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A global electricity scenario

how electric vehicles and battery storage will change the global electricity market in the 21st century

summary

The requirement of understanding the role of electricity production and storage for the design of future-ready homes has led TS Prototype-Creation to study the integration of Electric Vehicles into a buildings energy concept. This was in 2013. Six years later the predictions made with the model on the production of EVs turned out to be right.

Based on that study a triple Meta study was undertaken in 2019 considering all types of electricity production, storage and all mobility types. The study draws a long line enabling Architects of buildings, cities and infrastructure to plan more informed, future-ready and without overlooking important factors.
To ensure this the numeric model is based on a complete checklist of the author's assumptions concerning all electricity generation- and storage types and all types of mobility. Assumptions might play the greatest role in a model intending to describe a complex global development, which is dependent on technological mega trends, performance data of specific products, but also consumer behaviour in different countries.

The study was required as an indispensable tool for economic understanding, as a due-diligence project for TSPC and because all available studies are only specialized and not able to predict the multi-disciplinary progress of the economy. The study is undisclosed, intellectual property of TSPC.

The study shows on graphs 1-4 page 3 and 6 that in 2028 all electricity produced from fossil power plants could be stored in the batteries of EVs alone. Taking residential and municipal battery storage plants into account the date for storage of Global electricity production could be sooner.

The graph on page 7 shows a scenario for the next 100 years like it has never been predicted.

This publication

is the result of in-house studies
from 2013 to 2019 by
structural engineering bureau
TS Prototype-Creation
as part of the
research and development of
self-sufficient buildings

The study

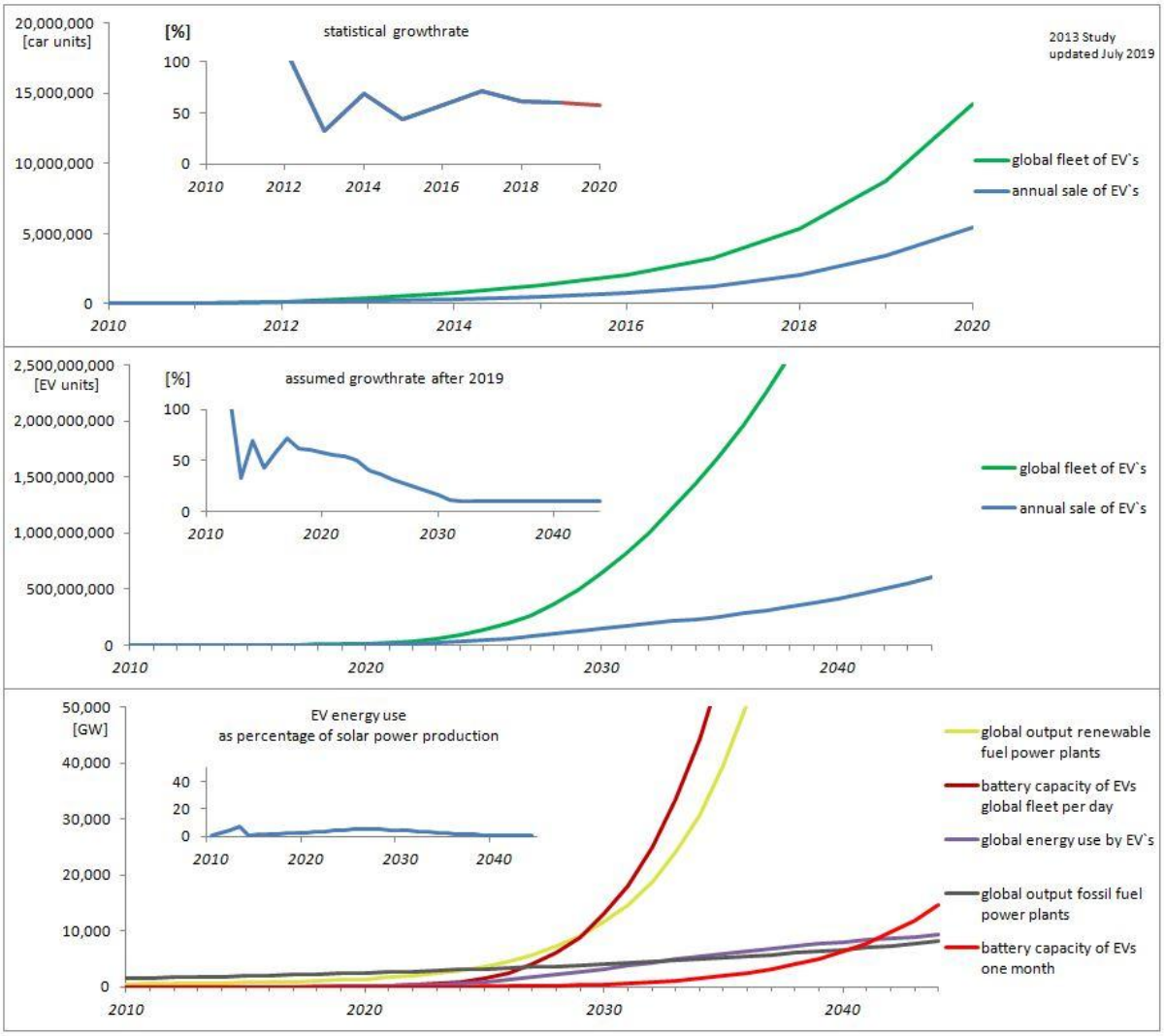
is based on statistics for EVs,
a complete list of assumptions
and a numeric model taking
all mobility & energy sources
into account

The author

Nicol-André Berdellé,
a structural engineer
specialized in
timber engineering and construction physics,
works on
architectural prototype development
and resource management
since 1998

Statistics for Electric vehicles and electricity production

data obtained from:
the Energy Information Administration,
the International Energy Agency "Key World Energy Statistics" 2013, 2017,
the Global Wind Energy Council,
the European Photvoltaic Industry Association,
the US Department of Energy "Renewabale Energy Data Book 2012,
BP "Statistical Review" 2014, "World Energy" 2015,"
"Global Renewable Energy Development",
the World Wind Energy Association "Wind Energy Report" 2012,
Global Windstatistics 2013,
Global Wind Energy Council "Global Wind Report Annual Market Update" 2013,
the World Nuclear Association,
the European Photovoltaic Industry Association "Global Market outlook" 2014,
Irena CSP Cost Analysis Series 2012,
REN21 Renewables "Global Status Report" 2019
Tesla Motors
International Organization of Motor Vehicle Manufacturers OICA



graphs 1-3

Excerpt from the technical documentation in the numeric model

The conservative growth assumptions are own estimates partly different from the estimates of other sources. Reasons for the conservative growth-assumptions include the growth of public transportation, car sharing/urbanization, e-bike use and home office vs. commuter-culture.

Statistics include annual growth rates of: 26% wind, 30% solar, 9% bio, 3.1% hydro, 2.6% geo and 5% for fossil power plants - all numbers as generated power (not installed capacity)
Furthermore an average of 80 kWh for an individual EV battery (in 2013) and an annual increase in the capacity of 7%. Life expectancy of the cars is 15 years. Energy use with a daily drive of 100km and 70mph (the energy consumption according to the Tesla graph of the Model S is only half of that for speeds under30mph.

Solar PV production = 75% of capacity based on own calculation in the "Facilitator Project". The annual growth rate of 30% is below the current growth rate but above conservative estimates like in the "Global market outlook for photovoltaics" of the EPIA.

Wind power 21% of capacity based on own calculation with Ren21 2019 and compared with statistics from the EIA from 2008 to 2012.

Hydro power 38% of capacity based on own calculation with IEA 2017, Ren21 2019 and compared with BP Statistical Review 2014.

Biomass power 70% of capacity based on own estimate - based on Ren21 2019 and BP Statistical Review 2014.

Geothermal power 70% of capacity based on own calculation with Ren21 2019, BP 2014 and compared with Renewable Energy Focus

not considered fully in the model concerning EVs

1#
EVs are 3x more energy efficient than combustion engines (2013):
"Converting the chemical energy to free electrons (electrical energy) can be greater than 90% efficient – some energy is lost to heat in cells and other battery pack components such as current conductors and fuses. The remaining components of the Tesla powertrain – the drive inverter and motor – are also extremely efficient. Overall, drive efficiency of the Tesla Roadster is 88% - almost three times more efficient than an internal combustion powered vehicle."
This only applies if the electrical energy is gained with photovoltaic. If it is generated in central power plants with fossil fuels the efficiency is only 50% better, because the conversion losses in power-plants are greater than that of the oil/gas providing industry...
It is realistic to combine the growth of power-production with photovoltaics with EVs because both are financed by private owners mostly and they are linked because the batteries are required for residential photovoltaics anyway

2#
EVs require much less primary energy (except their battery):
They require no infrastructure like gas-stations, gas-trucks, oil-pipelines, or oil-rigs

3#
EV batteries require lots of grey energy in their production:

The production of the Li-ion batteries is resource intensive. Only new batteries, or less heavy EV`s would make them comparable to combustion engine car

4#
EVs can act as co-generation units for homes without photovoltaics and or central heating:
They are a stand-alone, or island solution. If the car charges in the city, it can provide for a home in the outskirts. This can be a great (temporary) solution in many cases. Although heating a home would require stronger batteries, smaller, or smarter homes

5#
The more super-fast recharging stations are available (at traffic lights) the less batteries EVs need. The EV revolution could be based on gravity-energy-storage and not on batteries.

Total Primary Energy Supply

(global annual primary energy consumption for the production of all power and products made from energy sources like plastics from oil)

One third of TPES is used for transportation and not electricity generation. 75% of that is used for road transport = 25% of total

Part of the model is the Energy Use for power, because of increasing quality of living - lifestyle changes, is a Megatrend - TPES will always rise.
Also Energy Use for products, because of increasing quality of living, just a trend because more products will be made from chemicals gained from the ambient air in the future (atmospheric mining) and recycled, repaired, shrifted.

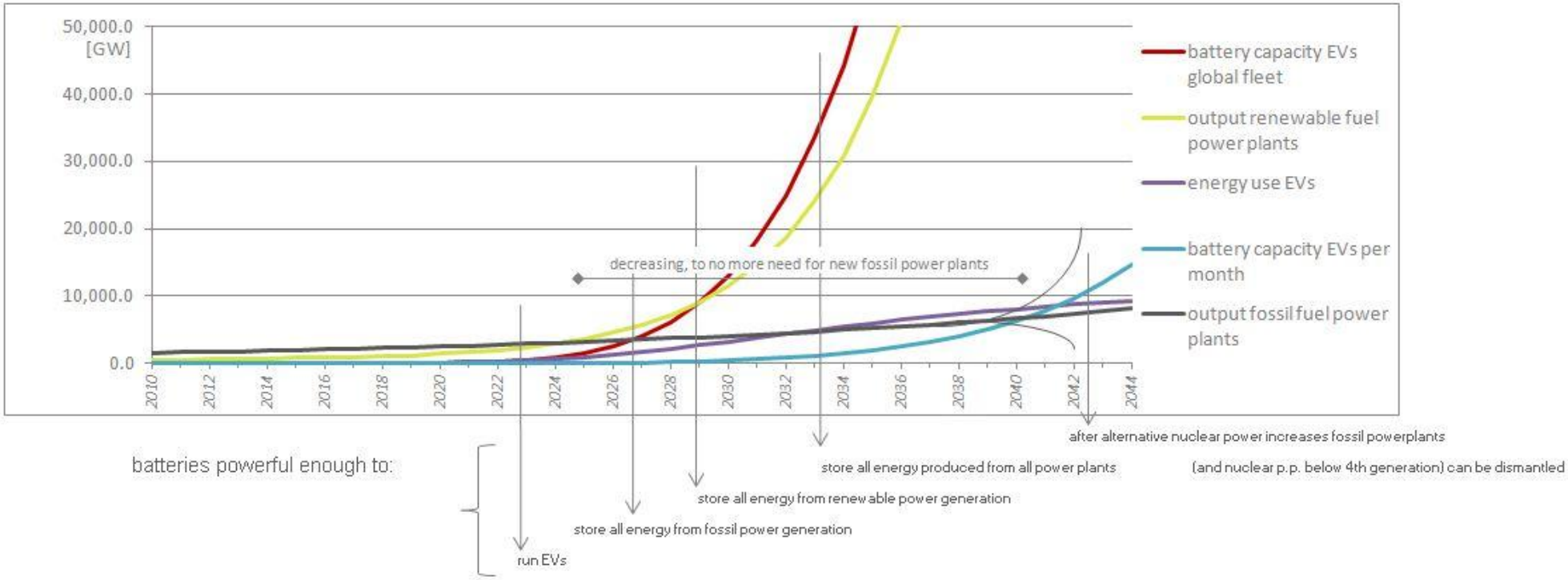
not considered concerning TPES

Energy Efficiency	"Energy Efficiency is the best Energy source" Megatrend because of heat barrier problem
Energy Substitution	for example warm water provision from solar thermal energy Megatrend - from fossil to solar to nuclear
Energy Savings	for example because of lifestyle changes current trend, more energy per person will be used in the future

A scientist's assumptions are important for deciding which technologies, processes, or practices become part of a (numeric) model. In this case the assumptions did not receive a numeric value and are not part of the analysis of the statistics seen on graph. The scope of assumptions would not have allowed for a reasonable weighing.
Notable there are embedded assumption by developers, investors and advisors in each technology.

The author's assumptions are based on the study of electric, thermal, chemical, biological, gravitational and nuclear storage for over 15 years (accumulator, compensators, water, salt, biomass, hydro, uranium, thorium fuel rods, hydrogen/fuel cells).
What more meaningful for architectural infrastructure can there be than solid state batteries, or compact nuclear fusion reactors ? Any type of Architecture is building the future and architecture must be future ready for the key-technologies of the 21the century, being available any time now.

Global Electricity Scenario changing by storage (in electric vehicles, EVs)



in 2028 all electricity produced from fossil power plants can be stored in the batteries of EVs alone

taking residential and municipal battery storage plants into account the date for storage of Global electricity production could be sooner

electricity is so important that it can be assumed that all electricity produced will always be consumed

but there will also never be a time when fossil power plants will useless

this global electricity scenario is mainly based on EVs and does not take others factors into account that might play a big role after 2040

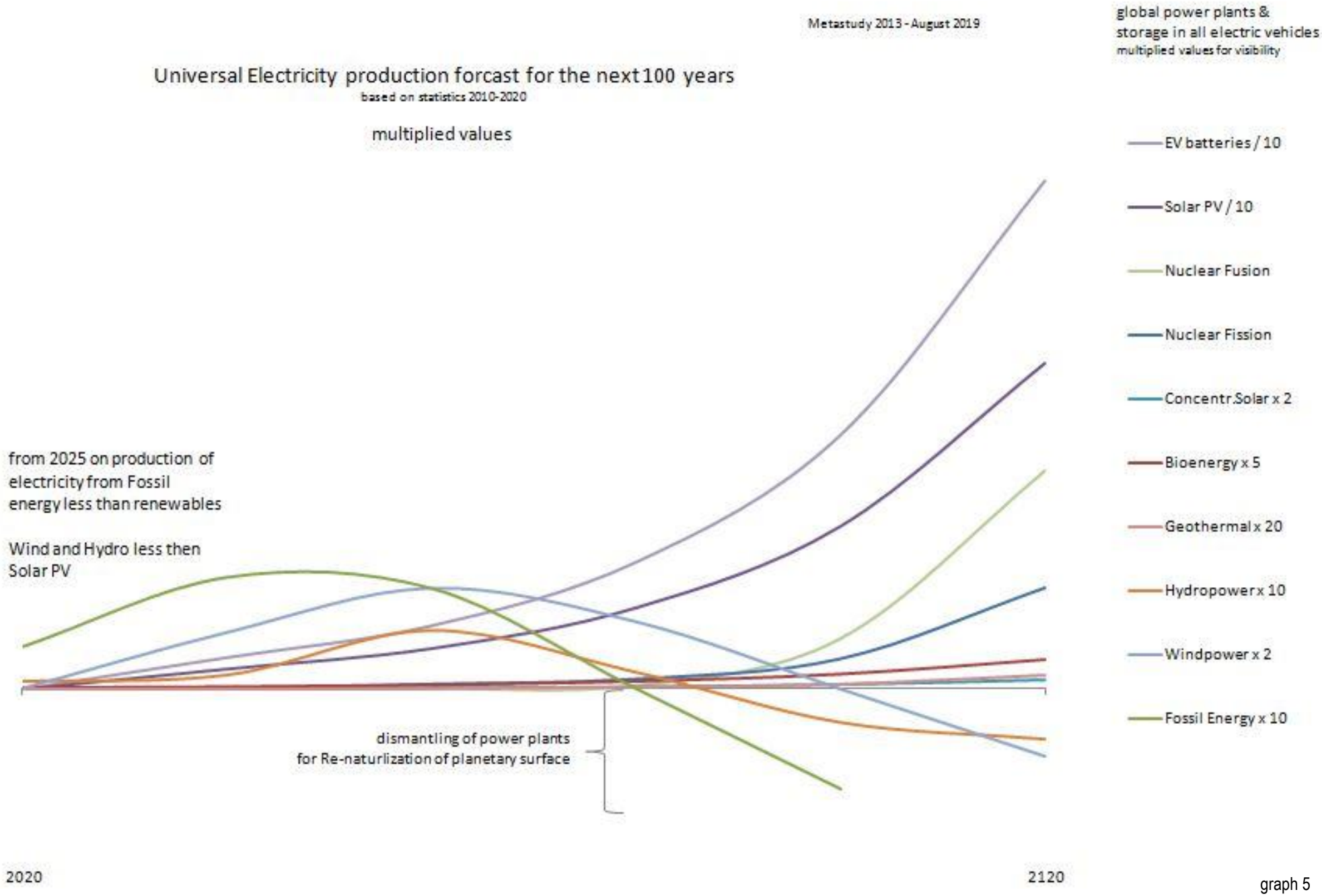
the use of electricity to generate rocket fuel is one future factor, although it is already being done

the use of electricity in aviation and for construction machines will be a factor

virtual realities keeping humans from using any vehicle because they spend their free time and work in VR

energy efficiency is not properly included yet

graph 4


Metastudy 2013 - August 2019
Universal Electricity production forcast for the next 100 years
based on statistics 2010-2020
multiplied values
global power plants & storage in all electric vehicles
multiplied values for visibility
EV batteries / 10
Solar PV / 10
Nuclear Fusion
Nuclear Fission
Concentr.Solar x 2
Bioenergy x 5
Geothermal x 20
Hydropower x 10
Windpower x 2
Fossil Energy x 10
from 2025 on production of electricity from Fossil energy less than renewables
Wind and Hydro less then Solar PV
dismantling of power plants for Re-naturlization of planetary surface
2020
2120

graph 5

Excerpt from the checklist of assumptions

This TSPC study differs significantly from other studies because the future of EVs is strongly dependent on assumptions. These assumptions go much further than the "List of Indicators" like in Fraunhofers publication "Energiespeicher-Monitoring" 2018. The list includes informed assumptions about mobility, the industry, energy generation and storage and resources.

Nuclear assumptions

assumption	Small Modular Reactors (nuclear) will be as small as container-size battery storage soon
reason	50 SMRs are being built right now, 150 different designs in progress, Bill Gates is main advocate
reason	SMRs are ultimate batteries, even better because their initial charge can last for decades
reason	future ready as they work anywhere, on the bottom of the sea as well as in space
consequence	everybody will use SMRs as soon as they are available in shipping containers
consequence	Ships will be electric, but have no main batteries (for own operation)
consequence	Trains and trucks might become electric
consequence	no municipal and probably no residential electricity storage anymore
consequence	another reason for no more centralized power plants
assumption	SMRs with nuclear waste will be produced
reason	need to deal with nuclear waste, unlimited energy supply in western countries
consequence	unlimited energy, everything about Evs gets faster and cheaper for everyone
assumption	Compact Nuclear Fusion reactors will be produced
reason	30 operational FRs, 2 GW reactors under construction
reason	the ultimate energy source with advantages only, many companies successfully working on it
reason	CFRs are ultimate batteries, even better because their initial charge can last for decades
reason	future ready as they work anywhere, on the bottom of the sea as well as in space
reason	completely safe, even against sabotage, or terroristic attacks (unlike fission SMRs)
reason	they just need water, not even dependent on nuclear waste or anything else on the planet
consequence	unlimited energy, everything about Evs gets faster and cheaper for everyone

EV minor assumptions

assumption	people will travel in groups and slow in the future
reason	they want the human experience
consequence	slower and larger vehicles which mean that nuclear propulsion is an option
assumption	there might be no more business travel or no distinction between business and leisure travel
reason	business is more efficient over the internet and virtual reality
consequence	slower and larger vehicles…
assumption	there will be flying EVs from 300km/h up to the sound barrier like passenger planes
reason	for the same reasons we do not just have helicopters, but also passenger planes
consequence	the airspace will have to be managed for these vehicles above the 150m proposed

Energy sources assumptions

assumptions	Total Primary Energy Supply - Energy Efficiency, Saving, Substitution, Virtual Energy and Consumption
assumption	windpower will lose in the race with other energy sources
reasons	wind turbines are hideous in the landscape, impair wildlife and traffic and yield less energy than nuclear power
reason	windpower is not future ready as it does not work in space
assumption	hydropower will loose in the race with other energy sources
reasons	hydroelectric dams impair wildlife, kill rivers and estuaries, these problems might be solved though
assumption	hydroelectric dams will remain operational for a while
reasons	they are costly to unbuilt and have advantages for tourism, fishing etc.
reasons	they cause erosion and contamination of agricultural areas with salts
reason	hydropower is not future ready as it does not work in space
assumption	bioenergy will continue to grow
reasons	human waste must be treated and the biogas, which stinks, can be used for electricity production
assumption	geothermal will grow slowly
reasons	too difficult, insecure, dangerous and not compatible
reasons	appropriate energy source in polar regions
assumption	wave power will stagnate because hideous and not profitable enough
assumption	all less profitable, or beneficial energy sources will stay in the mix
reasons	synergetic effects for energy provision, the industry and more security