

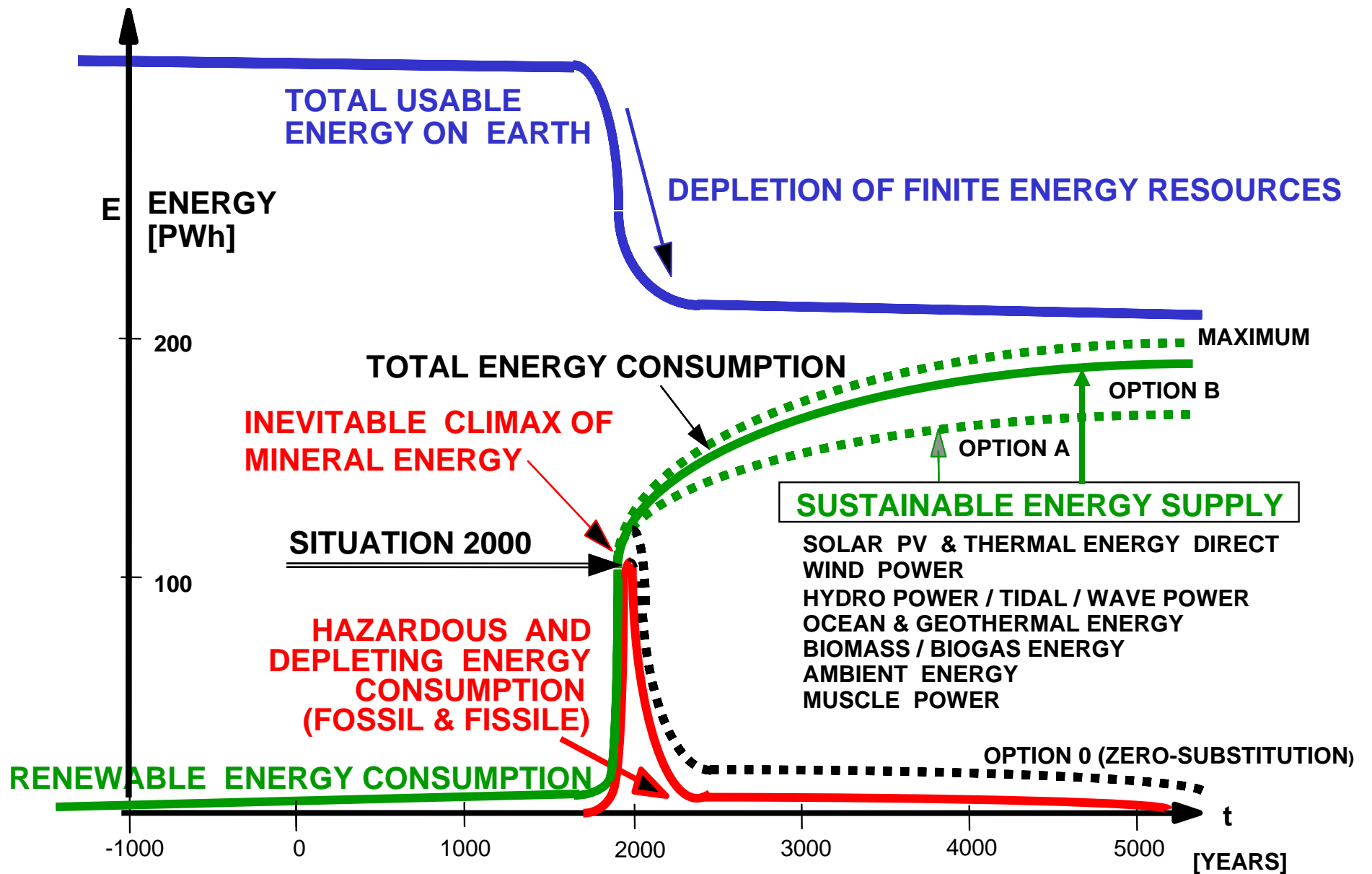
# **Clean Sustainable Energy**

## **Sources, Carriers and Storage**

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**Executive Secretary, International Sustainable Energy Organization ISEO**  
**Chairman of ISO/TC203/WG3 Technical Energy Systems Analyses**  
**President of the International Clean Energy Consortium ICEC**

# Energy Situation

- ❖ Total world energy use ~140 PWh p.a. → 16'000 GW at 8600 h  
> 80 % from finite, unsustainable mineral energy resources
- ❖ 4'000 GW installed electric base load and fluctuating power capacity world-wide (ground solar and wind power production is fluctuating)  
 $\Sigma$  Energy :  $\Sigma$  Electricity = 4 : 1 to 5 : 1 ratio
- ❖ 994 GW USA → 3,30 kW per capita (2010)
- ❖ 860 GW China → 0,66 kW per capita (2010) = world average
- ❖ 160 GW India → 0,16 kW per capita (2010)
- ❖ China plans additional 80 GW power capacity annually
- ❖ World needs minimum 400 GW p.a. more for economic growth, better life styles, electric mobility and replacements of obsolete, unsustainable thermal coal, gas, oil and nuclear power plants
- **All mineral fuels coal, petroleum, gas and Uranium  
must be replaced by clean energy in this century !**



# ENERGY HISTORY & FORECAST

SOURCE : ISEO

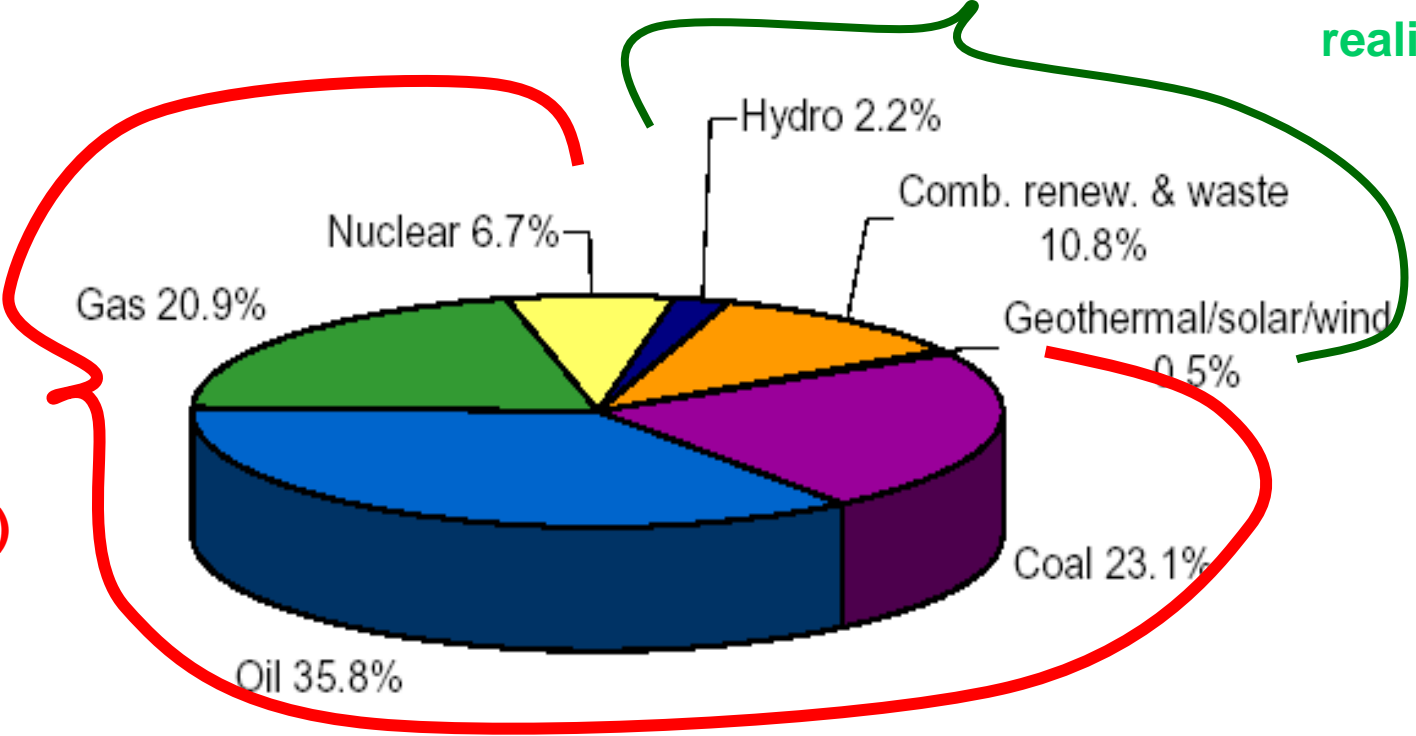


### Share of Total Primary Energy Supply\* in 2002

*World*

**Renewable Energies only 13,5 %  
according to IEA-OECD  
- over 20 % in reality**

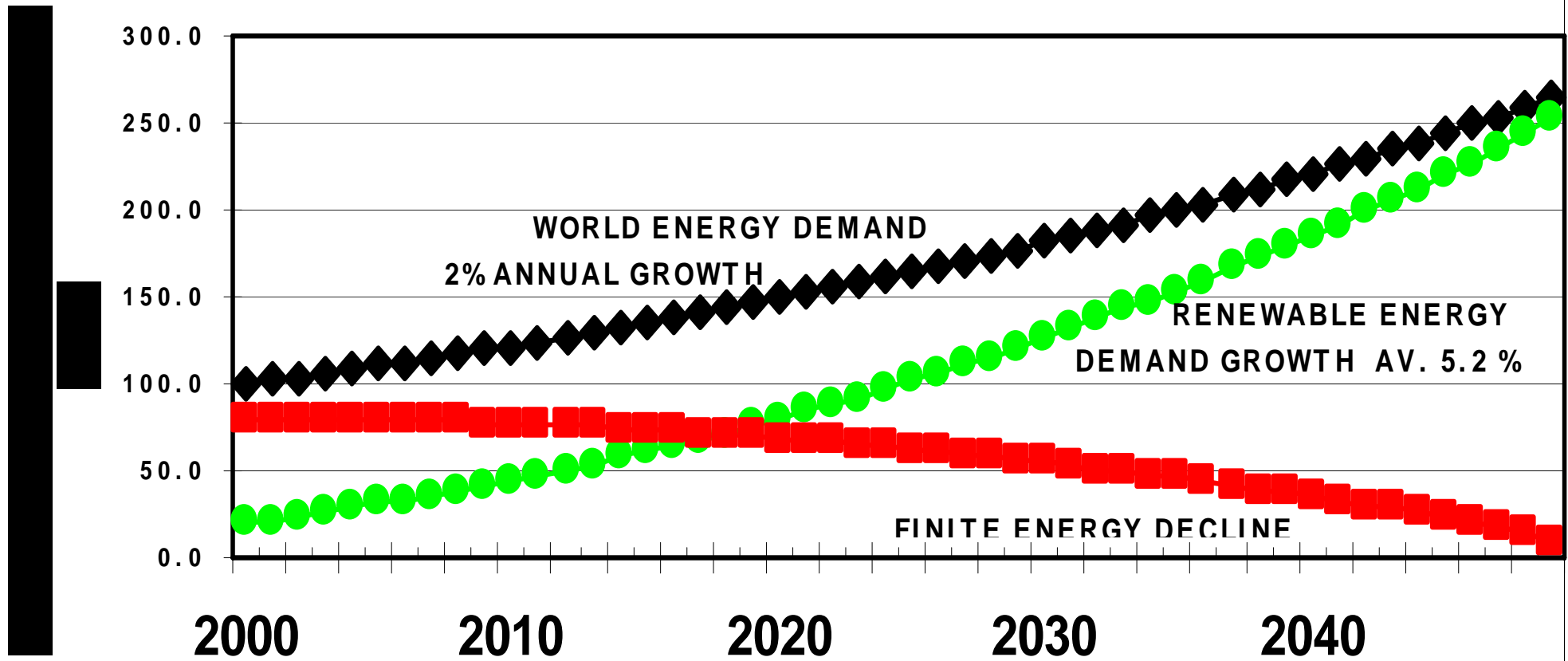
**Mineral  
Energies 86.5 %  
(Combustion  
Pollution, Depletion !)**



**124 PWh**



# WORLD ENERGY SCENARIO 2000 - 2050

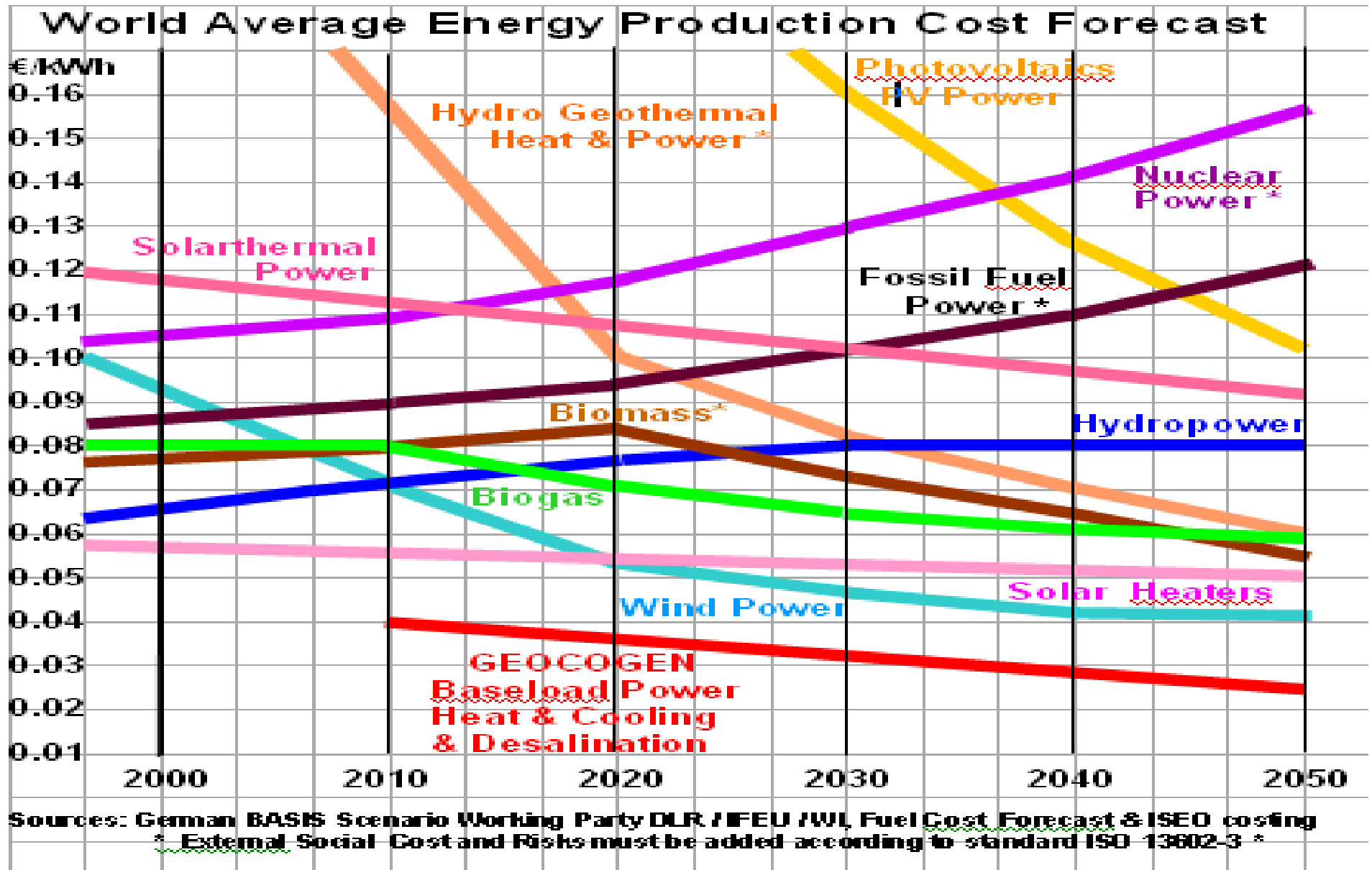


Source for Finite Energy Data: ASPO at [www.peakoil.net](http://www.peakoil.net) & Kyoto Protocol

<u>Energy Option</u>	<u>Immediately Feasible</u>	<u>Theoretical Potential</u>
- Bio energy (competing with food !)	(50)	(80)
- Hydropower	8	15
- Geothermal Electricity Conventional	2	} 400
- <b>Geothermal Energy Hot Dry Rock</b>	<b>80</b>	
- Geothermal Heat from aquifers	4	
- <b>Wind Power</b>	<b>53</b>	<b>160</b>
- <b>Solar Power PV incl. SBSP</b>	<b>60</b>	} 435
- <b>Solar Thermal Power</b>	<b>40</b>	
- Solar Direct Active Heat	20	
- Solar Passive Heat	10	
- Ocean Energy	15	200
- Heat Pumps	10	50
- Muscle Energy	1	10
- Novel Energy Technologies (R&D)	<u>50</u>	<u>200</u>
<b>Total Renewable Energy Potential</b>	<b><u>350 PWh/year</u></b>	<b><u>max. 1550 PWh/year</u></b>
<b>more than twice the present world energy consumption</b>		

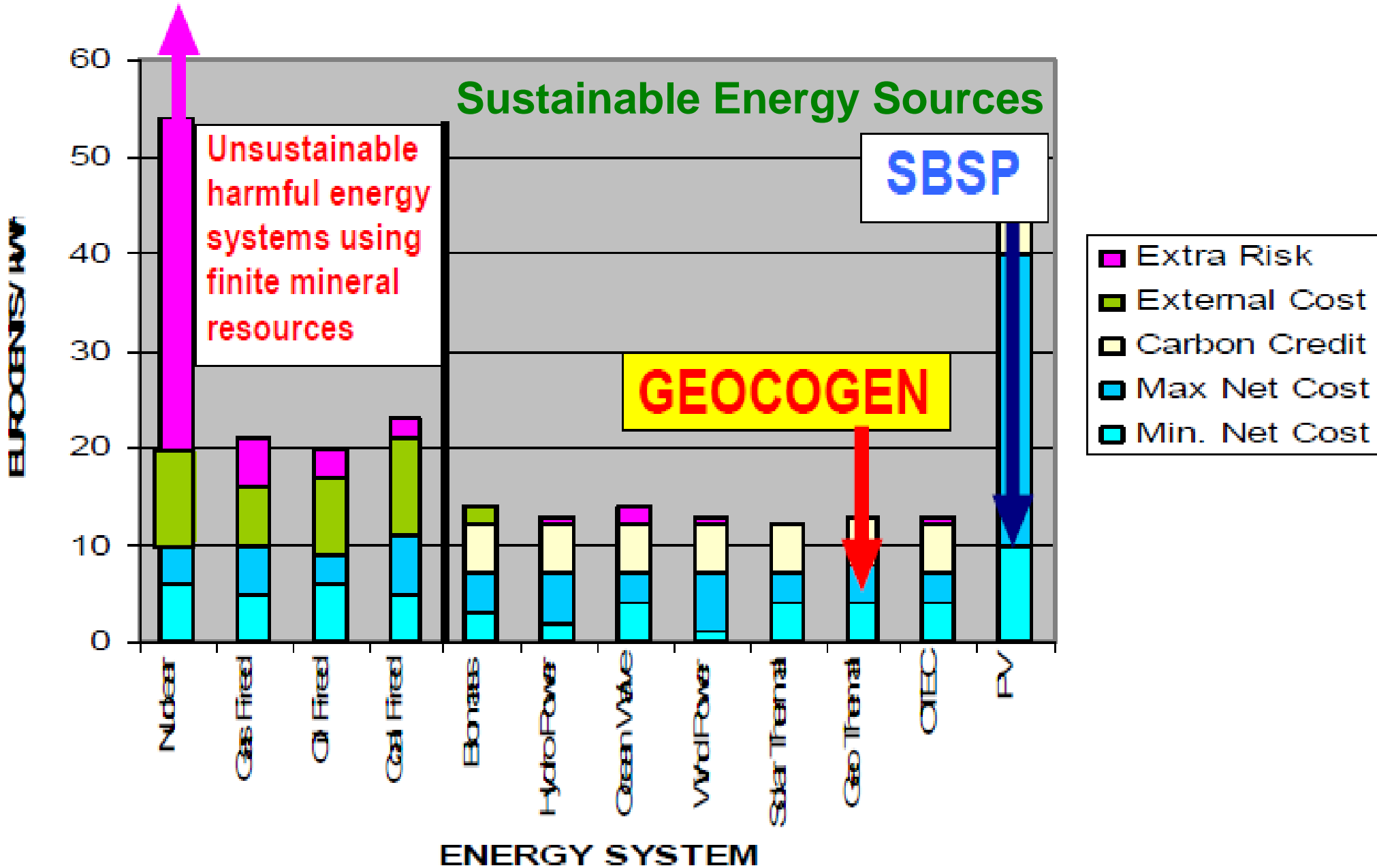
# Factors affecting electricity generation cost

- **Optimal system** type, size, location, taxes
- **Fuel prices** escalation, emission levies, taxes
- **Carbon Credits** € / \$ per saved Ton of CO<sub>2</sub>
- **External Cost** environment, climate and health
- **Risks** of disasters, wars, terror, contamination:  
exposure of power plants to sabotage, tornados, earth quakes or meteorites causing radioactive catastrophes, epidemia, explosions, leaks, spills



# TRUE ENERGY COST

Infinite Risks



# Deep Hot Rock Geothermal Energy

## Borehole systems

- a) Hydraulic fracturing by high pressure with relatively small energy yields  
or
- b) Boreholes to geothermal aquifers in open systems with limited energy



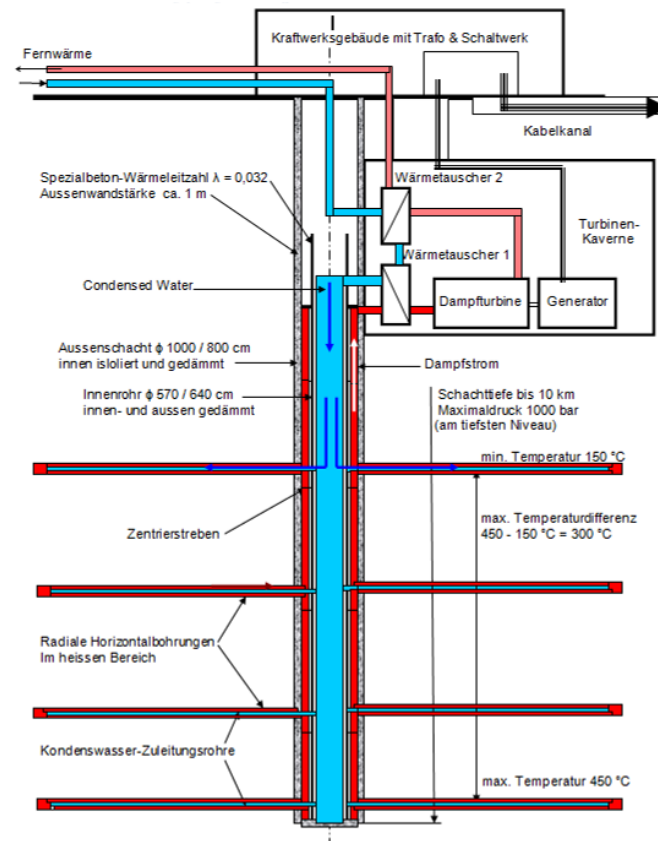
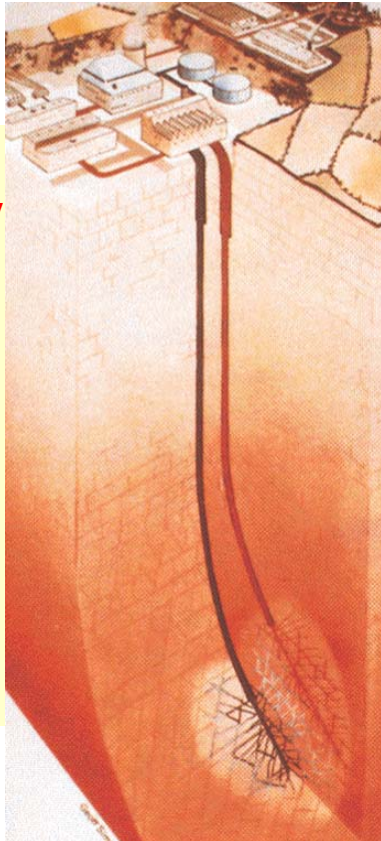
Hot-dry Rock system with safely controlled closed primary water cycle in insulated well and secondary steam turbine cycle with co-generation for district heating, AC, greenhouses, industry

### Disadvantages:

a) Water is finding way of lowest resistance = limited Energy yield

b) Only in hydro geologic strata often far from consumers. Often high energy transport cost. Often limited to heat production only.

Energy cost:  
5-10 €/kWh



### Advantages:

No yields by hazard !  
Super performance (GW).  
No fuels or waste problems.  
Excavated materials re-used.  
Base load power plus heat

Energy cost: 2-4 €/kWh

# Advantages of geothermal deep well energy co-generation **GEOCOGEN**<sup>®</sup> *high-power geothermal energy*

- Produces electricity and heat (suitable also for AirCon)
- Much lower net cost than any other energy source
- Can be built near agglomerations and substations
- Less energy transmission line cost – hence also less transmission losses than other power plants
- Invisible, no air or water pollution and no noise
- Ideal power source for clean electric vehicles
- No radiation risks or other health hazards
- Creates new clean sustainable jobs
- No waste disposal problems !
- Long life !

# Applications

**GEOCOGEN®**

**Electricity**

**Heat**

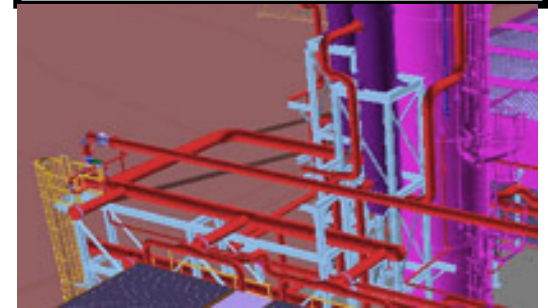
**By-Products Si etc.**

**District Heating**

**Spas**

**Agriculture**

**Process Heat**



# Typical **GEOCOGEN**® or SBSP locations

high-power geothermal energy

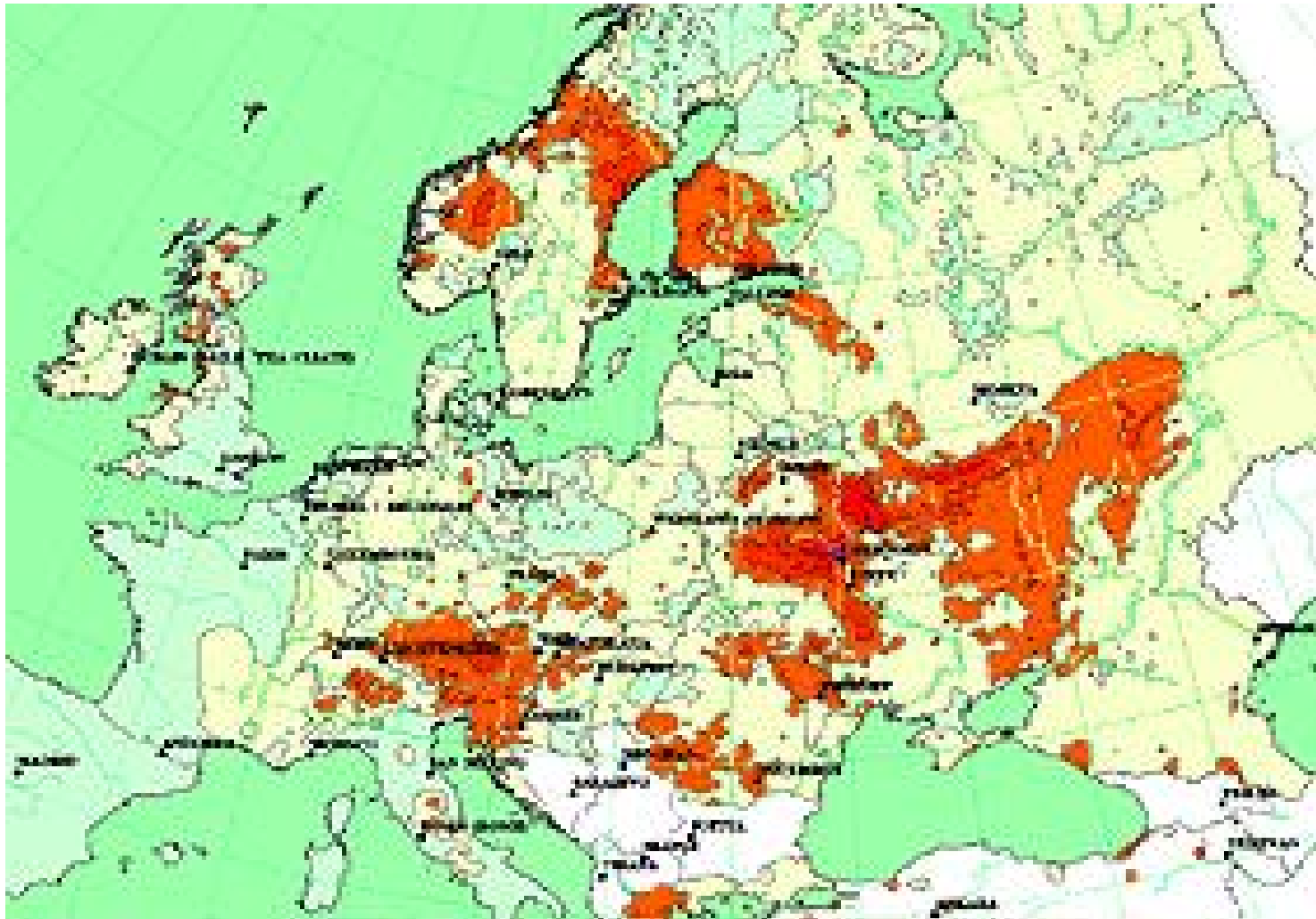
Example NRW  
Substitution of  
Nuclear & Coal



# Finite Nuclear Power (to be replaced)

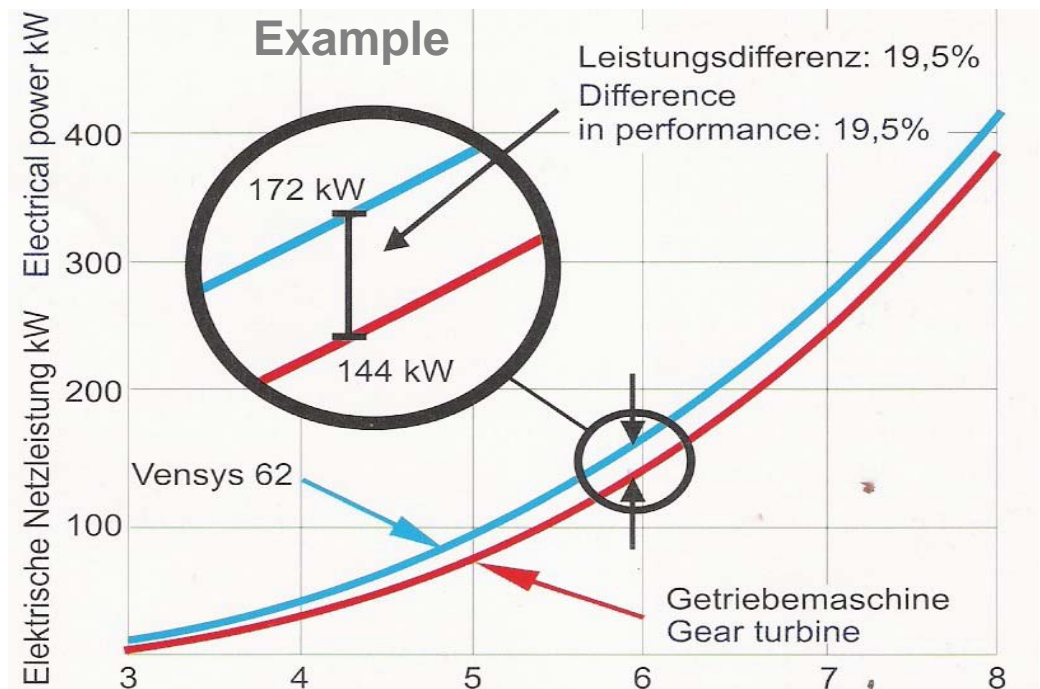


# Radioactive contamination of Europe including Chernobyl fallout.



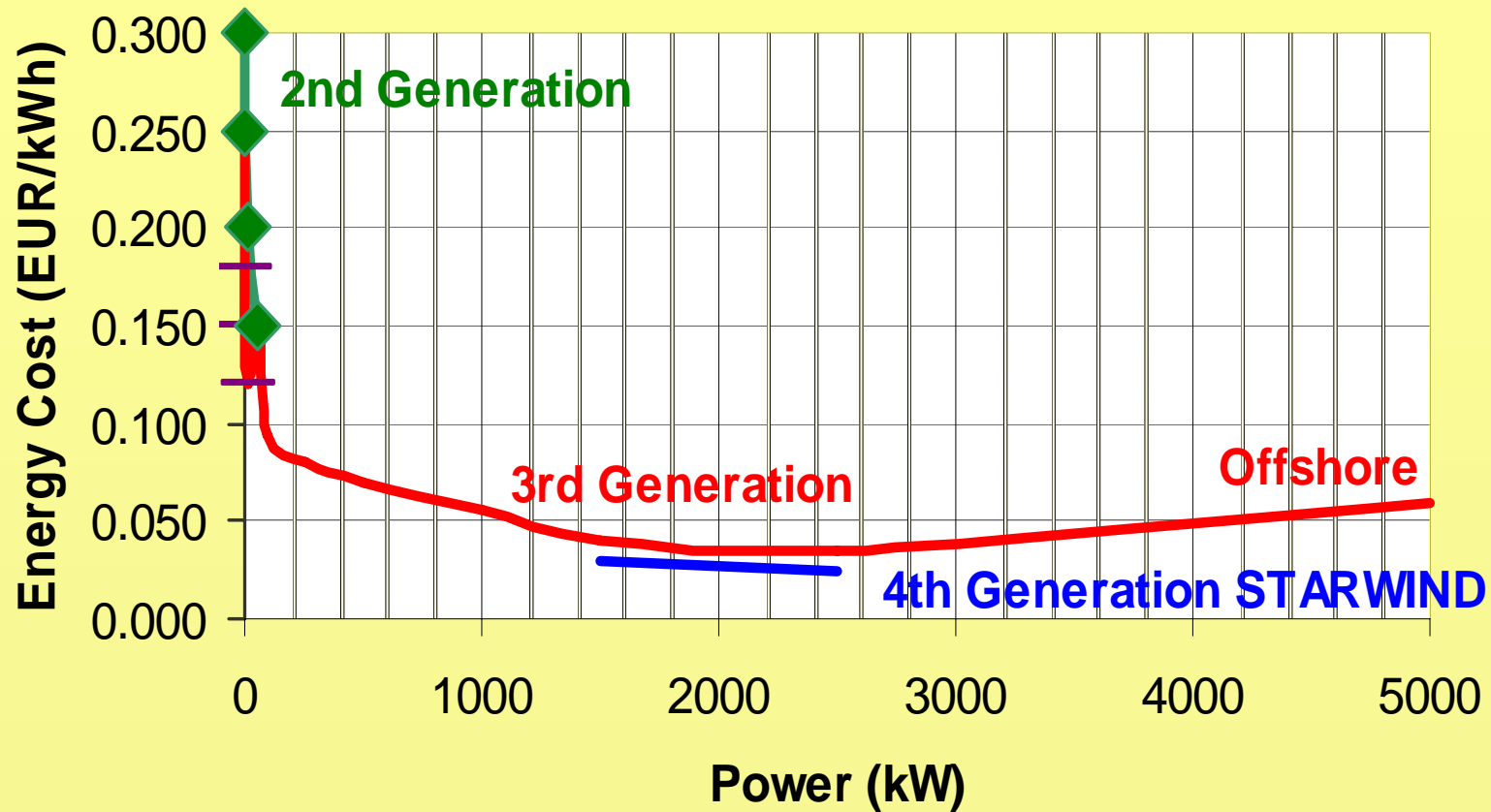
# 4th Generation STARWIND

- Gearless, permanent magnets, pitch controlled
- Advanced concrete tower at much lower cost
- Lower maintenance cost and very long life
- Highest efficiency / less copper and steel

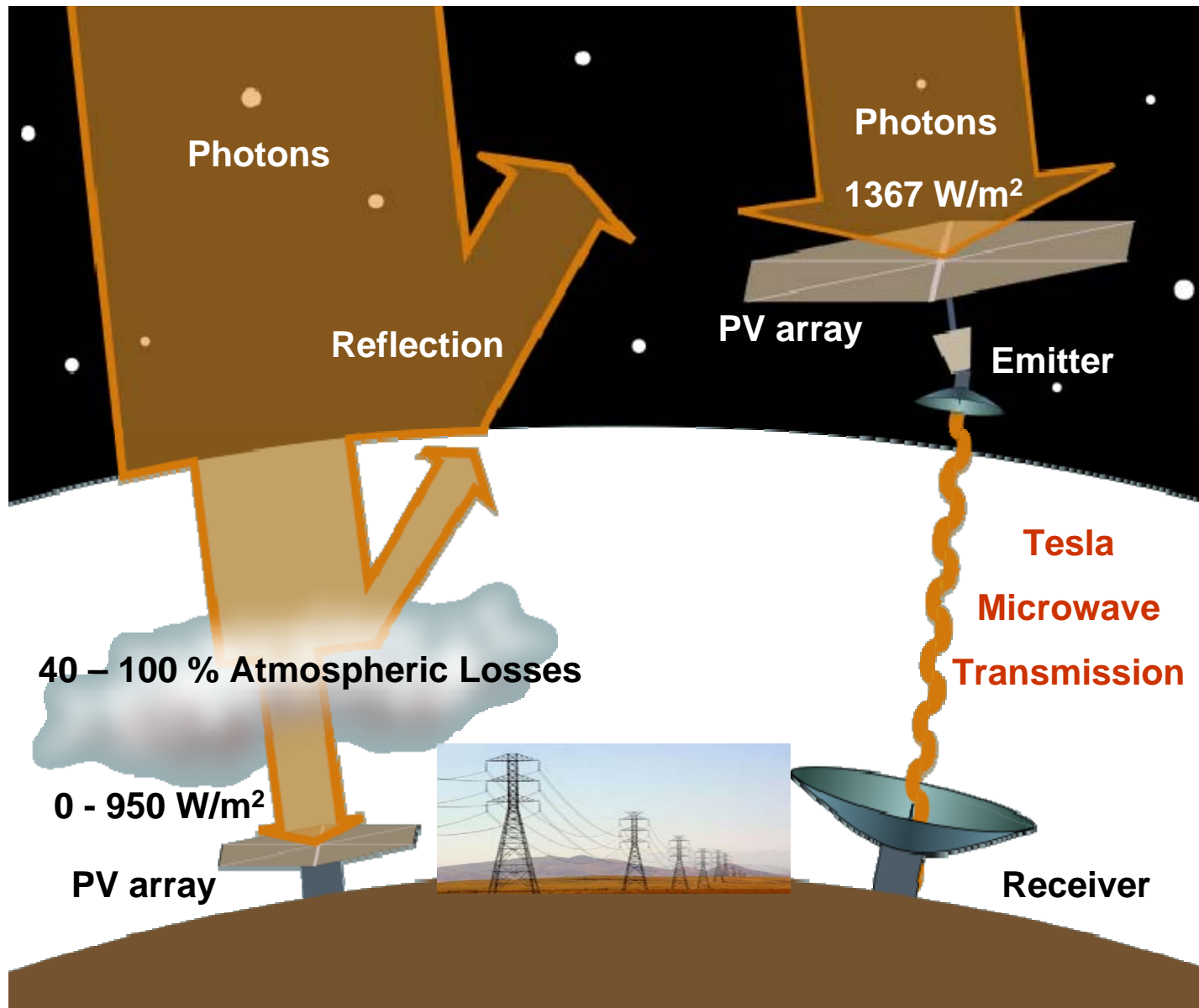


# 4th Generation Wind Power

Wind Power Cost



# Ground PV vs Space PV Power



# Advantages of Space-based Solar Power

- **Generates base load electricity**
- **Higher yield than terrestrial PV systems**
- **Can be stationed anywhere above consumption**
- **Less energy transmission line cost – hence also less transmission losses than other power plants**
- **Invisible, no air or water pollution and no noise**
- **Ideal power source for clean electric vehicles**
- **No radiation risks or other health hazards**
- **Creates lots of new clean sustainable jobs**
- **No waste disposal problems !**
- **Long life**

# **Tools for Clean, Sustainable Energy Implementation**

- **ISO 13602-1 Energy Systems Analyses Standard**
- **Joint ISO-IEC Standardization Committee JTC2**
- **Global Energy Charter for Sustainable Development**
- **International Carbon Credit Mechanisms (CDM, JI)**
- **Polluters pay accounting principle (world-wide)**
- **International Tax Reforms:  
more Taxes on Pollution – less on Productive Income**

## SUSTAINABLE ENERGY STORAGE OPTIONS

to match clean energy supply and demand – UPS, hourly, daily, weekly, seasonally

ENERGY STORAGE MEANS SYSTEMS	ELECTR. STORAGE		HEAT/COLD STORAGE	CHEMICAL (FUELS)	MECHANICAL STORAGE	ORGANIC STORAGE
	base load	peak power				
Electrochemical batteries	X	(X)				
Physical batteries	X	X				
Super capacitors	X	X				
Superconductors	X	X				
Heat or cold storage tanks			X			
Building mass			X			
Water (boilers, ice storage)			X			
Hydrogen, liquefied, compressed, met.hydr				X		
Hydrogen peroxide				X		
Methanol (synthetic)				X		
Potential energy					X	
Kinetic energy					X	
Hydraulic storage*					X	
Mechanical springs					X	
Air, steam, gas compressed					X	
Food for & in bodies						X
Biomass ((solid, liquid, gas)*				X		X
Metals (aluminium, zinc, magnesium etc.)				X		
Molten Salt			X			

\* Hydropower is a prime energy source but when pumped up also an energy storage system

\*\* Biomass and food are often considered as prime energy sources but are stored solar energy

# Carriers of Sustainable Energy

- Electricity > omnipresent & unlimited applications
- Microwaves > for energy transmission in space
- Water & Steam > for limited pipe distances
- Hydrogen > in pipelines & mobile storage devices
- Other Gases > in pipelines & underground conducts
- Methanol > universal synthetic liquid fuel
- Peroxide > in special tanks and pipes
- Living Beings > the oldest bio energy carriers (food)

# Specific International Standards on Energy, Environment and Quality



- ISO International System of Units (SI System)
- ISO 9000 series for Quality Management
- ISO 14000 series for Environmental Management
- ISO 13600 series for Technical Energy Systems (TC203)
- ISO Standards for Solar Thermal Energy
- ISO Standards for Hydrogen Technologies (TC197)
- ISO Standards for Internal Combustion Engines
- ISO Standards for Thermal Insulation
- ISO Standards for Air and Water Quality
- ISO Standards for Soil Quality
- ISO Standards for Ship Safety
- ISO Standards for Gas Cylinders
- ISO Standards for Cryogenic Vessels
- ISO Standards for Architecture



- IEC Standards for Photovoltaics (PV Systems)
- IEC Standards for Fuel Cells
- IEC Standards for Hydropower
- IEC Standards for Wind Power Generators
- IEC Standards for Electric Vehicles and Batteries
- IEC Electric Safety & Environment Protection
- IEC Electric Installations in Buildings

# Tasks of new joint ISO-IEC committee JTC2

**Energy is the largest economic sector, one of the key activities of ISO and the main reason for IEC.**

**Sustainable energy** became the generic term for the entire scope from renewable energies, clean energy carriers, energy storage, energy efficiency and clean mobility supported by

- **The United Nations Commission for Sustainable Development CSD and the UN-ECE commission for Sustainable Energy**
  - **The UN Environmental Program UNEP with the World Meteorological Organization WMO and their joint IPCC for the framework convention on climate change UNFCCC and the World Health Organization WHO**
    - **The World Conservation Union IUCN, the International Sustainable Energy Organization ISEO**
      - **The specialized NGOs on energy efficiency, renewable energy and energy carriers**

Due to the global importance of energy and the key role it is playing in both IEC and ISO a joint ISO/IEC effort is needed to resolve interdisciplinary problems in international standardization, which are becoming more and more important also for the UN organizations WTO, UNDP, UNIDO, UNCTAD, UNITAR and the World Bank Group.

Important subjects in both standardization domains are the clean energy carriers like **Hydrogen** which is split into ISO/TC197 & IEC/TC105, **Metrology** based on the SI system of ISO/TC12 & IEC/TC25, **Solar energy** also in the case of hybrid collectors and **Space PV**, **Geothermal cogeneration** with its steam turbines and generators, **Bio energy** also producing electricity, **Wind turbines** by IEC containing gears of ISO, electromechanical **Ocean energy** and the **electric vehicles** handled by ISO/TC22 & IEC/TC69. Some of these emerging technologies do not yet have ISO or IEC standards because of their interdisciplinary complexity with their mechanical, civil engineering, chemical process and electrical subsystems. They all need urgently a joint interdisciplinary standardization effort to enable the industry to produce such systems due to the rapid depletion of finite mineral energy resources with rising ecological and climatic concerns about global warming.

Hence a fully fledged **JTC 2** on energy is needed under the title **Sustainable energy technologies** with

- SC1 Terminology (replacing the JPC committee on energy efficiency and renewable energy)**
- SC2 Technical energy systems (ISO/TC203 to be harmonized with other TCs and SC1)**
- SC3 Energy statistics (ISO/DIS 13602-3 to be harmonized with SC1, UN, EU and IEA statistics)**
- SC4 Energy carriers other than electricity (hydrogen at ISO/TC197, peroxide, methanol etc.)**
- SC5 Geothermal energy (not yet existing in ISO or IEC - cooperation with CEN needed)**
- SC6 Bioenergy (not yet existing in ISO or IEC - only in CEN for some solid biomass)**
- SC7 Space energy (Space vehicles ISO/TC 20 & Photovoltaics IEC/TC 82)**
- SC8 Marine energy with its mechanical and electric subsystems in cooperation with CEN**
- SC9 Electric road vehicles and tractors (ISO/TC22, ISO/TC23, IEC/TC21, IEC/TC69, IEC/TC105)**

# Electric Mobility and Smart Grids

- > 90 % instead of < 20 % Energy Efficiency



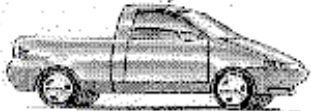
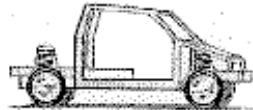
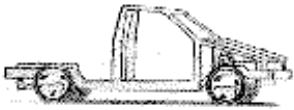
Electric Drives vs Combustion Engines

- Zero Pollution and Less Noise
- Cheaper Energy Logistics by the Grid
- Collective Peak Energy Storage Capability
- Perfect Energy Management
- Less Maintenance Cost
- Much Longer Life

# Proposed Electric Vehicle Platforms

105 Inch Wheelbase (2667mm)

90 Inch Wheelbase (2286mm)



Mid-Sized Pick-Up



Mini-Van



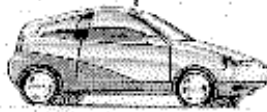
2-Door Hatchback



2-Door Wagon

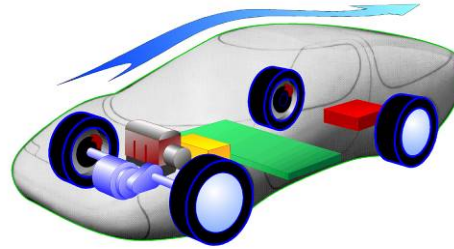


4-Door Sedan



2-Passenger Coupe

# EV Concept



# Solar Car



The Toyota electric RAV4



0 to 60 mph  
1/4 mile  
Range at 40mpk

4.1 seconds  
13.2 seconds  
100 miles

200 horsepower  
30 kW on board charger  
Powerful and slip regeneration

AC Propulsion's TZero



The electric GWiz



The Citroen electric Berlingo Van

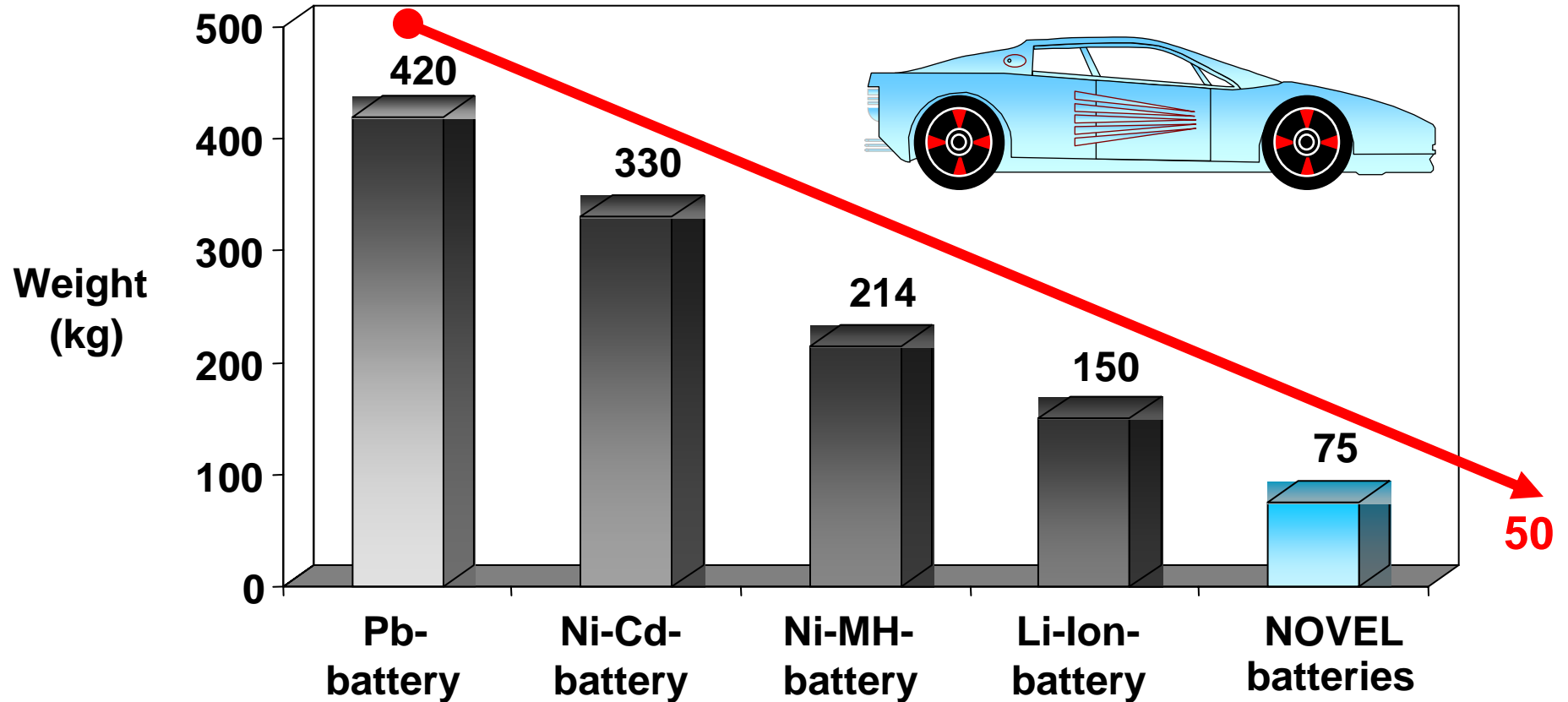


# Battery Charging



# Future Electric Cars - Long Range & Long Life

## Comparison of 15 kWh Batteries by Weight



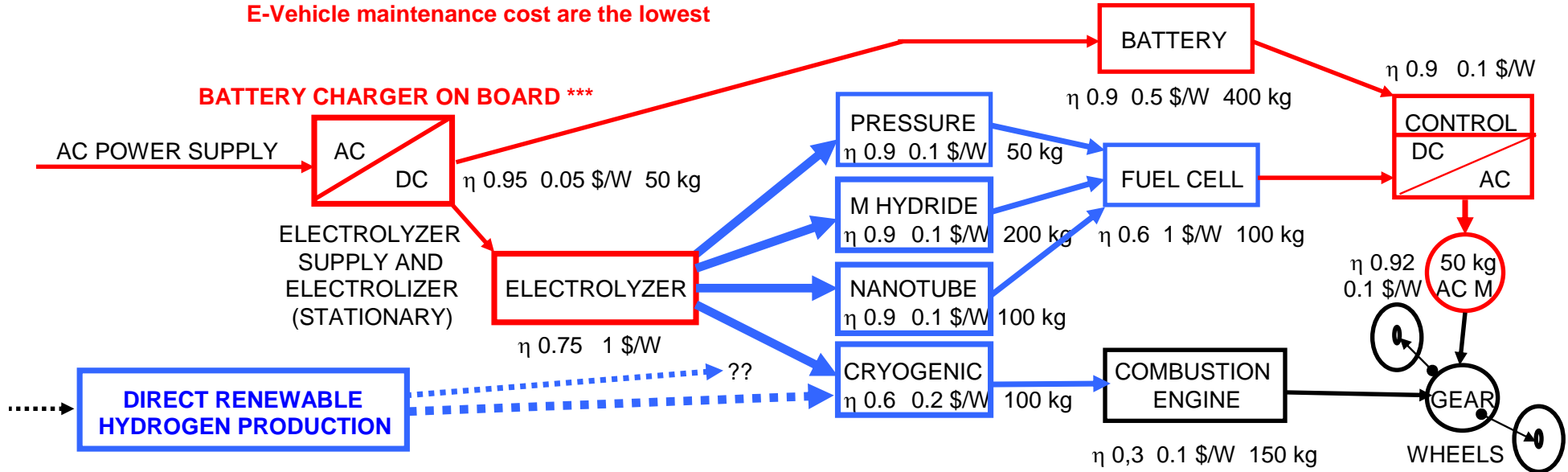
# COMPARISON OF VEHICLE DRIVE TRAIN COST (40 kW; 240'000 km over 6 years)

Drive Options Criteria	Battery NOVEL	Hydrogen Fuel Cell	Hydrogen * Combustion	Gasoline Combust.
	Li-ion or ZEBRA	Amb. Temp. Storage	Cryogenic Storage **	Gasoline Tank
Relative Drive Investment \$/W	<b>0,75</b>	2,35	1,35	< 0.20
Energy Cost \$/km	<b>0,03</b>	0,07	0,16	0,15
Relative Weight kg	<b>350</b>	250	250	200
Average Range km	<b>300</b>	400	200	400
Energy Efficiency %	<b>0,75</b>	0,32	0,13	0,13
E + Cap. Cost \$/km (Total Vehicle Cost)	<b>&lt; 0,20</b>	<b>0,56</b>	<b>0,46</b>	<b>0,28</b>

**Remarks**  
 \* a standard 4-cylinder combustion engine is used  
 \*\* gasoline version: 1\$/Liter, 10 Liters per 100 km  
 \*\*\* AC/DC charger on board the electric car for easier battery charging  
 \*\*\*\* cryogenic H<sub>2</sub> storage boil off loss depending on parking duration  
the same gear box assumed for all options  
 including energy management, storage and power train

> energy supply at 0,1 \$/kWh or H<sub>2</sub> at 1 \$ per Litre gasoline equivalent  
 > 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  
 > at 6 % interest over 3 years and 240'000 km usage incl. service & spares

**E-Vehicle maintenance cost are the lowest**



# The Merits of Bicycles & Electric 2 & 3 Wheelers for Good Health and Congested Areas

## Taiwan Mail Service



## Netherlands



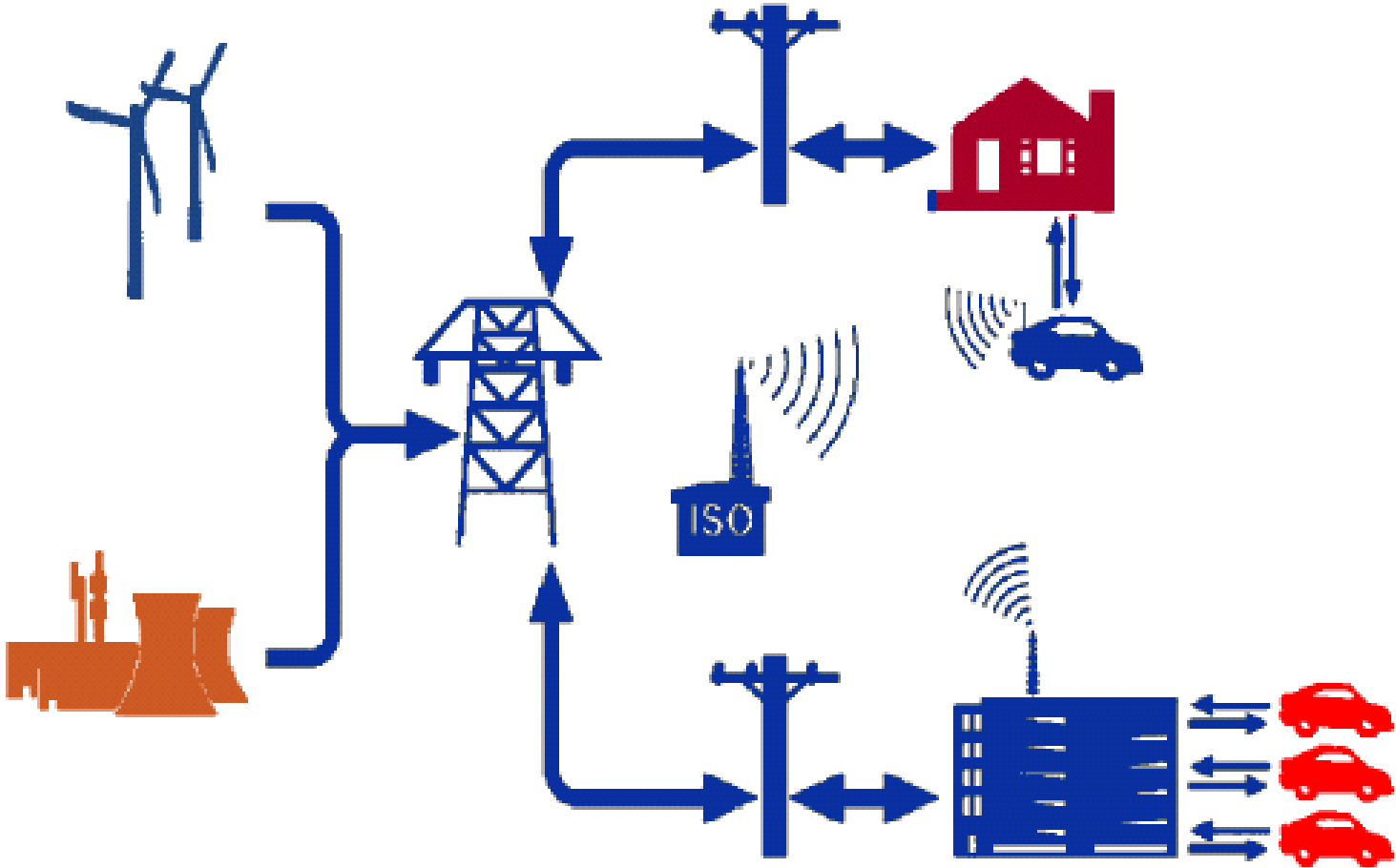
## Healthy Sisters



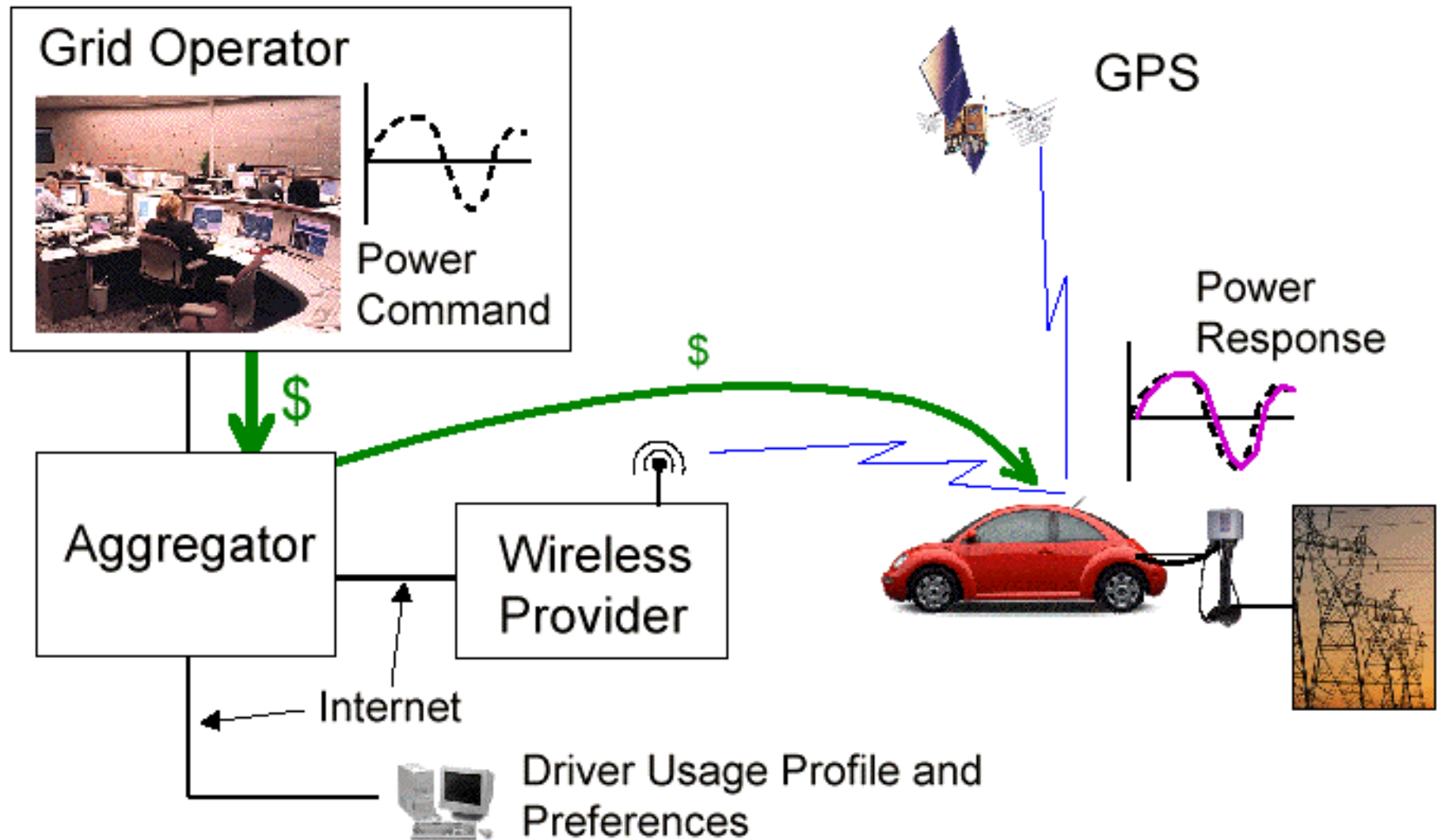
## China

# The link between electric vehicles and power

## The Smart Grid



# Smart Power Grid Practicalities



# International Sustainable Energy Organisation for Renewable Energy and Energy Efficiency

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**Preparatory Commission** e-mail: info@uniseo.org - http://www.uniseo.org



[www.uniseo.org](http://www.uniseo.org)

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