Climate Change: From Fossil to Solar, Wind, Hydrogen and Nuclear

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Content

“People employ euphemism to obscure
the human cost of the political agenda
they support.” George Orwell.

An oxymoron:
A sustainable holiday,
Fly long and far away.

Tags: Black Swans, Climate Change, Economics, Education, Fracking, Hydrogen(Geological), Innovation, Natural Gas, Nuclear, PlugPower, Politics, Russian Gas, Solar-and Wind Power, Super Grid, System Integration, The Netherlands without Natural Gas, Energy Transition, Storage Systems.

1.Prologue

It is wintertime and unavoidable, winter is there. The outdoor temperature is 5°C.
Did I enough to contribute to reduce climate change? I am comfortably reflecting the subject matter in my house.
Not too much sun, too much wind and a non-existence of a massive-electricity-storage system.
Well, there is no problem behind the horizon. The base load for my house, warm water to take a shower, is supplied by nuclear power from France. The heat pump is powered by electricity

produced by the swing power plant using natural gas.[1]
Still I have some doubts whether I made the right decisions. Of course, I took the passive measures for energy conservation, i.e., maximum insulation. However, was it a good move to replace my highly efficient central heating boiler powered by natural gas by a heat pump powered by electricity?
I know, I was not left a choice. But still, does my heat pump really contribute to a carbon dioxide (CO_2) reduction?
Let's do some calculations.
My gas fired condensing central heating boiler had an energy efficiency of about 100 %. The heat pump is fired by electricity. Alas, no sun and too much wind or no wind at all. No mature storage system, i.e., proven technology, is available. Consequently, the electricity I need is produced by the swing production system based on natural gas. This centralized produced electricity is delivered by a CCGT[2] system with an efficiency of 65% or a system without combined cycle and an efficiency of 35%.
As I mentioned, it's a winter day the outdoor temperature is about 5℃ . Consequently, I am afraid the COP (Coefficient Of Performance) of my heat pump is about 1. I am not sure, due to the greenhouse gases, the winter outdoor temperatures will become lower than 5℃ in my country. On the other hand, I am not sure about the effect on the outdoor temperature due to the instability of the polar vortex.
Still, to do the calculations, I expect the heating of my house goes with an efficiency of 65% or 35%. I start worrying. There is no reduction of CO_2 , at the contrary. I am depleting more CO_2 than I did with my old-fashioned gas fired central heating boiler with an efficiency of about 100%.
In order not to contribute additionally to the CO_2 level, the COP of my heat pump need to exceed 2 depending on the type of powerplant. When the powerplant has as feedstock biomass, wood pallets or chips, the situation is even worse. Since biomass produces about twice as much CO_2 as my gas fired central heating boiler.
So, in wintertime the COP of my heat pump should exceed at least 2. Well, there is no problem at all unless electricity for my heat pump is imported from France or Germany[3], excluding lignite as feedstock. I am afraid not to sleep comfortable.
Now, after a couple of years, not much has changed: there are still the problems with the low voltage grid to fit in electricity produced by solar and wind. Consequently, the electricity for my heat pump is produced most of the time by centralized powerplants resulting in lower efficiency

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[1] It looks dangerously different October the 13th , 2021. A storm is hitting the world. Natural gas prices rocketing sky high. In 2022, we are still in the middle of this perfect storm: no sun, no wind, and a geopolitical situation.
[2] CCGT: Combined cycle gas turbine. The primary turbine is a hot gas turbine and the secondary turbine is a steam turbine.
[3] Germany is out of the question in 2022. Since Germany is closing down all their nuclear power plants, Germany has become a net importer of electricity. Energie Wende or Catastrophe. Consequently, Germany is strongly dependent on Gazprom with the related geopolitical problems. Germany is working hard to reduce their dependency on Russian gas. Germany has been warned in about 1990. September 2022, Russian gas is no longer available.

than realized with my good old high efficiency central heating boiler.
I started reading again in my book by Goldstein, et al "*A Bright New Future*". What's in a name? Winter is there.
Summer 2021. I considered to install solar panels, knowing the capacity and consequently stability of the grid problems are not solved yet. So, I contacted the grid operator with the question whether or not to install solar panels. Well, I got the advice to look around in my neighbourhood to get an idea of the solar panel density(sic). I also contacted the installer about the subject matter. I got the impression they never thought about grid capacity and/or grid stability. Again, I concluded no solar panels on my roof.
Transition? Well, a special one is to replace your high efficiency gas fired boiler by an air conditioning system with the option of heating, obviously powered by electricity. Any idea how the electricity is produced? It is begging the question.
We will meet our self-created black swans.
To mention one: laws which fix the future instead of the usual issues like behaviour.
In the following chapters you will meet a few more swans.
What we need is robustness, Taleb.

2.Introduction

Due to unacceptable earthquakes[4] related with depletion of the Groningen gas field, the Dutch government decided to fade out the use of natural gas for residential(household) consumption without any idea how to implement fading out.
Did these earthquakes come as a surprise? Well, I think not. These possible effects are neglected since the income generated by gas production of this Groningen gas field constituted an important part of the governmental yearly budget. As a consequence, some 40 years ago the so-called Dutch decease was created. To constitute a sovereign fund some 70 years ago was never thought of.
The solutions for the earthquakes in the northern part of The Netherlands is part of the project to ban fossils fuels of the Dutch energy market by the year 2050.
By fading out the use of the Groningen gas field a new storage system for the security of supply was needed. To this end a storage system in a former gas field has been constructed. This storage system came into operation in 2015. Well, with an institutionalized problem: Gazprom acquired about 45% of the gas storage with a swap for so-called cushion gas (4 billion m^3). The problem: Gazprom does not comply. Hence, the strategic gas reserve is not there(June 2022).
No fossil fuels, no natural gas[5], what's next? Transition/transformation: which measures to

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[4] At the very beginning of natural gas production in The Netherlands possible geological problems were already indicated in the regional press.

[5] It would be a real innovation when producing natural gas to leave the carbon part deep down below and bring the hydrogen part above the ground: a beginning of pipe solution instead of an end of pipe solution like CCS(Carbon Capture and Storage). We are coming close now, The Economist(24): "*They will take methane emitted from landfill or being flared off at oil-production sites, and turn it into cleaner-burning hydrogen, along with a pile of fluffy black powder*

take?
In The Netherlands, the parties concerned(single issue associations[6]) swear by wind-and solar power.
Without security of supply and security of availability of the alternatives, the transition from natural gas to wind- and solar power is a farce.
This transition is forced upon the citizens of The Netherlands showing the vulnerability of the democratic institutions. Parties considering how this transition should look like do not represent the Dutch people. They are not elected as they should be. They represented no constituents, just single-issue associations. But that is just another story (Noordzij).
As a leading principle we should employ energy security: the availability of sufficient supply at affordable prices:
- physical security and cyber security,
- access to energy,
- national and international policies,
- investment,
- diversification.

(Yergin).
So are we thinking locally or globally?
I cite here The Economist(13): "*One step towards halving emissions by 2030 would be to ramp up such renewable-electricity generation up to half the total. This would mean a five-to-tenfold increase in capacity. Expanding hydroelectricity and nuclear power would lessen the challenge of all those square kilometres of solar panels and millions of windmills. But increased demand would heighten it. Last year world electricity demand rose by 3.7%. Eleven years of such growth would see demand in 2030 half as large again as demand in 2018. All that new capacity would have to be fossil-fuel free.*
And electricity is the easy part. Emissions from generating (power, Nz) plants are less than 40% of all industrial emissions. Progress on reducing emissions from industrial processes and transport is far less advanced. Only 0.5% of the world's vehicles are electric, according to BloombergNEF, a research firm. If that were to increase to 50% without increasing emissions the production of fossil-fuel-free electricity would have to shoot up yet further."
Remark: in my paper a lot of numbers are used. Some are educated guesses. Consequently, for example changing the number of residences in The Netherlands, given in this paper, not necessarily change the national gas consumption. The latter number is taken from the annual report of the Central Bureau of Statistics(CBS). However, it does change the gas consumption

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called graphene." Not a solution deep down, but on the surface. *"The wonder material graphene may have found its killer application."* Basically we are looking for Geologic Hydrogen. May 2023, projects on the production of on-shore Geological Hydrogen are reported, e.g. www.usgs.gov .

[6] NGO's or better call them QAUNGO's since in the Netherlands these associations are subsidised with taxpayer's money. QUANGO's: a lot of influence without any political responsibility.

per residence. Assume the number of residence larger, it will certainly complicate the transition.

3.The Problem

Natural Gas, what is it all about?
Let's focus on domestic gas consumption in The Netherlands.
We may assume the domestic gas consumption to be about 1500 m^3/y is. In words: fifteen hundred cubic meters per year.
With a massive energy saving (conservation and improvement of efficiency of gas consuming equipment) program, this domestic gas consumption can be reduced to one 1000 m^3/y [7] in the year 2050.
I did not include the energy consumption(electricity) for air-conditioning. It may dwarf the consumption equivalent of natural gas, The Economist (7).[8]
The number of households in The Netherlands is about six million. Exact numbers are found in the reports by CBS. A governmental bureau of statistics. The numbers I use suffice to demonstrate what the order of magnitude of the problem will be.
Total domestic natural gas consumption is nine billion m^3 per year in 2018.
The type of gas is so-called low calorific gas. This gas is supplied with 100% availability and 100% security of supply without offtake obligation by the domestic gas consumer.
To find out about the effects of "*The Netherlands without natural gas*," we need to know the energy content of the gas consumed. We assume the energy savings programme results into a consumption of six billion m^3/y. Since, before starting with cutting the connection with the gas grid we start to collect so-called low hanging fruit: reduction of energy consumption[9], i.e., insulating houses.
The energy content at our doorsteps is presented in the block below.

> The energy content of 1 cubic meter ($\mathbf{1\ m^3}$) is 31,65 MJ/$\boldsymbol{m^3}$; so-called low calorific gas. MJ: mega joule. Mega is $\mathbf{10^6}$ and 1 J(oule)= 1 Wattsec. The calorific value of natural gas, of residential gas consumption, energy conservation and efficiency improvement included,: 31.65× 6× $\mathbf{10^9}$ MJ/y(ear). This is about 200× $\mathbf{10^9}$ MJ/y. We need 2× $\mathbf{10^{11}}$ MWattsec. Usually, Wattsec is translated into kWh: 5.5× $\mathbf{10^{10}}$ kWh. To translate this into production capacity, I assume an availability of the production units of 8000 hours/year to be a reasonable assumption, not for sun and wind by the way. We need 5.5× $\mathbf{10^{10}}$ kWh, so about 7× $\mathbf{10^3}$ MWatt is necessary.

From the preceding block, we learn 5.5× 10^{10} kWh is the energy to be produced as replacement of natural gas. Obviously, this amount of energy is delivered at our doorsteps by means of electricity.
How many electricity production units do we need?
For electricity production the production capacity is usually given. See block above. This capacity

[7] With energy saving I mean better insulating of houses. So, the houses do need less energy for heating and cooling.
[8] IEA : 2000 TWh/y, T=Terra.
[9] Without massive back-up – or storage systems, solar- and wind power are irrelevant.

of 7× 10^3 MWatt is not the production capacity we need. This 7× 10^3 MWatt is a mean value which could give you the impression the gas consumption to be homogeneously distributed over a year.
It is not. [10]
The problem to be solved is: 5.5× 10^{10} kWh to be delivered at our doorstep on a yearly basis.
Keep in mind: this 5.5× 10^{10} kWh is a mean value.

Now, there are a few problems more to be dealt with. These problems are summarized in The Economist(18), *The energy shock*, and by Meyer(2) in The Atlantic. Citation of Meyer: "*Governments and companies have built the global energy system around natural gas almost without a second thought. Now it's costing them."* [11]

4.Dealing with The Problem

As mentioned in the section on The Problem we need a capacity of about 7× 10^3Megawatt to replace residential gas consumption in The Netherlands. In this section the assumption is to solve the Problem with reliable, mature technology. Meaning: security of supply and security of availability. In addition, everybody has access to the energy supply system.
Natural gas will be replaced by electricity at the doorstep (Transition). For example, we can choose an electricity production units with capacity of 1000MW each. We need seven of them. Keep in mind the number seven to be the bare minimum. It is not only the average demand that need to be covered, but also the extremes including the additional reserves for calamities. This additional reserve can be estimated to be 20%(Yergin). So, we need 8.5× 10^3Megawatt production capacity. However, maximum necessary capacity can still exceed the latter capacity due to peak demand.
We know for sure this transition will be gradual. Until it is not. In The Netherlands representatives of Quango's would like a revolutionary stile of transition. Meaning a lot of turmoil, due to blackouts. They are not hesitating to present such an awful message: a Revolution will be helpful.
I assume, politics will choose for gradual approach, supported by the availability of alternatives. By assessing the alternatives, I bring to notice natural gas is now delivered to the households with 100% availability, 100% security of supply with no off-take obligation for the households(residential gas consumer).

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[10] The calculations are made for the replacement of natural gas. No attention is paid to the usual consumption of electricity for dish washers, etc.
[11] The geopolitical situation. In addition, due to single issue organisations(NGOs), the oil majors reduced their investment program with 50% since 2014. Consequently, the consumer are confronted with price inflation of natural gas by more than 200%. Thank you NGOs. May 2023, a single issue organisation(NGO) was extremely happy by preventing the off-shore production of 14 billion m^3 natural gas. In this way the NGO was thinking to prevent the production of NO_x , while the LNG carriers were sailing by the production location. NO_x?

4.1. The alternatives

4.1.1 Gas from Biomass

We can blend gas from biomass with natural gas. In The Netherlands we have a lot of experience with this type of blending. How much gas from biomass(biogas) can we blend with natural gas? Stated in another way, how much natural gas can be replaced?
Assume the percentage of biogas to be 5% of the residential gas consumption. Hence, we must substitute 300 million m^3 of natural gas by biogas with the same calorific value. There is a chemical limit to the amount of biogas. Biogas constitutes for example carbon dioxide (CO_2) like nitrogen[12] an inert gas. However, carbon dioxide influences combustion in such a way that cooking appliances evaluated and evaluated for low calorific gas do no longer operate in a safe way. Safety is one of the important testing issues of gas appliances. I am not dealing here with the possible pollution resulting from the use of biogas.
There are technological solutions to solve the carbon dioxide problem. Alas, a conversion of all cooking appliances is needed. This conversion is far more extended, to say the least, than the conversion needed for the introduction and application of natural gas from the Groningen Gas field. The latter operation was executed in 1955 through 1965. The conversion was needed to facilitate the switch from town gas [13] to natural gas. Nowadays there are a lot more appliances than in the years up to 1955. The conversion will be a lot more extensive and expensive.
In addition to the question whether we can replace 50% of natural gas by biogas, there is the question of a possible yearly production of 3 billion m^3 biogas equivalent to natural gas. This is begging the question.
Security of supply to mention something?

4.1.2 Hydrogen

There could be an advantage in the application of hydrogen. It is about the possibility of using the existing gas transport-and distribution system. Suppose we can use the system for transport and distribution, and we replace natural gas by hydrogen. How much hydrogen do we need to replace natural gas?[14] The calorific value of hydrogen[15] is 1/3 of the calorific value of low calorific natural gas per m^3 and the same pressure. To substitute hydrogen for natural gas completely we need 18 billion m^3 hydrogen. Will this happen? Again, begging the question.
Suppose hydrogen to become the substitute for natural gas. A conversion(retrofitting) of all the residential appliances is necessary. It's about the replacement of the burner systems. Prohibitive costs? Obviously, it is a trade-off between the stranded costs of the gas distribution systems and retrofitting. These stranded costs are estimated to be billions of euros.
I did not comment on all the transport and distribution problems, e.g., higher pressures.

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[12] In The Netherlands so-called low calorific gas is distributed for households. This gas contains a considerable amount of nitrogen (N_2) about 15%.
[13] Town gas is a mixture carbon monoxide (CO) and hydrogen (H_2) .
[14] Blending of hydrogen with natural gas and /or grid separation I did not consider.
[15] Calorific value of hydrogen(H_2) is 10,8MJ/m^3.

Nevertheless, let us look into the possibility replacing 1/3 of natural gas by hydrogen(not considered to be blending). See block below.

We need to produce 6(=18/3) billion m^3 hydrogen. This will be produced by electrolysis. Furthermore, we assume to produce 1 kg hydrogen with about 50 kWh(electrolysis). What capacity do we need? Well, with given density of 0.09 kg/cubic meter we need a capacity of about 4×10^3 MW (for 8000 hours). This estimate is based on a homogeneous distribution in a year. This assumption is not correct. Half of the capacity can be estimated to be homogeneously distributed. For this, we need 2 units with a capacity of 1000 MW each. This is a sort of base load. The other half is centred around the winter period. In the section on Transition, I made a distribution of capacity during a year. I will use the same distribution here. So, therefore, the peak capacity in addition to the base load can be estimated to be about 4000 MW. We need in in total a capacity of 6000 MW. Now we investigate the case the peak capacity is needed during 1/3 of the winter period (=2000 hours). Then we need a peak capacity of 8000 MW. Due to calamities, the installed capacity needs to be about 10000 MW. Here we considered a part (1/3) of the winter period. The peak capacity needed for one day can be higher.

I did not consider storage of Hydrogen. Suppose we have an idea about the logistic of the distributed storage system. In that case a capacity of about 4×10^3 MW (for 8000 hours) will do. In addition, I did not pay attention to natural-gas leaks in the present-day gas grid and the consequences for using hydrogen in that grid (The Atlantic sept 2018). In The Netherlands, the grid operators estimated the costs for adjusting the grid to Hydrogen to be € 700 million(2020, March).

The capacity needed to produce hydrogen assumes natural gas to be the feed sock for the power production. Just for the sake of flexibility.

Natural gas? Think about this for a while. We ban natural gas for residential application. Still, we need it to produce hydrogen. Do we reduce greenhouse gasses in this way? Well, the solution for this problem is wind-and solar power, electrolysis, and a mature storage system. How much storage do we need for security of supply of hydrogen?

The subject matter of storage, transportation and distribution of hydrogen is paid attention to in various publications, e.g., Jain, S., et al.

In reality, in the near future green hydrogen will be produced by electrolysis, using wind-and solar power. In this way hydrogen is one of the means for storage of the surplus of solar and wind power. Hydrogen can be used, e.g., in fuel cells. To think in terms of security of supply of hydrogen, the best way to produce hydrogen is by means of nuclear power. Since whatever we think, wind and solar remain intermittent.

Coal fired powerplants is no option. Is it?[16]

Other ways to produce hydrogen is by steam reforming of methane. The downside of this production system is carbon dioxide production. On the other hand, CO_2 is produced in a concentrated way that CCS can be applied efficiently.

In 2020 the European Commission announced a plan to develop a hydrogen infra structure.

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[16] In Europe we are in the middle of an energy crisis. The Economist(18) denote this to be a Transition crisis. The quango's in The Netherlands are overly excited about the close down of the coal fired power plants. Why? Well in case of a gas shortage these coal fired power plants can no longer be used. To them, this part of the transition revolution! What a transition. This all changed by the war in Ukraine, 2022, started by the Russians. Coal fired powerplants are up and running again in The Netherlands.

The natural gas transportation- and distribution system can play a key role. However, I hope for not too much dreaming. To introduce a modern technology to some scale costs time. Blending hydrogen with natural gas is one of the ways for a feasible introduction. Markets considered are production of steel and transportation(lorries) using compressed or liquified hydrogen and fuel cells. In addition, the shipping industry(transportation) is another promising market. The Commission is also planning to work on integrating energy systems. Exergy is key. Caveat: industries delivering and using excess energy come and go, to formulate it mildly. Even with a European integration of the energy system, back-up systems are needed.
The Economist (15) in its section on science and technology, presented a survey of the possibilities of hydrogen. There the possibilities were summarized in a question: *What will be the niche?* The possible applications, markets, were the same as indicated by the European Commission: the steel producing industry and transportation by lorries and shipping. In The Economist another application mentioned is home heating. National Grid (Britain) thinks gas-fired boilers which heat the homes can cope with a mixture of 20% hydrogen and 80% natural gas. The manufacturers could develop dual fuel systems for both hydrogen and natural gas. Considering the replacement time of the home heating boilers, 15 years, the switch from natural gas to hydrogen can be realized in a couple of decades.
At the Olympics of 2021(2020) some examples of the application of hydrogen are demonstrated. Cars and busses powered by hydrogen with fuel cells. Fuel cells, already more than 20 years promising and far away from the mass market of transportation and the decarbonising of this market.
The Economist(17), in relation to the Olympics, reported about the activities of Japan with respect to the subject matter. It is about applications in heavy industry and what is called the hard-to-decarbonise sectors.
Some examples:
- slashing carbon emissions from steelmaking, direct reduction iron(DRI),
- solar farms in combination with battery and hydrogen storage,
- reducing costs of the electrolytic process to slash the costs of making clean H_2 from H_2O.

In The Economist (21,22) the possible applications of hydrogen are presented and discussed in further detail. In The Economist(22) the special case of domestic heating is mentioned. *Replace the central heating boilers by electric heat pumps or retrofit boilers to burn hydrogen? On an efficiency basis, electrically powered heat pumps beat domestic boilers fired by hydrogen quite handily. But retrofitting urban housing already equipped with boilers to burn hydrogen may be more attractive in some places than trying to fit heat pumps into every building.*
The hydrogen cycle: i) electricity produced by wind and solar power, ii) electricity used to produce hydrogen by means of electrolysis, iii) stored hydrogen, iiii) hydrogen used for power production for electrically powered heat pumps and/or burned in boilers. Again, a hydrogen storage system is key..
The subject matter is paid attention to in The Economist (25) in the section *Heat, hope and hydrogen* of the Technology Quarterly. The conclusions do not differ in an essential way with the aforementioned conclusions.

4.1.3 Russian Gas

The residential natural gas consumption covered by Russian gas? Then, we export our environmental problems to Russia.
Obviously, Russian gas is not excluded. In The Netherlands Russian gas, after blending with nitrogen (N_2) is already distributed up to June 2022. A major change in the geopolitical situation disrupted the supply by Gazprom. Hence, the urgency of integrating the Dutch gas transport and distribution system with liquified natural gas (LNG).[17]
Netherlands without natural gas? 50% of the electricity is produced by natural gas fired power stations in the Netherlands. So, in 2021 Western Europe is in the middle of a transition crisis. No plan exist how to deal with natural gas shortages. Well, we can blame the Russians. This makes sense when the Russians are playing geopolitical games. Meaning they are not a trustworthy trade partner. In The Netherlands, there is no plan B how to deal with the Transition or Energy crisis. There is no plan at all, dealing with no wind, no sun and limited hydro power due to drought. There is no reliable substitute for natural gas.
The Economist(19): " *As it (Europe, Nz) shifts away from fossil and nuclear power and embraces renewables, the region has not properly dealt with the need for redundancy on the grid"*.
Where the Dutch lawmakers/legislators aware of this? It is begging the question.
By the way, in the so-called soft cold war, Gaz Prom is an excellent actor (Belton, Kaplan)[18], to put it mildly.

4.1.4 Electricity

A massive conversion: all residential appliances must be replaced by electric fired heat pumps. At the doorstep we need 8.5$\times$ 1000 MW. Still a mean value.
Keep in mind: 50% of the electricity is produced by natural gas fired power stations in the Netherlands. 8.5$\times$ 1000 MW for electric fired heat pumps not included.
What fuel mix will be used to produce the electricity? Electricity for which we do not have, in The Netherlands, a mature storage system[19]. So, we need a flexible production system.
It is of some importance to choose a fuel mix with maximum economic advantages for The Netherlands.
What to choose as the fuel mix for power production? We can choose coal, nuclear and natural gas. Coal and nuclear we use for the base load, natural gas for flexibility.
Coal. Limburg will be the county of our choice as the mining site. We do not import coal for the time being. Improvement of employability in the county of Limburg.
From the very beginning we must pay attention to damage control related with coal mining.
When employment in the county of Limburg is not an issue, we can import/buy lignite in

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[17] July 2022. Winter is coming. In Europe, we will have to deal with a war like distribution system dealing with the shortage of natural gas. In Germany, the politicians are preparing the German people for the situation.
[18] Whether this really is a soft cold war 2? Gas export by Gazprom is used as geopolitical instrument, to put it mildly.
[19] Storage systems, such as pump accumulation, hydropower (cooperation with Norway), are investigated and applied on a small scale. The technology of pump accumulation is also referred to as pumped-storage hydropower. The total worldwide capacity is 165GW (The Economist 25).

Germany. In that case we are in the same “Energie Wende”[20] league as Germany. Germany a favourite country for holidays, vacations, etc. A mild northern climate and a lot of sun. Observe the number of solar panels in the country.
Modern coal gasification technology can be implemented. It has been done before. The advantage: carbon dioxide can be captured at the source at high pressure. However, there is a problem. Coal has become expensive due to an investment slump in oil-and gas fields since 2014, The Economist(18).
The other element of the fuel mix is nuclear energy. Obviously, the most modern technology will be used. It will be a stimulant for R&D in The Netherlands.
The choice for the fuel mix is based on the need and availability for swing production. Consequently, **natural gas** is included at least on the short term.
However, **nuclear** power is a more promising solution on the longer term. A promising solution to integrate renewables into the grid. It’s not just about base load. Nuclear power works around the up’s and downs of solar and wind power. Nuclear power can produce fuels when solar and wind power is high. Alternately produce electricity when solar and wind do not contribute to grid electricity (Goldstein, et al). In this way natural gas can be phased out on the longer term in a feasible way.
On page 155, Goldstein et al produced some terrifying numbers for Sweden when the country start closing their nuclear facilities. “…… *To meet demand of about 150 terrawatt-hours (TWh) per year, wind, and solar production of more than 400 TWh would be needed, along with grid upgrades. The cost of electricity would increase fivefold…….* “.
Nuclear is back on the political agenda in The Netherlands. This is based on a programme of the Dutch liberal (European liberal) political party VVD: *“100% clean Dutch electricity”*. It is about security of supply in relation to urban planning. For example, about the area of twenty soccer fields is needed for a 440 MW nuclear power plant. To create the same capacity with solar panels, the area of about 900 soccer fields is needed. Well, that is really something to pay attention to in The Netherlands.

5.Further Considerations on Dealing with The Problem

5.1 Conversion

To replace 6 billion m^3 (energy saving included) natural gas by electricity in The Netherlands, leads to a massive conversion. We do not have any experience with conversion at such a scale. We do have an experience with a conversion from town gas into natural gas. This conversion happened some 60 years ago on a relatively small scale. This experience is not of much help.
To develop a sense of urgency I present here a number adopted from Rhodes(page 298) for the

[20] Or Energy Catastrophe: Closing down the nuclear power plants and becoming dependent on Russia. Furthermore, the fear of fracking in Germany is playing a devastating role, The Economist(26). However*, “German firms have been using the technique in the country since the 1950s, with not a single reported incident of serious environmental damage.”* Not only Germans considered fracking dangerous. Even Putin, the self-declared expert on fracking, warned the Germans that fracking “*black goop spew out of kitchen taps.*” Let us not start to think about conspiracy in Germany. It is not about conspiracy, it is about fairy tales.

time it takes to switch: "*Since natural gas burns hotter than propane or town gas, some twenty million gas appliances had to be adapted or replaced. That took ten years from 1967 forward*."
For the conversion operation we need technicians(m/w). Now, these technical trained people are not there.
Conversion costs? Costs have been published in May 2018 by the housing associations for a segment of the housing market: counsel housings. A number? The costs are estimated to comprise about € 108 billon. The details?
What about the grid capacity and stability? Looking into the subject matter, I think the transition timetable will be obsolete on short term. Grid and distribution systems need to be built and come into operation. The operators are faced with huge time delays. This is also due to a shortage of qualified staff. To give an idea about the extent of the construction effort: the transition needs some 80000 kilometre of new grid infrastructure. An investment of about € 100 billion. This just about The Netherlands.
Internationally, grid redundancy can be created by internationally connecting the grids⟹interconnectors. In this way virtual storage capacity is created on the grid, The Economist(20).

5.2 Solar – and Wind Power

So far we did not pay attention to wind-and solar power for replacement of residential application of natural gas. If we do consider wind-and solar power as an energy source for residential application, we must compare the security of supply and availability of wind-and solar power with the security of supply and availability natural gas.[21]
100% availability and 100% security of supply without a robust and distributed storage system is impossible for sun-and wind power. This storage problem must be solved. Grid stability need to be managed. Most probably just 15% of 8500 Megawatt can be covered by wind-and solar power. Even with this percentage we need flexible production units for peak demand.

An example, 2022-05-17. A frontpage story in a Dutch newspaper about grid(stroomnet) stability and solar panels

Storing bij tienduizenden huizen als zon volop schijnt

Stroomnet bezwijkt onder zonnepanelen

Zeker 75.000 huishoudens met zonnepanelen op het dak kunnen regelmatig hun zonnestroom niet kwijt. Er is dan zó veel aanbod in de wijk dat de netspanning te hoog oploopt en het veiligheidssysteem de zonnepanelen uitschakelt.

derhalf miljoen huishoudens hebben zich gemeld bij de netbeheerders om stroom terug te kunnen leveren. Eén op de twintig huizen met zonnepanelen, schatten de netbeheerders, heeft nu al last van uitval door te hoge netspanning. Als er in de straat of wijk meer panelen komen, wordt de kans op storingen nóg groter.

op als de zon uitbundig schijnt en de opbrengst van de panelen hoog is.
Als de panelen tussen 12.00 en 16.00 uur niets doen, is dat al snel een schadepost van 5 euro per dag. De netbeheerders hebben berekend aan de hand van data van vorig jaar dat 75.000 huishoudens gemiddeld elf uur per jaar

It is about too many solar panels in your neighbourhood.

[21] Discussing alternatives to natural gas, I assumed a 100% availability and security of supply of this relatively clean fossil fuel. Well, in 2021 I am not so sure about security of supply. This is related with the transition crisis in 2021. Suddenly, the Black Swan was there.

In the scientific section of the Volkskrant, Sir Edmund (March 3rd, nr 2, 2018) attention is paid how to fit the residential produced electricity into the grid. No technological problem was expected. However, in The Netherlands the low voltage and high voltage grid are not designed for a fluctuating supply and demand of solar and wind power. In addition, the residential electricity producer(m/w) does not guarantee security of supply and availability. In May 2023 the situation was even more extreme.

In The Economist(2) December 6th 2014, attention has been paid to storing renewable energy on the grid. The Economist: *"Matching output to demand is hard with wind and solar power. The answer is to store surplus juice on the grid until it is needed".*
It is 2014, and Alevo, a Swiss company is mentioned. A company started to make new batteries that can store serious amounts of electricity. May 2018, Alevo filed for bankruptcy; www.greentechmedia.com .
Well, such things happen. All the hopeful things about stationary storage did not materialize yet. To develop a mature system cost a lot time. Do we have that?
Obviously, new storage technologies will become available for the market: in the Business section of The Economist(5) July 21st 2018 vanadium flow batteries (VRBS) are mentioned. As will be mentioned time and again: to arrive maturity will take decades.
Let us elaborate a little further on solar – and wind power. In the section The Problem we calculated the capacity for The Netherlands to be of 8.5×10^3 Megawatt at the doorstep. Here, in this section, we assume this installed capacity to be build up by PV units and wind turbines. Nothing has been said so far about the efficiency of these power production units. I assume, security of supply and availability is secured one way or the other. Furthermore, we may be lucky to reach an efficiency of 25%. See the block below.

What does 25% mean? (See also Appendix 2). Of course, we can determine the efficiency of a wind turbine for that matter of a solar system. Under controlled, laboratory conditions we can measure efficiency. Simply stated: output/input. However, in the real world of wind turbines and solar systems we are not always sure about the input. Hence, we better speak of the Probability of Availability instead of efficiency. As a matter of fact, all the capacity numbers mentioned subsequently are mean values. In the following text I still use the expression efficiency. Keep in mind: Efficiency is meaningful when a reliable back-up system is available. A back up system could be a mature distributed storage system and/or well-known production capacity based on natural gas, coal and nuclear of 8500 MW. Since the back-up capacity needs to be flexible the only option will be natural gas: imported LNG or imported pipe gas. Conclusion: without a storage system solar – and wind power just add capacity and do not replace incumbent capacity. We need a production capacity of about $3.4\times 10^4 (= 4\times 8500)$ MWatt, based on the 25% efficiency. Since the capacity of 8.5×10^3 MWatt has been obtained from the amount of energy delivered at the consumer's doorstep. Assume half of the production capacity is created by wind. Consequently, we need 17 GW production capacity of wind turbines. Assume 2 MW per turbine. Then about 8.8×10^3 wind turbines need to be installed. I did not use a robust, massive, and mature storage system. Well, it is not there. The above-mentioned number of wind turbines is still based on a yearly mean value. As indicated in Appendix 2 a mean value is meaningless. In the Appendix 1 it is shown the ratio of solar to wind power equals about 1/3 and not to be 1/1.

As mentioned (the block above), we need a production capacity of 34 GW to replace 6 billons

$m^3$of natural gas. Keep in mind this amount is obtained by implementing an energy savings(conservation) program resulting in a reduction of use of natural by about 30% (numbers 2018). In addition, the 34 GW is assumed to be sufficient for heating even in wintertime. It is not. No wind and no sun: no comfort mildly formulated.
34 GW is deduced from annual energy consumption. However, we know daily consumption fluctuates with major seasonal differences. With help of data from the daily consumption, we get an idea of the need for storage systems and the maximum production capacity needed.
In Goldstein, et al some sobering numbers are given on "*The wind is not always blowing, and the sun is not always shining*". Page 37-38.

5.3 Electric Vehicles

In the observations no attention is given to the capacity needed, in addition to the 8500 Megawatt, for electric cars (See section 8 on Electric Vehicles). In The Economist(3), March 3rd -9th 2018, *Reinventing wheels*, an estimation is given for the additional production capacity: "*The switch to electric vehicles will require more generating capacity. UBS, a bank, estimates that it will increase European electricity consumption by 20-30% and new infrastructure, such as charging stations and grid upgrades*." Just another element of the transformation process.

5.4 Transition/transformation

Transition: the consequences of the change from the use of natural gas into using electricity are mentioned with a lot of ignorance. However, keep in mind without security of supply and availability (storage capacity) we only can rely on our natural gas distribution system in The Netherlands. Under the assumption natural is still available (2023).
Part of transition is conversion of gas appliances when hydrogen is distributed. Not just conversion, but also replacement of appliances and adaptation of the distribution system. Talk of the town in The Netherlands is the replacement of central heating boilers by electrical driven heat pumps. Where does the electricity comes from without wind and solar? This is begging the question.
In the Technology Quarterly of The Economist (25) an overview is presented of what the transition still needs.

5.4.1 *Intermezzo. Hurricane Heat Pump*

What is the capacity needed for a heat pump to supply the heat for a shower and for heating the residence? Based on the yearly gas consumption and energy conservation, we will obtain a number between 10 and 15 kW (about 12, say). This assumes the need for warm water during two hours per day the year round[22]. Furthermore, we estimate a need for heating capacity during 1000 hours per year. In addition, the cooling capacity is of the order of magnitude of the heating capacity. For a typical winter day, we need 10-15 kW. I do not consider the problems related with a low temperature heating system and warm water production.

[22] Think about the temperature of the water considering health risk.

Let's assume to extract from the outdoor air the energy with a temperature difference of 5 ℃. So, we have an air-to-air heat pump. How much air do we need? We take the heat capacity of air at constant volume. For a given density at 10 ℃ we extract 4.4 kWsec/m^3. 12 kW is needed so we must transport 4 m^3/sec (including losses). Now suppose the diameter of the suction side of the ventilator to 0.5 m. Then the velocity at the entrance of the ventilator is about 20 m/sec or 72 km/hour. The amount of air whereof the heat is extracted must again be ventilated outdoors. Velocity difference between entrance and outlet is about 145 km/hour.
This will happen mostly in urban area. What kind of hindrance is to be expected in a representative street of a representative town?
Any idea about the noise level?
End of intermezzo.

In The Economist(4), March 17th 2018, some aspects of the complexities of decentralised power production are indicated. As a citizen I like to hear the government to communicate about these complexities. Well, I am afraid this will not happen (Noordzij).

6.Fallacies

One of the major problems is the role government, regional(county) and national, in trying to direct technology development by picking winners. The role of government is to make laws and implement them. The role of government is not to choose technologies. This will kill innovation. In the Netherlands there are a few counties which collected a lot of money by selling their stakes in energy companies. So, for example, the county of Gelderland in The Netherlands obtained some € 3 billion. The county Council is considering spending over € 300 million to stimulate technology development. Not by making laws, but by picking winners.
The best way to spend this money is not to throw the money of the taxpayer on technology but give it back to the taxpayer. Greenhouse gases should be taxed. Knowing this, the industry will innovate.
Obviously, by spending a lot of money during a long period of time, something will be found (www.leennoordzij.me 2,3).
In addition we can wait for the booms and bust in economics of solar- and wind power.

7.Solar Energy and Wind Energy

I will pay attention to the solar- and wind energy situation in The Netherlands (April 2018). A situation indeed. It is becoming much faster a disaster as expected. Instead of security of supply – and of availability, grid stability is rapidly becoming a major problem. How come?
Well, the Dutch government is subsidising solar- and wind energy with billions of euros. Subsidising the so-called proven technology on a large scale. Consequently, solar energy is disturbing grid integrity - and stability, spending and spoiling taxpayers' money. In the meantime, innovation is killed. Why innovate when proven technology is subsidised? Hence, the taxpayer is supplied with technology, which will be obsolete in a couple of years. This is how transition will work?

In July 2018 the Dutch regional press paid attention to the storage problem. The well-known systems are reviewed, batteries, pump accumulation, hydrogen, and intelligent grid. None of which has reached maturity. I do not include storage systems where electric cars are involved. This asks for a sort of Plan Economy. A disaster on beforehand. A Dutch professor of Sustainability and Transition Knowledge mentioned even a dictatorship-light to accelerate energy transition since the professor saw a lot of “foot-dragging”. Hopefully, the dictatorship remark was a tongue in cheek remark. If not, a short course in history could wake up the professor. We, still, live in a liberal democracy (as defined by The Economist(8) September 15th, 2018) with laws and rules. By the way, any idea about the waste produced by obsolete solar panels?
Also energy consumption is mentioned. Well, the least we can do is start with reducing energy consumption. The low hanging fruit. Extremely urgent in 2022.

8.Electric vehicles

Now, let’s focus for a moment on electrically powered cars (sedans, etc).
How much capacity do we need for feeding the batteries of these cars? Suppose this charging is done by solar – and wind power. What capacity do we need?
We have in the Netherlands 10 million cars, say. 10% of these cars we assume is on the road daily (24 hours). Furthermore, we assume a consumption of 16 kWh/100 km, a small car by the way. We also assume the car is driving 20000 km per year. So, this car is consuming
32×10^2 kWh/y.
Hence, approximately, the one million cars on the move are consuming 3.2$\times 10^6$ MWh/y. This consumption asks for a capacity of about 400 MW solar and/or wind power. Caveat, now the availability comes into play (i.e., security of supply and security of availability). This results in an efficiency of about 25%. Consequently, for these cars on the road we need a production capacity of 1600 MW of wind and solar power. So, with no wind and sun, a backup capacity fired with natural gas of 400 MW should be available.

8.1 A Platform for Balancing the Grid.

In Section 10 Transition will be paid attention to. Here I like to mention that the high voltage grid operator- in The Netherlands- TenneT (2020, April) mentioned the development of a platform to support the balancing of the grid. In this way the supply of electricity into the grid by, e.g., stationary cars (ev’s) can be facilitated. The low voltage grid operator will be key, since TenneT will be a mediator, sort of, by making their platform available.
To make this work, there is an incentive by paying the car owner a fee. I suppose this fee reflects the non-obligation of supply by the car owner.
Note: The car batteries have been loaded by solar – and wind power, and/or by use of natural gas.

9.Energy Transition and the societal consequences.

The Netherlands is a liberal[23] representative democracy. So, the citizens may expect the lawmakers(legislators) in the House of Representatives to investigate the problems related with the complexity of transition and the chaotic start described in the next section. However, in The Netherlands we have a situation. Government has delegated the discussion about transition to so-called platforms. No lawmakers(legislators) involved.

In De Volkskrant June 9th 2018 a survey is presented of the possible societal consequences of energy transition. The title of this survey reads: "*Divide the pros and cons of the green revolution in a fair way"*. Political attention to the related problems is of major importance. The legislative- and the executive branch of government must pay attention to the problems related with transition in due time. Do not forget about time consuming law -and rulemaking related with the subject matter. The nimby problem.

In this survey my attention was specially attracted by the tacit assumption of the availability of the technology needed to make the transition work.

Without proven technology for storage there is no security of supply as mentioned before. It will take at least a decade or more to show up with mature grid scale battery storage.

In addition, it is almost a hoax to make the people believe by consuming electricity they contribute less to greenhouse gasses. Nonsense, the residential electricity consumer is contributing more. Rebound effects included. The consumer thinks electricity to be a sustainable energy. Oh, what an "Energie Wende", or better Energy Fiasco/Debacle.

10.Transition, the Process

In The Netherlands Transition means to be in the year 2050 only dependent on sustainable energy sources. For the household market this translates into solar- and wind power and hydrogen.

Transition deals with the process: How to reach B (2050) started at A (2018)?

For B we must deal with the assumption no natural gas in 2050. I suppose in the transition period we have to rely on natural gas of the same amount as consumed in 2018.

Let's start in 2018 with an example of an alarming story.

In Dutch newspapers you can read stories about household willing to be disconnected from the gas grid and rely only on electricity produced by their solar panels. Oh, by the way, when the sun does not shine obviously the electricity grid, high-and low voltage, is there as a backup. What is alarming, people takes electricity "from the grid" for granted. It comes "out of the wall", just like that. In addition, these consumers are happy and proud to tell you that they are contacted by the electricity supplier, the low voltage grid operator, about their strongly fluctuating electricity intake of the grid. They do not have any idea what will happen when a couple of neighbours are also disconnected from the gas grid. A black-out is around the corner,

[23] Liberal: The Economist(8) September 15th, 2018.

literally. This is just an example, a small scale residential one. It could help when these disconnected consumers pay a backup fee. In addition, the reimbursement for feeding the grid with solar panel produced electricity short be finished. The residential producer is basically using the grid as storage for overproduction. The cost of this storage can considered to be balanced by the amount of electricity taken from the grid.

In The Economist(11) December, 22nd 2018, you will find more on the subject matter.
What I did not expected the problems related with solar power arise so soon in The Netherlands. However, an additional surprise, the problems are showing up in rural areas in the first place and not so much in urban areas. This is due to huge solar farms operating in rural areas. The grid out there cannot cope with the energy produced. The present-day grid was never developed for two-way traffic due to individual electricity production by solar panels.
In section 5.1, I paid attention to make the grid suited for the two-way traffic: an investment of about € 100 billion. Not to mention the absence of qualified staff to implement the adjustments.

10.1 *Intermezzo: A Hilarious Solar Park Operator's proposal for grid capacity*

As mentioned above problems with grid capacity already arises in rural areas. One of the solutions presented by a solar park operator in January 2019 is to disconnect the solar park from the grid when the grid capacity is insufficient. Well, you cannot believe your eyes reading this. When is the grid capacity insufficient? Indeed, during a period with a lot of sunshine. So, disconnect the solar panels from the grid when the sun shines and reconnect them to the grid with no sun. Subsidies have been collected. So, what is the problem? Problem solved.
In September 2019 the government, the executive branch of the Trias Politica, admitted the capacity and integrity problems of the high voltage and low voltage grid. It is about time. It is a huge problem indeed.
End of intermezzo.

There is also a large-scale version of negligence. In one of the counties in The Netherlands a large wind park will be developed (2018). The capacity of this park is planned to be 320 MW. The legal structure of the park is limited liability company subsidised by the taxpayer. The taxpayer is not a shareholder by the way. 320 MW and no robust storage system. The park will be connected to the national grid. Consequently, the incumbent power producer is faced with an additional 320 MW power fluctuation. This is obviously the lower limit since peak demand will be much higher. One could call this free riding on fossil fuels. By the way, fossil fuels originate from biomass. The project manager of this 320 MW wind project mentioned this capacity sufficient for 280.000 residential units. No wind? No problem, natural gas is still out there. Furthermore, peak capacity is not indicated.
Both examples, small scale and large scale, indicate the problems we are facing. It is really worrying. The start of the transition in this way can become rather chaotic. It is already chaotic in 2021. We are looking a Transition Crises in the face.
The solutions for grid stability and integrity are rather complex to put it kindly..

Back to “from A to B”.
Obviously, you need to know what B most probably looks like. Still, you need a plan C to deal with Black Swans, like the aforementioned Transition Crises[24] we have to deal with in 2022. The pressure groups in The Netherlands never realized that we need fossil fuels in the transition period. Especially, natural gas is a bridge to the future of a fossil free society. Alas, the incumbents are sitting on their hands with respect to investment in fossil. The Economist(18): “*But legal threats, investor pressure and fear of regulations have lad investment in fossil fuels to slump by 40% since 2014.”*
In the section The Problem, I made an estimate of the capacity needed to live without natural gas. In that section it was found the capacity needed at the doorstep of the Dutch households to be 7000 MW. Considering the extremes and capacity needed for accidents the actual number is 8500 MW. This capacity, I repeat myself, is based on security of supply and security of availability. I translated this security with an efficiency of about 25%. This could be considered unrealistic. I have no problem with such considerations. The alternative is a massive storage system or swing production based on natural gas(if available) of at least 5000 MW.
In the block below an example is given based on a not too unrealistic capacity distribution. I consider it to be a lower estimate.

To illustrate this by a not too unrealistic example. Divide the year in the four seasons. Half of the yearly gas consumption, 5.5×10^{10} kWh given in the section The Problem, for the households is used for taking a shower and things like that: 2.75×10^{10} kWh. This is a homogeneously, at least daily, distributed consumption pattern. This can be produced by a capacity of 3500 MW. However, heating does not show such a homogeneous pattern. Assume this consumption to be zero during the summer season, 1.375×10^{10} kWh in the winter season, 0.6875×10^{10} kWh in spring and 0.6875×10^{10} kWh in autumn. From this example you will notice the capacity in the winter season to be: 3500 MW+7000 MW= 10500 MW. Considering the extremes and capacity needed for accidents the actual number is about 12500 MW. If we assume the energy supply for household solely based on solar- and wind power, including extremes and accidents, we need something like 34 GW. You may conclude this latter number based on an efficiency of the supply chain of about 25 %. Obviously, you can plug in another number. However, it is important to make a quantitative analysis. This 34 GW is the 2050 situation. Just on solar- and wind power.

Now the next question to be answered is: how much storage capacity do we need in the grid? Alas, it will look like an educated guess, since going “from A to B” is not an abrupt change. It will be a continuous process. We need a number for the storage capacity at our “doorstep”. We need something of the order of 100GW, considering the security of supply and availability of solar -and wind power. This distributed storage capacity must be integrated in the grid. A grid that needs to be reliable and stable.
You can make various scenarios for the equilibrium-2050 situation. Scenarios based on hourly energy consumption. Does modelling of the various scenarios make sense? May be. Going “from A to B” is a rather complex process with a lot of players involved. So, starting with A, the final B

[24] In 2021-2022 we are in the middle of this crises with sky high prices of natural gas. It is almost obscene to hear that this crises stimulates the acceleration of the disconnections of the gas grid. People thinking and talking this way do not realize the inception of a second Transition Crises with no gas at all is in statu nascendi. We absolutely need natural gas in the transition period even after 2035.

you obtain can be different of the B you thought off in the first place. If we take care of the unknown final B in the scenario's then the modelling makes sense.
Households, those who can afford it, are installing solar panels. Wind farms are built in various communities and counties. The grid operators are busy to cope with increasing fluctuations of the energy supply without a mature intelligent grid. The households installing solar panels are somehow conditioned to consider electricity as a natural given resource. They take electricity "from the wall" for granted. So local, regional, and national politicians need to start to communicate the problems resulting from the lack of a mature and reliable storage system. Up till now politicians like to talk about B. Talking about B does not make it happen.

People installing solar panels should be aware of the problems related with a lack of storage capacity. As a wakeup call these private investors should oblige to the same rules as the incumbent power producers and distribution companies. With no compliance, a fine must be paid. In addition, these private installers of solar panels should be forced by law to install storage capacity. A capacity sufficient to storage a day production of their panels, say. Furthermore, this capacity needs to be increased, by law, with 10% each year, say. Another possibility to prevent free riding, sort of, is to pay a fee for back-up facilities, like additional production capacity.

A scenario: Let 's say within about 5 years, no wind, and no sun and about 3° C. What will happen? Insurrection, revolution?
Furthermore, the transition starts with a phase of pilot projects. For example, a group of households of the grid; a group of households supplied with hydrogen, etc. So, a learning curve is created. The first results are not convincing. What we did learn from these results that transition will cost a lot of time and a lot of money.

11. Climate Change in The Netherlands?

In September 2019, the EASAC(European Academies Science Advisory Council) released their report on Biomass. In this report they paid attention to the sustainability of burning wood pallets(biomass) in power stations on climate change. It appears not to be sustainable. Burning wood pallets creates additional CO_2 not to mention the other exhaust products like particulates, etc.
In June 2020 the report on the Nitrogen oxides problems in the Netherlands has been published: *Niet alles kan overall,* Remkes e.a.
In The Netherlands, The Government allocates about € 11.4 billion to subsidies this burning of wood pallets as part of The Transition process. An "Energie Wende" to the core.
In the EASAC report the subsidy is qualified as "burned" Taxpayers money.
Obviously, the power producers qualified the EASAC report to be nonsense. Well, I do understand that, losing their subsidy(Taxpayer's money, € 11.4 billion) leads to stranded assets; former coal fired power stations.
In addition, the secretary(minister in Dutch language) of Economic Affairs &Environment(Sic)

qualified the report as a kind of fake news. At the same time, he qualified the advice of the Remkes Committee on the subject matter to be an "odd advice". Remember, the function of the Remkes Committee is to advice the Government. The advice was not, to stop spoiling Taxpayers money. No, the advice was to reconsider the subsidy of the allocated billions of euros for biomass. Why an "odd advice"? Well, according to the Secretary of Economic Affairs and Environment the advice was a negative judgement of the Government Policy. Uh? To cite the Secretary of State in the Dutch language: "*Wat Remkes adviseert, gaat tegen ons beleid in. Ik vind dat een wonderlijk advies*". A crystal-clear example of double Dutch.

There is more. The Netherlands, one of the densest populated countries in the world is the second largest exporter of dairy products, etc. Does that create environmental problems? It does. The environmental problems are such that some courageous politicians indicated the stock of cattle to be reduced by half. Consequently, the subsidised farmers are protesting on a large scale. See the above picture. This picture also illustrates to some extent that about 20% of the Dutch farmers has been catapulted into millionaire's heaven with help of taxpayer's money. The agriculture situation In The Netherlands is summarized in The Economist, October 26th 2019. It is not about the chemistry of environment pollution; it is about politics.
Three quarters of the production in the Netherlands of dairy products are exported to states, members of the European Union.
A Dutch farmer really innovates when also exporting the manure to the other European states.

Climate change in The Netherlands? There is no climate.

12.Newspeak

- Intelligent grid ≡ no massive storage system available.
- Residences disconnected of the gas grid ≡ the connection is replaced upstream but is still there at a huge cost.
- Energy neutral ≡ more electricity needs to be produced by means of gas and/or nuclear energy.
- Odd advice ≡ some advice you don't like.
- Transition ≡ The Netherlands without natural gas.
- Development aid ≡ a vacation in the tropics.
- The Netherlands without natural gas ≡ more natural gas is needed.

- Acceleration of Transition≡ no availability of natural gas.

13.Discussion and Conclusions

First and for all: it is about complexity and connectivity. To conclude: this is not about to create paralysis. It means think and realize we are part of a non-linear system (Mitchell Waldrop, Chapter 9 *Work in Progress*).

Conclusion: The Netherlands without natural gas? A technical problem? No?
To replace the household gas consumption by electricity, a capacity based on a not too unrealistic model of 12500 MW is needed. Which fuel? I assumed coal and uranium. Will that happen? I think not. Since, both fuels are for base load. Coal is most probably out of the question[25]. Unless we start to import electricity from Germany. May be, a window of opportunity is developing for nuclear as base load. For peak load something else must be done. So we need to have an idea what to do. Expect natural gas to play a key role.

Conclusion: *Low-Hanging Fruit*. In the chapter on The Problem, an energy conservation program is mentioned. This can be considered a lower estimate, since in The Netherlands about 30% of the houses are poorly insulated. But still, let us start with energy conservation program: insulation of houses. Then we obtain with this so-called low-hanging fruit a reduction in natural gas consumption of 3 billion cubic meters. With 1 cubic meter of natural gas, we produce about 1 kilogram of carbon dioxide. So, by better insulating the houses we reduce relatively easy this amount of carbon dioxide ejected in the atmosphere. Especially of importance considering the geopolitical situation(April 2021).

Conclusion: In the first place I like to recall the report of the "Staatscommissie parlementair stelsel, The Netherlands(www.denederlandsegrondwet.nl): Some years ago, the Dutch Government gave birth to the so-called Remkes Committee. This committee got the task to advise The Government on the policy for improving the functioning of The Trias Politica, or in casual language, improving the functioning of the democracy. So far, so good.

Transition needs to start with a communication and a dialogue of our political representatives, lawmakers(legislators), about the real problems, costs for example of the steps to be taken in the process of transition. No newspeak shall be used like feed-in tariffs to explain the problems. Just tell the consumer, the constituencies, to reduce the dependency on fossil fuels comes with a cost.

The communication has been started February 2019. It became a drama. The executive used out of date numbers published by one of their Policy Institutes. The costs were estimated far too low. What happened next? An old-fashioned way of blaming the messenger. We, the constituency, were told the Policy Institute produced the wrong numbers. Please politicians, you are not forbidden to use your own brains. Is it too much for you to

[25]Anno June 2022, coal is no longer behind the horizon. Due to geopolitical problems, to put it mildly, the key role of natural gas is no longer guaranteed.

find out, ask a question, whether the data were already obsolete? Data of 2017. It was not an entertaining moment for our liberal democracy. Not of great help to stimulate an energy transition programme.

Explain the necessity of an investment in the residential area of € 235 billion (taxpayers' money) to reduce just 15 % of the total greenhouse gas production in The Netherlands. Furthermore, it is important to explain all the measures taken in The Netherlands will contribute to a worldwide temperature reduction of 0.0003% (Het Financieele Dagblad December the 29th 2018). Do not let the populists do the communication job.

As an example, the analysis in this paper is based on 30% energy conservation. This conservation can be done by better insulating the houses at a fraction of € 235 billion. Politicians must communicate energy conservation comes with a cost. Hopefully, a cost equal or less than the net present value of the conserved energy.

The Economist (23), March 26th 2022:"*The challenge of getting net zero, therefore, is not primarily budgetary but structural: how do you design politically viable policies to ensure the transition actually happens?*"

Explain to the constituents in the past we never accounted for the real costs of fossil fuels.

Our lawmakers(legislators) should not delegate their task of dialogue and communication to people with all kinds of fancy thoughts about technology of which the maturity is still behind the horizon. And about the process of implementation of this technology by referring to the conversion in the past of so-called town gas to natural gas. Politicians should protect the citizens from such snake oil salespeople.

The conversion from central heating boilers fuelled by natural gas into heat pumps fuelled by electricity will one of the major parts of the transition process. Explain to the people, eligible for choosing the legislation of our liberal democracy, how the electricity is produced without any wind, too much wind or no sun. In that situation, the electricity will be produced by natural gas.[26]

So, prevent representatives of single-issue organisations to explain the necessity of getting rid of natural gas, since it is impossible. People need to know without wind or sun, electricity will be produced by natural gas at least for peak load. In that case it is a small step to conclude your old-fashioned condensing central heating boiler produces less greenhouse gasses than your electrical fired heat pump. Electricity produced in the latter case by a natural gas fired central power plant.

Politicians speak up. Do not let single issue representatives play your role. These people are not interested in your constituents. They think to be always right and, caveat, act in the so-called general interest like any dictator. In addition, these people think massive subsidies will do the transition work and stimulate innovations. At the contrary, massive subsidies will stifle innovation.

Explain to the Dutch people the problems we are facing. Do not delegate the subject matter to single issue, non-democratic, non-liberal, organisations. We need to realize that solutions to

[26] Hydrogen can be of some help when it is applied as a storage system for wind and solar power.

reduce the effects of climate change come with costs for investment. In addition, explain that positive return on investment is an illusion. In most of the cases the return will be negative. Not for the environment by the way. Keep in mind I just mentioned the energy part of the climate change problem.
A clear picture is needed. If not, people will make up their own reality.
See the example in the block below.

Sitting in your armchair, listening to the discussions of the legislators (m, w) in the House of Representatives (Tweede Kamer) on climate change and the essentials, a hoax comes to your mind. Why is that?
The depletion of the Groningen gas field leads to a reduction of income for the government. To solve the resulting budgetary problem the usual suspect is to raise taxes. However, this is not communicated. The government's reasoning, supported by the legislators, is to increase the costs of natural gas delivered at the doorstep to stimulate(sic) sustainability in the residential energy market, i.e., to reduce the consumption of natural gas to zero. Keep in mind, from the discussion above we learned about the necessity of natural gas as the swing fuel for electricity production. In addition, the budgetary problems are (partially) solved by increased electricity consumption due to all kinds of electronic equipment and the rebound effect. By raising the tax on natural gas, the government thinks to stimulate energy conservation and a transition into electricity consumption. A sort of push system. Well, just a prediction, not changing this push system into a pull system by the residential energy consumer will lead to chaos. What to do about the "stranded assets" resulting from the reduction of natural gas consumption? For example, you have just installed a high efficiency central heating boiler. Depreciate it overnight? So, unless politicians, legislators, and the executive branch of the Trias Politica, start to communicate, conspiracy is around the corner: tax increases disguised after the veil of the climate change program to compensate for the depletion of the Groningen gas field.

13.1 *Intermezzo. The decline and fall of liberal democracy*

The task of the politicians in The Netherlands becomes more complicated due to the actions taken by single issue associations without political responsibility. Obviously, the actions of those groups are not the real problem. The problem arises when these groups want to be right by means of the courts, the judiciary. One of the branches of the Trias Politica without political responsibility. Then it can happen, and it happened (October 2018)[27]: a judge side stepping into another branch of the Trias Politica, i.e., the legislation with political responsibility. The vulnerability of our democracy is illustrated by the support given by an opposition party of the verdict. An opposition party of the House of Representatives; the legislators. Having no idea what a liberal democracy really means.
In June 2019 the executive branch of the Trias Politica finally realized the existence of their constituency. The government finally started to listen to their constituency. And consequently, made more realistic plans. The government is in the driver's seat and not the Supreme Court.
End of Intermezzo.

Where does the electricity for the heat pumps really comes from? Wind- and solar power? Wind – and solar power, sustainable energy? It is almost an oxymoron. Capacity problems and grid integrity is not paid attention to. Storage problems will last for a considerable time. Keep in mind the amount of time it takes before a mature storage system penetrates the market in a

[27] It happened again in 2021.

massive way, 25 years? We do have some experience in this respect. Think of the introduction of electricity in the past. Yergin (page 559):"*'Even accelerated energy transformation will take decades'. Adding to the challenge is the complexity of systems integration. Combining three of four dozen technologies for a smart grid system is far more difficult – and time consuming - than producing a new iPhone app"*.
Calamities will occur.[28]

13.2 Grid capacity and Integrity, Hydrogen.

As mentioned before, grid capacity, high- and low voltage grid, is a major problem. Research has been started recently to deal with the grid capacity problem.
No easy answers are available yet. That will take some time. It is about research. The low voltage distribution grid needs to be improved. An infrastructure of an 80000 kilometres is needed. Think of electric vehicles, heat pumps, induction cooking, etc. Billions of euros. The numbers I read in the newspapers "improve" day by day.
Well, it is about intermittency. Not only the absence of wind and solar, also an abundance of wind and solar. It is prohibitive for the grid operators to construct a grid lay out for the highest possible solar intensity and wind power. Of course, prohibitive with respect to costs. Estimates for consumers in the Netherlands are of the order of a yearly increase of their energy bill of least 5%.[29]
It is far easier to build a solar park than to expand the grid capacity to serve this abundance of supply. February 2023, a black swan came along. Due to laws and rules related with the release of nitrogen oxides and ammonia in the atmosphere in The Netherlands, the grid operator is strongly restricted in increasing the capacity of the grid. This is not very helpful in improving the grid capacity and stability in order to connect solar panels to the grid. It has been mentioned before, what is needed is storage capacity. For storage, hydrogen can play a significant role. A role for direct storage. An indirect way of storage is to supply households with hydrogen instead of natural gas. Again, to realize this we need time. Energy transition just started in the Netherlands.

Again, and again a comparison is made with the conversion of town gas into natural gas. An activity performed some 60 years ago. A conversion two orders of magnitude smaller than the conversion/transition needed now. Again, politicians speak up. Do not leave this to the so-called specialist lacking the overall view. Hydrogen is an option. We do have a gas distribution grid. However, in older urban areas the gas distribution grid needs to be replaced in order to distribute hydrogen.
The consumer is stimulated to install a heat pump and suddenly it is concluded hydrogen is the

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[28] It happens much sooner than expected. In the beginning of May 2018, no sun, and no wind. Capacity shortage did almost happen. Still, we are faced in The Netherlands with, order of magnitude, just 10% of the energy supply by sun and wind. Gas powered energy supply is needed as a backup.
[29] In 2021, this 5% is small beer compared what happens with the gas and electricity prices due to the transition crisis. Th cost of gas consumption exploded with more than 150%.

replacement for natural gas. Stop this stimulation and start with a small number of pilots.
The European gas transport companies are looking into the subject matter (http://www.theworldofhydrogen) with a long-term view. Quote of the Report on The European Hydrogen Backbone(Guidehouse): *"Large scale hydrogen consumption require a well-developed hydrogen transport structure."*
Here I like to also cite The Economist(13) and (16) (September 21st 2019, October 31st 2020) on Hydrogen Power: *"In the end, hydrogen's impact will be limited by the basics fact that it is, ultimately, just electricity in disguise. It remains an inescapable inefficient option. For some applications, though, its advantages-its energy density, its ability to burn and its compatibility with existing infrastructure- could make it an attractive fit despite that drawback. To paraphrase another famous advert, then, the hope is that hydrogen might prove to be the Heineken of clean energy; able to refresh the parts of an economy that electrification cannot reach"*.[30]
In addition government should not pick winners[31] in order to stimulate conversion(Noordzij,2). This system of picking winners will result into a waste of taxpayers' money.
Without Natural Gas after closing of the Dutch gas fields? I hope not. Let's buy some time to extend the construction LNG-equipment. To cite Yergin:" *Gas-fired generation would swing into action when the wind dies down and the sun doesn't shine"*. Is this what the Dutch households are told and might hope for?
Conclusion: Without a storage system solar-and-wind power just add to the incumbent power production. The latter based on gas, coal, oil and nuclear. Of these four, gas is the swing fuel, i.e., the back-up fuel.

13.2.1 System Integration and Sector Coupling.

The supply of the various resources in our energy system is changing due to noticeably effects of climate change. So, in The Netherlands some players in the energy supply chain have started a discussion about system integration/sector coupling (Tonneyck, et al.). What could that be? Well, it is about tuning of energy demand and energy infrastructure. The thinking at the time of the publication (2020) is the need for the organisation of this tuning of change in energy systems and the various users in the supply chain. How to organise this complex situation? I consider this to be a very subtle activity.
The subject matter is not technology, but the organisation of the above-mentioned tuning. Hopefully, system integration is not just a mantra. It should be an action for the creation of a robust energy production, distribution, and application system. Complexity and sustainability

[30] PlugPower, active with products like hydrogen fuel cells for electricity production, October 2020.
[31] These days the conversion technology for the heating of the houses is proposed to be a hybrid system of a heat pump (electrical driven) and a gas fired boiler. A gas fired boiler. This sounds already as an oxymoron. Spectacular energy saving numbers are communicated. Well, is there any idea about the relation of the outdoor temperature and the efficiency of this so-called hybrid system? During a rather cool winter the COP of the heat pump can fall by about 50%. In addition, this hybrid system indicates another conversion. Another conversion needed when natural gas is no longer distributed. The aforementioned hybrid system is already reality. Rather modern apartment buildings equipped with a heat pump as a central heating system need an auxiliary gas fired boiler for wintertime and warm water with a temperature of 60° C (healthcare regulations).

are major issues. First and for all let it be a simple, robust system with not too many interfaces. Complexity and chaos go hand in hand. Is it large scale versus small scale? Top down or bottom up? Push or pull? Or is there one single effective instrument: taxation? In addition, I hope the players do not try to emulate entrepreneurs.
In the report, the self-organising principle of the players in the energy system is mentioned. Agent based modelling could be a helpful tool. The players in the energy supply chain should be leading.
With the view on nuclear, The Economist(1) 2012, and all the electronics involved, passive safety will be a major issue (Electromagnetic Pulse, EMP).

13.3 The European Super Grid. A virtual storage system.

A reliable connected grid throughout Europe is needed. *The Seams study* (Fairley) could be key to design, construct and connect a European wide grid. Of course, work is going on in Europe. However, *the Seams study* with the simulations can be a supportive tool to motivate politicians. To summarize Seams in a simple way, when there is surplus capacity as a result of wind and solar at one place in Europe, there should be the possibility to transport this surplus to other parts of Europe. In this way a virtual storage system is created in the grid. Absolutely necessary, considering the long lead times for massive alternative storage systems.
Stronger connections in the grid between East and West would accelerate growth of wind – and solar energy, reducing the reliance on fossil fuel, especially coal.
The grid needed to be upgraded to make it work: a reliable, sustainable, and affordable power system.
The Seams study supported the effectiveness and efficiency of advanced long-distance energy transmission technologies.
To paraphrase the Seams report: "*Surplus power from solar plants in the west flooded eastward, where the sun was setting. And as the sun set the Midwest's expansive windfarms began to spin sending power Westward minimizing the use of fossil fuel fired generators*".
The Seams[32] study showed grid operations over a period of 12 years, because the simulated equipment would take several years to build.
Exchanging power enable distributed generators to serve a wider area, reducing the number of plants required. Consequently, this reduces operations of the remaining fossil fuel generators. National cost reductions are obtained by linking up transmission lines to form a European wide network: a Super Grid. The reliance on fossil fuels will be reduced. Not to mention the CO_2 reduction.
An example of the Super Grid under construction is presented in The Economist(20). It is about interconnectors. Interconnection of offshore windfarms over longer distances and hooking up offshore windfarms to onshore power grids. The idea is to separate consumption from production in space instead of in time . In this way a virtual storage system is created. Whether hydropower reservoirs can play an important role in the future as Norwegians hydropower

[32] I am not aware of a European "Seams" study.

plays a role now in the system integration, depends on the effect of climate change(drought) on hydropower. "*Add enough links to enough places, and electricity becomes a tradable commodity. For a local grid manager, reducing carbon emissions becomes a case of buying and selling the right contract rather than building a solar or wind farm in the wrong place."*
Increased transmission helps the grid to respond to extreme events.
Again, the transition into renewables will be enhanced.

13.4 Natural Gas, a long bridge to the future of renewables.

Gas fired centralized power generation is what we need at least to mitigate to some extend the fluctuations on the grid due to solar- and wind power. Fluctuations which can lead to brownouts and, even worse, blackouts. Do not forget the gas fired swing system does contribute to the greenhouse gases. Admitted, in a lesser extent than without solar- and wind power. To enumerate: we still need natural gas to mitigate intermittency of wind power not residential distributed, but a centralized system. That will come with a cost. These costs are not communicated with the consumer. Another serious problem.
In the US natural gas has off set most of the drop in the use of coal. This effect drove most of the drop in America's carbon pollution in 2019.
In Europe, too, cheap natural gas has shifted the market away from coal. For this reason, natural gas has been hailed as a "bridge" fuel[33], a way to cut coal's emission while preparing for a cleaner energy system, such as nuclear. However, renewable cannot by far play this bridge role. As a matter of fact, renewables will just meet new energy demand.
The above text is from The Atlantic (December 2019, Meyer). I consider the position taken in this article rather optimistic. Look for example in India. Most probably Meyer is not aware of the policy route taken in The Netherlands away from natural gas without any mature storage system of solar and wind power.[34]
The subtitle of Meyer's article: *For the third year in a row, carbon emissions from fossil fuels have hit a record high.* In addition, the circumstances changed dramatically in Europe due to the reduced investments by the oil majors. Consequently, we have a natural gas crises and there is a shift back to coal.

Yergin mentioned in his book, page 610, (some argue) *the possibility of high-quality wind resources that are spread out from one another.* What does that mean? Suppose we install a wind farm of nominal capacity on the North Sea of 1 GW. This farm exists for example of 100 wind turbines 10MW each. Now, one day you sail from Rotterdam Europoort to Newcastle up on Tyne. The North Sea as flat as a pancake. Can that be? Yes, it can. So, therefore, you need

[33] In June 2022 to consider natural gas as a bridge fuel can be considered a pipe dream due to the geopolitical situation. Meyer(2): "*In a crisis, natural gas is just as variable as renewables*".
[34] The energy shortage in 2021 made a lot of policies obsolete. What to think of shortage of commodities like silicon. *"It is an irony of our incomplete, abortive energy transition that a shortage of Chinese coal can increase the price of solar panels in America",* Meyer(2), The Atlantic October 13th 2021, The Atlantic *climate newsletter*.

another-mirror- wind farm of 1GW located at a place with high-quality wind resources producing wind power with a security of supply of 95%. Hence each wind farm installed has another 1GW windfarm backup system with a security of supply of 95% and vice versa if and only if you want to get rid of natural gas for your backup system. Costs? Comparable with a storage system?

Conclusion: This 1 GW nominal back-up-or better called mirror-windfarm can be a benchmark, sort of, for a storage system. Or for the swing production system fed wit natural gas. Dependent on the efficiency of the windfarm, 30-50% say, we need a 300-500 MW gas fired power plant. The load following source.

Note: with efficiency I mean real efficiency, i.e., output divided by input. Security of supply is something different.

Here, the super grid comes into play. By connecting the various off-shore windfarms with an undersea super grid and coming onshore to realize the connection with the on-shore grid virtual storage can be enhanced.

Conclusion: For the baseload, the option with an equal carbon footprint as solar we need nuclear power plants (Rhodes, page 324).

In The Netherlands, the government started with some action to get rid of natural gas.
How? Well, the start is with lowering the tariffs of electricity and raising the tariffs of natural gas. Why? To stimulate the replacement of central heating boilers fired by natural gas by heat pumps fired by electricity. Will people invest on a significant scale in heat pumps? Obviously not. Lowering the tariffs of electricity results into an increase of electricity consumption. A rebound effect, sort of. The consumption of natural gas will not decrease. Et voila, a miraculous increase of greenhouse gases.

Do we contribute, in the Netherlands, to lowering the depletion greenhouse gases on a world scale? Hardly.

The Economist(6) August 4th 2018, Briefing on Indian Energy, *The Black Hole of Coal.* There you will find sobering conclusions. Like the conclusion: "*If demand for electric cars picks up, with growth in the number of electric vehicles, for example, coal may become yet more important in the energy mix and the gains from burning less petrol will be offset*".

Well, this offset mentioned by The Economist is already happening in China. There, considering energy from "well head to burner tip", electric vehicles are more polluting than vehicles using gasoline for internal combustion.

Well, reading about India can be very instructive, The Economist(10), December 8th – 14th , 2018.

"*Nothing can be done to save the world as we know it, so nothing need to be done"* . The Atlantic, Science Section, September 2018. Cited from the book of W. T. Vollmann: *Carbon Ideologies, Vol. I, page3.*

Cynical? No, very realistic. A few numbers:

about 1 billion people without electricity. Let's supply them with one light bulb of 50 Watt. The capacity needed is 5×10^4 MW. So, for a little bit of light we do need 50 powerplants of 1000 MW each. Well, one could remark this capacity to be small beer with respect of the world capacity of about 20-25 billion GW. However, these 1 billion people are also longing for air

conditioning, etc. In The Economist(12) February 9th 2019 the subject matter is further illustrated in the International section. So, an additional sobering example given by Goldstein et al page 50: *"To add 100 million people to the grid per year, each using just a tenth of the average US consumer, would require new electricity production of 130T(erra)Wh/year".*
By the way, do we know how much agriculture contributes to the greenhouse gases? Could it be possible that these contributions dwarfs the residential contribution due to energy consumption?
Local governments are facing huge problems with what to choose: all electric, hydrogen, etc.?

13.5 Nuclear Energy, climate change and hydrogen

Nuclear energy the base load and back-up?
Well, this depends on the colling capacity. Hence, the availability of fresh water. Summer 2022, this can become a major hurdle. Then, hydrogen as storage capacity can come into play. Of course, this looks silly: electricity created by wind and solar power used to produce hydrogen by means of electrolysis. Then, use this hydrogen to produce electricity. Silly, yes. However, at the end of the day it is about the costs of an alternative back-up system where hydrogen produced this way is part of a massive storage system.

13.6 State of the Art and a couple of Black Swans

In 2018 the Dutch government decided the country, the residential energy consumer, should stop using natural gas and use instead electricity produced by wind and solar: The Transition. Where are we on this road to transition after five years, 2023? Well, a lot of wind parcs and solar parcs have been installed. No massive storage is available yet.
Some new house are disconnected from the grid with an electric fired heat pump installed. Alas, the heat pump is feeding into a high temperature heat exchange system. So, with outdoor temperatures about zero °C the indoor temperature is about twelve °C. What a transition! The experts commented that a low temperature heat exchange system would have been better. However, such a system comes with a cost which were not included in the construction costs of the residences. That is cold comfort for the renters. Well, this is just an example of transition failure.
Does the politicians realize that the above-mentioned failure can hardly be corrected? Building new residences in The Netherlands is a major problem related with nitrogen oxides and ammonia in the atmosphere and in the ground, respectively. Consequently, existing residences has to be adapted to the application of electrical fired heat pumps. How to install low temperature heat exchange systems in old houses, twenty years old say? Impossible.
Furthermore, the high voltage grid operator in The Netherlands Tennet forecasts the lack of sufficient electricity production capacity after 2030. This is related with well-known problems related with the dependency of wind and solar on the weather. In addition, Tennet seems to believe the super grid, virtual storage, will not be functioning near 2030. Tennet is rather vague whether this super grid will ever be there. The Tennet representative just mentioned the possibility to extend the grid connections with the UK and Scandinavia. This comes with a caveat. Hydropower will become uncertain in a changing climate.

This problem could have been prevented when the gas fields under the North Sea were exploited. The super oil-and gas majors reduced their investment program with more than 40% since 2014. Consequently, they did not invest in the gas fields under the North Sea. Considering the recent gas prices, the investment would have been profitable. Again, here is another caveat. The single-issue associations like Urgenda and Milieudefensie in The Netherlands could have created problems and prevented the oil-and gas companies from producing the urgently needed gas. These single issue associations did create problems. May be the super majors presumed this. Hence, the Dutch citizens could have thanked Urgenda and Milieudefensie for the high gas prices. What worries most is the single issue associations claiming how the future would and should look like. Well, rather arrogant isn't it?
Here I like to cite a special report of The Economist(27):
*Time and again, business leaders say that what they want is consistency. When they make a 15-year investment(*an oil-and/or gas field, N*z), they want to be sure that taxes and regulations at the end of that period will still be the same as at the start. Fiddling with the rules leads to uncertainty, which discourages investments.* How prescient.
More black swans, The Economist (28): *Without reliable alternatives, price increases boost inflation, lower living standards and make environmentalism unpopular. If governments do not manage the energy transition more carefully, then today's crisis will be the first of many that threaten the vital move to a stable climate.*

14.Epilogue

The above discussion seems to be small beer after reading The Atlantic July/August 2018 issue: *Scientist Uncovered a Disturbing Climate Change Precedent*. Summary: "*During the rise of mammals, Earth temperature spiked in a scary way that the planet may experience again soon". The carbon captured millions of years ago, will be released in our time in a truly short period. So, there is nothing mysterious about a much higher carbon dioxide content, not to mention methane, of the earthly atmosphere".*
What is the above discussed transition all about? Well, alas it most probably is "Kurieren am Symptom".
To cite Revelle at Harvard (Yergin, page 451): *"By bringing fossil fuels to the surface and burning them, human beings are simply returning the carbon and oxygen to their original state".*
Is climate change considered to be a problem in The Netherlands? I do not know. After having installed your solar panels, you think you did a great job. So, it is time to regale yourself with a vacation in the tropics. The so-called rebound effect, The Economist(9) October 27th 2018. Just a few tons of carbon dioxide needed.

14.1 Child Crusade and Climate Change.

February 2019. K12 pupils are demonstrating in The Hague (Governmental and legislative residence of The Netherlands). To what avail? It's great to see children demonstrating against climate change. It would be much better to see children convincing their parents not crossing the Netherlands from north to south and from east to west during the weekend to do something jolly ("Leuk", in Dutch). To convince their parents not to spend vacation/holidays in Asia, South America, etc, to mention a few places outside The Netherlands.

14.2 "The earth, a greenhouse planet of the past and of the future".

Illustrated by KAL's Cartoon, The Economist (April 20th 2019).
The role of humanity in changing planet earth atmosphere into a greenhouse atmosphere can be considered important. However, "*On geological timescales, human civilization is an event, not an epoch.*" (Brannen, 2). In The Atlantic issue of October, Brannen (3) reconsidered the Anthropocene after a discussion with the palaeontologists of The Anthropocene Working Group. Citation: "*Whether our civilisation is transient or not, its effects on the living world will last forever"*. Do we conclude this, or will The Beings, populating the earth in the future, draw this conclusion? Well, I am not so sure. Think of the expansion of the Universe. In some million years, The Beings will lack references to conclude about the Big Bang. So, to make the comparison: are The Beings able to conclude about Climate Change caused by the human beings?
Well, the IPCC Report July 2021 does not make us hopeful. The IPCC Report April 2022 seems to play the Cassandra role. It certainly put you not in a cheerful mood. There is not much time left.

14.3 Modelling Climate Change.

To have any idea what will happen in the coming decades with respect to climate change, we need modelling and a lot of measurements.
Modelling, problems to deal with are the non-linearity of the problem and the known unknows. How to model? As mentioned the processes are non-linear in such a way that linearization is meaningless.
We should have an idea of what the effects are of the change of temperature as a function of time. Then the article of Brannen (4) in the Atlantic, *The Terrifying Warning Lurking in the Earth's Ancient Rock Record*, a history of extreme climate change, is sobering reading.
To summarize: Our climate models could miss something big. To cite a few lines: "*Of more immediate interest today, a variation of the composition of the Earth's- atmosphere of as little as 0.1 percent has meant the difference between sweltering Arctic rainforests and half a mile of ice a top of Boston. That negligible wisp of the air is carbon dioxide."*
With respect to known unknowns, the effect of iodine particles on Cloud formation need to be mentioned. The subject matter is discussed Quanta and Kozlov in the science section of the Atlantic: *The Arctic has a Cloud Problem*.

15.Literature.

Belton, C., *Putin's People, How the KGB Took Back Russia and then Took on the West*, William Collins, London 2020.

Brannen, P., *Scientist Have Uncovered a Disturbing Climate Change Precedent*, The Atlantic Science section July/August, 2018.

Brannen, P., 2, *The Anthropocene is a Joke*, The Atlantic, Science section, August 2019.

Brannen, P., 3, *What Made Me Reconsider the Anthropocene*, The Atlantic, Science section, October 2019.

Brannen, P., 4, *The Terrifying Warning Lurking in the Earth's Ancient Rock*, Features, The Atlantic, March, 2012.

De Volkskrant-Sir Edmund, *Iedereen het net op,* 3 maart nr. 2, 2018.

De Volkskrant-OPINIE, *Verdeel de lusten en de lasten van de groene revolutie eerlijk*, 9 juni 2018.

EASAC*, Report On Biomass and Bio Diversity*, www.easac.eu , September 2019.

Fairley, P., *How a plan to save the Power System Disappeared*, Section Politics, The Atlantic August 20th 2020.

Goldstein, J.S. and S.A. Qvist, *A Bright Future and How some countries have solved Climate Change and the rest can follow,* Public Affairs Hachette New York, 2019.

Guidehouse, *European Hydrogen Backbone, How a dedicated hydrogen infrastructure can be created*, July 2020.

Gutman, R., *Dozens of Massachusetts Homes Exploded. A Gas Expert Weighs In.* The Atlantic, Science Section, September 2018.

Het Financieele Dagblad, *……maar de verbouwing kan slimmer en goedkoper*, December 29th 2018.

Jain, S., et al, *Hydrogen: Value Chain and its Challenges as a future Fuel*, Formatex Research Center, www.formatex.info , 2013.

Kaplan, R.D*., In Europe's Shadow, Two, cold wars and a Thirty-year journey Through Romania and Beyond*, www.Randomhousebooks.com , 2016.

Meyer, R., *Big Trends That Increased Earth's Carbon Pollution*, Science Section, The Atlantic, December 2019.

Meyer, R. (2), *The Energy Crunch, in Six Paragraphs*, The Atlantic's *climate newsletter*, October 13th 2021.

Mitchell Waldrop, M., *Complexity, The Emerging Science at the Edge of Order and Chaos*, Simon & Schuster,1992.

Noordzij, L., *Democracy, and its Vulnerability*, www.leennoordzij.me , 2018.

Noordzij 2, L., *Innovation, and its Fallacies*, www.leennoordzij.me ,2018.

Noordzij 3, L, *Government, and Innovation*, www.leennoordzij.me , 2018.

Quanta, and M. Kozlov, *The Arctic Has a Cloud Problem*, Science, The Atlantic, March 2012.

Remkes, J.W., e.a*., Niet alles kan overal, Eindadvies over structurele aanpak Adviescollege Stikstof Problematiek,* June 2020.

Rhodes, R., *ENERGY a human history*, Simon & Schuster, 2018.

Taleb, Nassim N., *The black Swan, The Impact of the Highly Improbable*, Second Edition, Penguin Books, 2010.

The Economist(1), *The dream that failed, A special report on Nuclear energy*, March 10th 2012.

The Economist(2), *Smooth operators*, Technology Quarterly, December 6th 2014.

The Economist(3), *Reinventing Wheels*, *A special report on Autonomous Vehicles*, March 3rd 2018.

The Economist(4), *Geopolitics of Energy*, A Special Report, March 17th 2018.

The Economist(5), *Beauty and long life*, Business section, July 21st 2018.

The Economist(6), *The blackhole of coal*, Briefing on Indian energy, August 4th 2018.

The Economist (7)*, In praise of air-conditioning*, Leaders, August 25th 2018.

The Economist(8), *The Economist at 175, Reinventing liberalism for the 21st century*, September 15th 2018.

The Economist(9)*, Energy Efficiency*, Section Finance and Economics, October 27th 2018.

The Economist(10), *The Environment in India, Poisson all around,* December 8th 2018.

The Economist(11), *Distributed energy, Solar eclipsed*, Business section, December 22nd 2018.

The Economist(12), *Electricity for the poor and What light reveals*, International section, February 9th 2019.
The Economist, *KAL's Cartoon*, The world this week, April 20th 2019.

The Economist(13), *Briefing Climate Change, The Climate Issue,* September 21st 2019.

The Economist, *Dutch Environmentalism, Nitro Dissidents*, Europe section, October 26th 2019.

The Economist (15), *Hydrogen Power, Another look in the toy box,* Section on Science and Technology, July 4th 2020.

The Economist(16), *Climate change and innovation,* Business Section, October 31st 2020.

The Economist (17), *The Hydrogen Business, Burning Clean,* Business Section, July 24th 2021.

The Economist (18), *The energy shock,* Leaders, October 16th 2021.

The Economist (19), *Energy Supplies*, Europe Section, October 16th 2021.

The Economist (20), *Electricity Grids, An Undersea Change*, Business Section, October 16th 2021.

The Economist (21), *Climate change and innovation, H_2's hope and Hype,* Leaders, October 9th 2021.

The Economist (22), *The hydrogen economy, A very balancing act*, Briefing, October 9th 2021.

The Economist (23), *Free exchange An EPIC challenge*, Finance & economics section, March 26th 2022.

The Economist (24), *Carbon Nano Materials*, Science and Technology Section, May 18th 2022.

The Economist (25), *Climate Technology, The energy transition,* Technology Quarterly, June 25th 2022.

The Economist (26), *Charlemagne, Let the sleeper awaken*, section Europe, July 23rd 2022.

The Economist (27), *Companies and the State,* Special Report, February 22nd 2014.

The Economist (28), *Energy shortages, Gas puzzlers*, Leaders, September 25th 2021.

Tonneyck, S.A., H. Wiltink en J.P. van Soest, *Handreiking Sein: Een verkenning naar de orkestratie en organisatie van systeemintegratie in Nederland*, Energie Dialoog Nederland, 2020.

Vollmann, W. T., *Carbon Ideologies, Vol. I&II*, VIKING/Penguin, 2018.

Yergin, D., *The Quest: Energy, Security, and the Remaking of the Modern World*, The Penguin Press, 2011.

Appendix 1: an example.

Nowadays you can find in your in-box offers to install solar panels on the roof top.
Let's consider such an offer to represent the mean possible solar system per house. I will use the numbers given in section The Problem.
Based on 10 solar panels about 2.4 MWh will be produced. Obviously without a storage system. Consequently, the grid is the storage system.
In the foregoing sections we explained the need to replace 5.5×10^{10} kWh natural gas equivalent. Keep in mind: a massive energy saving program is involved.
With the energy production of 10 solar panels, you find the number of solar panels to replace 5.5×10^{10} kWh natural gas equivalent: 2.4$\times$ 10^8 solar panels.

The investment for 10 solar panels, tax credit included, is € 3500. So, the total investment for 2.4$\times$ 10^8 solar panels is € 85 billion. To make the comparison with natural gas, a storage system

is necessary. It is rather difficult to give a number for the costs of a storage system.
A number for a back-up system is available with the assumption that the power needed is 60% of the peak capacity of the solar-and wind power. This back up system is a combination of base load and peak load to balance the variable load of wind – and solar power.
To take a complete picture we also need a number for the costs of replacement and conversion of a heating system. I infer the use of heat pumps with a sufficient large COP in order not to need auxiliary equipment in the winter season. How many heat pumps do we need?
Well, it depends on the number of houses. Based on the solar panels, 10 per house, the number of houses should be: 24×10^6. That is certainly not the case. The number of houses is about 6 million. So, we see at once the possibilities of solar system: including a reliable storage system the solar power produces about 25 % of the energy needed[35]. I repeat myself time and again: no storage system involved.
With the number of houses estimated to be 6 million, the investment for installing heat pumps(conversion) becomes 6 million times the costs of installing a heat pump. I estimate the costs of installing a heat pump to be € 10.000. Hence the total costs are € 60 billion.
Notice the number mentioned in the section on Further Considerations on Dealing with The Problem. There the amount of about € 100 billion for a segment of the housing market is given: € 100 billion. By the way both conversion costs are of the same order of magnitude.
For a given household consumption of 1000 m^3/y, we find the equivalent 10 MWh. Well, with 10 solar panels the production is 2.4 MWh. So additionally, about 7.5 MWh needs to be produced by wind power to have an equivalent of about 1000 m^3/y. As we know, this equivalence is based on simultaneity. This is most certainly not the case. Most of the 1000 m^3/y is consumed in wintertime and most of the 2.4 MWh is produced during summertime. Again, a back-up system is needed or, in the future when available, storage capacity.
About 50 % of the 1000 m^3/y is homogeneously consumed daily to produce warm water. This equals 1.25 MWh in a ¼ year. Let's assume 80% of 2.4 MWh solar power is produced in a ¼ year. From these numbers the conclusion can be drawn for the need of a daily storage capacity of .625 kW. Batteries for this capacity are available.
To cover 1000 m^3/y, 7.5 MWh produced by wind power is needed. Wind power will be produced more centrally. This is making the storage problem a bit easier to be solved.

Appendix 2: Efficiencies.

I used various numbers for the efficiency of solar- and wind power. Sometimes 30%, sometime 10%. This illustrated some ambiguity to say the least. In Goldstein, et al, some 25% is given as a percentage of the available peak capacity.
Why different numbers and what is efficiency meant to be?
A metaphor:
A person is willing to cross a river. This person cannot swim, and the mean depth of the river is 1

[35] I did not include so-called solar panel parks(farms). With solar parks included about 50% of the energy is produced.

meter. The height of this person is 1.8 meters. Would you advise this person to cross the river?
For solar- and wind power capacities are given. Are these capacities mean values based on an availability and yearly production? Goldstein, mentioned 25% as percentage of peak capacity. Not knowing capacities is not reassuring. Since for example, at the very moment you need peak capacity no sun and no wind. So, what is the efficiency of a non-available production system? Suppose we have an output of a wind turbine. Then we have a so-called capacity factor. This factor is defined to be the total yearly production of the wind turbine divided by the maximal possible production. This factor is about 25%. When a capacity of a turbine is mentioned the nominal or maximum capacity is meant.
Further reading on Wind farms: www.nl.mwikipedia.org *Wind Energie.*