON OF CLEAN VEHICLES (40 kW; 240'000 km over 6 years)

<table>
<thead>
<tr>
<th>Drive Options</th>
<th>Battery</th>
<th>Hydrogen Combust.</th>
<th>Hydrogen Storage</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOVEL</td>
<td></td>
<td></td>
<td></td>
<td>a standard 4-cylinder combustion engine is used</td>
</tr>
<tr>
<td>Fuel Cell</td>
<td></td>
<td></td>
<td></td>
<td>** gasoline version: 1$/Liter, 15 Liters per 100 km</td>
</tr>
<tr>
<td>H2+O2</td>
<td></td>
<td></td>
<td></td>
<td>** AC/DC charger on board the electric car for easier battery charging</td>
</tr>
<tr>
<td>HYMOBIL</td>
<td></td>
<td></td>
<td></td>
<td>*** cryogenic H₂ storage boil off loss depending on parking duration</td>
</tr>
</tbody>
</table>

#### Criteria

- **Relative Drive Investment**: $/W
- **Energy Cost**: $/km
- **Relative Weight**: kg
- **Average Range**: km
- **Energy Efficiency %**:
- **E + Cap. Cost**: $/km (Total Vehicle Cost)

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<th>Hydrogen Storage</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Drive Investment</td>
<td>0,75</td>
<td>2,35</td>
<td>1,35</td>
<td>&lt; 0.20</td>
</tr>
<tr>
<td>Energy Cost</td>
<td>0,03****</td>
<td>0,07</td>
<td>0,16</td>
<td>0,15</td>
</tr>
<tr>
<td>Relative Weight</td>
<td>350</td>
<td>250</td>
<td>250</td>
<td>200</td>
</tr>
<tr>
<td>Average Range</td>
<td>300</td>
<td>400</td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td>Energy Efficiency</td>
<td>0,75</td>
<td>0,32</td>
<td>0,13</td>
<td>0,13</td>
</tr>
<tr>
<td>E + Cap. Cost</td>
<td>0,20</td>
<td>0,56</td>
<td>0,46</td>
<td>0,28</td>
</tr>
</tbody>
</table>

#### Remarks

- The same gear box assumed for all options including energy management, storage and power train.
- Average weight of energy management, storage and power train with one tank filling or one full charge (plus extra charges at stops).
- Total efficiency over whole energy chain to gear box.

#### Energy Cost

- at 6% interest over 3 years and 240'000 km usage incl. service & spares

#### Energy Efficiency

- total efficiency over whole energy chain to gear box

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**Source:** ICEC, CH-8055 Zurich / GRG info2@icec.ch
The Merits of Bicycles and Electric Two & Three Wheelers for Good Health and Congested Areas
Freight Transportation must undergo drastic change towards inter-modal road-rail-barge-freighter transportation by means of standard ISO containers in conjunction with the improvement of the railway network and modern container handling systems.
Ship-Road-Rail Freight Container Transloading Facility
Air Transport
> a tough environmental problem <

It is responsible for excessive pollution in very sensitive atmospheric layers. It may be resolved by hydrogen jet engines, as demonstrated already in the Eighties, or by air ships lifted by inert gases and propelled by clean fuels.
Hydrogen Aeroplanes

Space Shuttle

Clean Airships
CONCLUSIONS

» Clean vehicles, fed by renewable energy are needed to satisfy individual mobility

» Clean Mass transport for people has to take the pressure off traffic congestions

» Clean inter-modal freight transport must be developed at a much faster pace

» Air transport must become cleaner, quieter

Innovation coupled with huge investments can and will fulfil these tasks
RECOMMENDATIONS

- Accelerate the development of efficient, quiet and non-polluting drive systems
- Implement more electric rapid transit & inter-modal freight transport systems
- Design and manufacture clean, lighter, quieter, safer, recyclable vehicles
- Implement clean, renewable energy supply systems at a much faster pace!
www.uniseo.org