Future Transportation with Smart Grids & Sustainable Energy

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Abstract

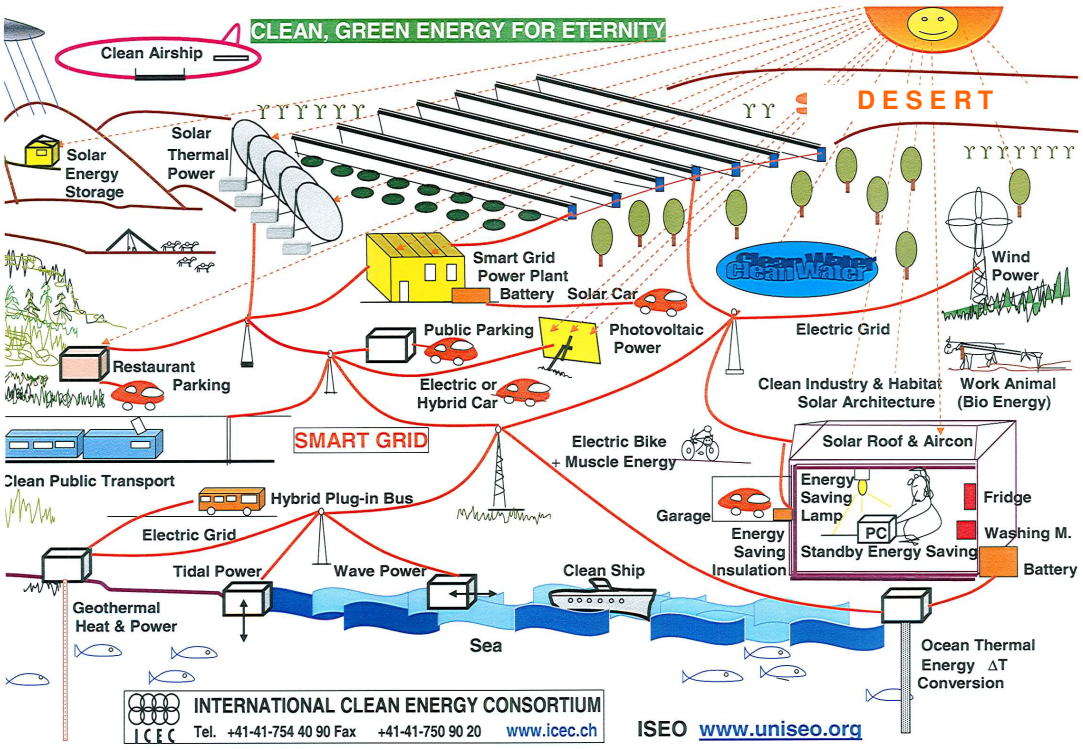
Transportation is facing fundamental change due to the rapid depletion of fossil fuels, environmental and health problems, the growing world population, rising standards of living with more individual mobility and the globalization of trade with its increasing international transport volume.

To cope with these serious problems benign, renewable energy systems and much more efficient drives must be multiplied as rapidly as possible to replace the polluting combustion engines with their much too low efficiency and high fuel logistics cost.

Consequently the vehicles of the future must be non-polluting and super-efficient, i.e. electric. The energy supply must come via smart grids from clean energy sources not affecting the health, climate and biosphere. It is shown how this transition to the clean, sustainable energy age is possible, feasible and why it is urgent.

The important role of international ISO, IEC and ITU standards and the need for better legislation by means of the Global Energy Charter for Sustainable Development are also highlighted.

Keywords: Sustainable Energy, Smart Grid, Environment Protection, Clean Mobility



The complexity of the future global sustainable energy system intelligently interlinking a multitude of decentralized clean energy sources with efficient stationary users and electric vehicles with millions of buffer batteries

1 Introduction

The main challenge of the 21st century is the transfer from a polluting, utterly destructive to a clean, sustainable world economy, particularly as regards the transport sector. About one third of the total world energy consumption is nowadays used for the transportation of people and goods, of which over 90 % consist of polluting, finite fossil fuels. These mineral resources are declining rapidly, resulting in increasing prices due to steeply rising demand and the inevitably decreasing supply from more and more expensive oil and gas fields.

The only way forward for the increasing world population with its rising demand for public and individual mobility are clean transportation systems based on renewable energies. Since most fuel supplies are declining or insufficiently available, such as bio fuels and hydrogen, polluting and the combustion engine's efficiency is extremely low, the days of the hazardous fuel age are soon counted.

The conventional wasteful energy logistics, i.e. fuel distribution by road, rail, waterways and pipelines will be substituted by the elegant and pollution free electric grids which will be "smarter", i.e. adapt to the loads intelligently with hydraulic and buffer storage by millions of vehicle batteries.

2 The Energy Dilemma

Since the peak of petroleum production has been passed in most producing countries and the consumption is still rapidly increasing, not the least because of the very fast growth of the emerging economies in Asia and Latin America with their greed for easier mobility - supply cannot cope any more with demand, resulting in rising fuel prices.

The consequences of the growing fuel demand are the worsening pollution causing health problems, frightening weather catastrophes and negative national trade balances hurting the poorer nations but also rich industrial countries like the USA with their hundreds of billions fuel imports from instable regions resulting in oil wars costing many more billions of Dollars.

Neither bio fuels can ever fully replace the fossil fuels by stealing food from the growing world population, nor dear hydrogen. Hence the only way out of the dilemma is **electricity from millions of renewable energy sources and electrically driven transport**. The smart grid will be the efficient link between the industry, transport and housing sectors. Millions of electric sockets with remote meter reading and billing will interconnect the batteries of the users and the multitude of power sources.

Energy supply for a growing population is facing fundamental change for four 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

4- The only economically viable energy transport mode is electricity by means of smart grids

The realistic energy scenario in Fig. 1 shows the future we are facing. Either we go full speed to feed smart grids with decentralized renewable energies and off-the grids in remote locations and for heat, or we return to the energy scarcity of ancient times and forget our modern mobility comforts on the ground and in the air.

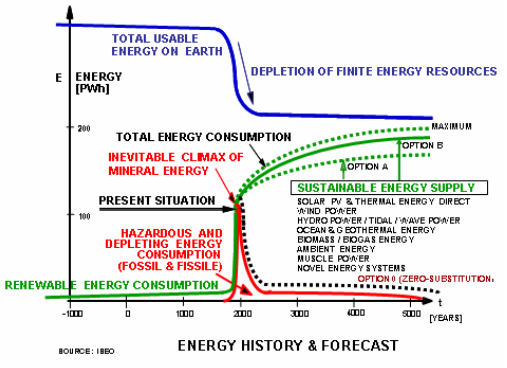


Figure 1: World energy Scenario long-term [2]

The scenario in Fig. 2 is on a different time scale under the optimistic assumption that the annual world energy consumption growth will be 2 % only. The required "green" energy increase to compensate for the inevitable mineral energy decline and to satisfy the consumption growth will necessitate an investment of a least a Trillion $ per year - the size of the world defence budget !

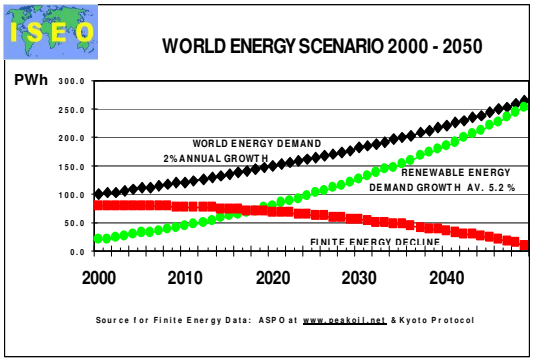


Figure 2: World energy Scenario mid-term [2]

The good side of this transition to the clean, sustainable energy age is that electric energy from renewable sources will replace fuels with their inefficient engines. In other words the combustion engines with only 15-25 % energy efficiency must be replaced by electric motors with over 90 % efficiency, hence stopping the squandering of transport fuels to the extent of about 1/3 of the total world energy consumption This will reduce the transport share of total energy consumption to less than 1/10 of energy production, if sourced from the unlimited solar, hydro, wind, ocean and geo energy, instead of from polluting and risky fossil fuel fired or nuclear power plants, to be distributed by smart electrical grids to millions of plug-in users.

To cope with these serious problems, all benign, competitive, renewable energy systems can and must be **multiplied as fast as possible** to replace the conventional combustion as shown in Figure 3 with emphasis on conversion to clean electrical end-use energy.

Energy Option	Immed. Feasible		Theor. Potential
- Bio energy	50		78
- Hydropower	8		14
- Geothermal conv. pow.	2	)	
- Geothermal hot d. rock	20	}	388
- Geothermal Heat	4	)	
- Wind Power	53		160
- Solar Power PV	6	)	
- Solar Thermal Power	40	}	435
- Solar Active Heat	20		
- Solar Passive Heat	10	)	
- Ocean Energy	15		202
- Heat Pumps	10		50
- Muscle Energy	1		10
- Novel Energy	100		200
Total RE potential	339	PWh/year	1537

Figure 3: World-wide energy sources [2]

Hence the transport sector will naturally become the pace maker of the modern energy economy, because there is no other choice than to abandon all finite, depleting fuels with their inefficient engines.

Conclusions of the ISEO Energy Study

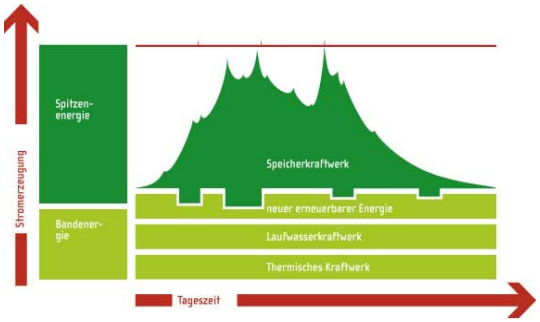
1. **There is more affordable renewable energy available on Earth than humankind ever needs at the foreseeable population growth rate.** [4]
2. **Renewable energy systems are competitive with the depleting non-renewable sources - even more so, if the "polluters-pay" total costing principle is applied.** [5]
3. **All nations are able to become fully self-sufficient with renewable energy, and therefore can drastically reduce pollution by clean, efficient power and transport .**
4. **The remaining fossil mineral energy resources can and must be conserved for higher added value purposes in the chemical and metallurgical industries.**

Sources [2] [4] [6]

3 The Smart Grid

Since there will be millions of decentralized renewable power sources, the role of the electric grids is becoming very important to balance the energy demand variations with the fluctuating power generation from the irregular sun and wind, complemented by more constant energy sources like geothermal and wave power or run-on the river hydropower. Hydraulic energy storage also contributes to the balancing of the varying power consumption, called "energy symphony" in concert with other renewable energy systems. The batteries will play an increasingly important role in this global balancing act between demand and supply.

The decentralized control and remote meter reading can be digitally transmitted by high frequency signals over the power lines or by state-of-the-art GMS telecommunication, as proven already since many years for the stationary meter reading.



The electric grid operators will apply advanced computerized energy management methods to serve millions of public and private remotely metered recharging stations for vehicles.

The billions of electric vehicles and trains on this planet will provide a smart collective energy buffer storage capability amounting to a multiple of the world's total power generation capacity and thus serve also as peak shaving reserve managed by the intelligent power grid computer system.

4 The tasks for the industries

The extreme energy imbalance between the past and actual road and rail transportation modes and the resulting waste of energy in combustion engines is illustrated in Fig. 4

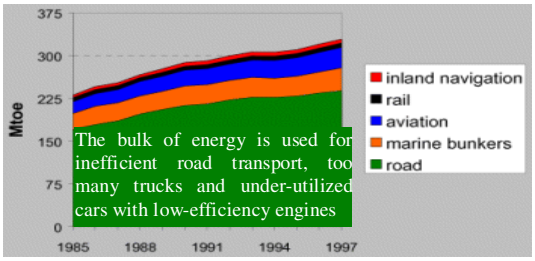


Figure 4: Energy discrepancy in transportation

Two good answers are more public transport by rail and intensified inter-modal transport by electric trains and waterways as illustrated by Fig. 5 and 6.

Figure 5: Rapid transit trains to relieve road traffic

Figure 6: Inter-modal cargo transportation

However, since individual transport is one of the basic human urges and needs, it must be satisfied for professional and leisure purposes.

I characterized the car of the future and the task of the automobile industry at the UN Rio Environment & Development Summit in 1992 as follows:

Comfortable, Light, Zero-Pollution

Quite, Safe, Long-Life, Recyclable

Electric with Low Maintenance Cost

Navigation System Saving Energy

What has been done since the Rio Summit where the International Car Manufacturers Association participated actively with a big side event ?

Bigger combustion engines, more Diesel engines and heavier cars were the main result, but luckily also some hybrid vehicles and over 20 Million e-bikes in Chinese cities emerged under the pressure from ever rising fuel cost, growing climate change awareness and suffocating urban congestions.

The need for mass produced electric vehicles becomes evident with rationalized power trains as shown at the example in Fig. 7.

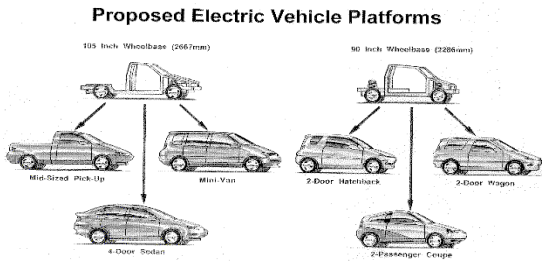


Figure 7: Future electric car platforms [1]

The other urgent task is the development and mass production of advanced batteries and better super-capacitors since fossil fuelled hybrid vehicles are only an expensive temporary solution [6].

The recharging of the batteries is state-of-the-art with internationally standardized plugs & sockets and electronically metered tele-controls for credit card charging by the operators of these smart grids. The electricity rates are only a small fraction of the ever rising fossil fuel cost.

Batteries will perform several hundred Wh per kg weight with sufficient peak power for acceleration and thousands of charging cycles over their life outliving the expected vehicle lives. Fuel cells can hardly compete with advanced batteries.

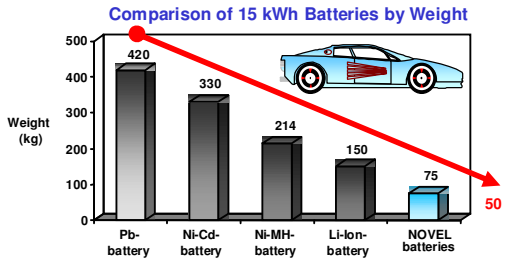


Figure 8: Advancement of traction batteries [3]

Fig. 9 shows the merits of electric Two-Wheelers for good health by exercise and in congested areas

Figure 9: Electric two-wheelers

The challenge for the vehicle industry thus is:

- **stop producing fuelled combustion engines**
- **lighter vehicles needing much less energy**
- **plug-in super-efficient electric drives**
- **more efficient lighting & air conditioning**
- **smart energy-saving navigation devices**
- **more electric battery charging systems**

5 The tasks of the Governments

To enable the rapid transition to clean, sustainable transportation the infrastructure for the electric mobility must be drastically improved with credit card plug-in stations as shown in Fig. 10. The same has to be accomplished in all private parking areas.

Figure 10: Plug-in parking areas

6 The role of international standards

International ISO, IEC and ITU standards for batteries, capacitors, electric motors, clean electricity generation systems like wind power and hydropower, methods for energy systems analyses, vehicle safety, plugs and sockets, fuel cells, ICT etc. etc. are indispensable for the rational mass production of clean vehicles, and for the smart grid needed for the integral implementation of the clean, sustainable energy age. The international standard for the analysis and comparison of technical energy systems ISO13602-1 allows to choose the most competitive sustainable energy options [5].

The "Global Energy Charter for Sustainable Development" serves as an overall guideline [2].

7 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 further developed at a much faster pace**
- **Air transport must become cleaner, quieter**

Innovation coupled with huge investments and smart government policies can and will fulfil these urgent tasks !

8 Recommendations

- **Accelerate the implementation 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**
- **Install remote metered recharging plugs on all private and public parking lots**
- **Implement the smart electric grid for controlling power demand and supply**
- **Implement clean, renewable energy supply systems at a much faster pace !**

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