

There is a big difference between having electricity just as the sun shines, 24-electricity, and 24×365 electricity.

1,000 kWh/a electricity just when the sun shines

1 kWp PV

1,000 kWh/a 24-electricity. Electricity all the day but only with the yield of this day.

1 kWp PV

3 kWh bat.

1,000 kWh/a 24×365. Huge conversion losses

2 kWp PV

6 kWh battery

**Power to Methanol or Methan
Storage for Methanol or Methan
CCPP Combined Cycle Power Plant**

**This is the situation here in Austria far away from the equator.
Closer to the equator, 24×365 electricity is far easier.**

There is a big difference between replacing 8 kWh thermal energy by 1 kWh electricity at scooters (very small gasoline engines have terrible efficiency) and replacing 1.6 kWh thermal energy by 1 kWh electricity by changing cement production from heating the clinker by burning to heating it by electricity.

8 kWh of gasoline in a gasoline scooter replaced by 1 kWh of electricity in an electric scooter



3 kWh of gasoline in a gasoline car replaced by 1 kWh of electricity in an electric car



1.6 kWh of some burnable materials replaced by 1 kWh of electricity at heating clinker



Every component of our civilization must be examined for profitability transitions that have already taken place and those that are yet to come.

We cannot design our future based on already outdated conclusions:

- **Large apartment buildings vs. single-family homes**
- **Traditional village layouts vs. the new energy-optimized**
- **Urbanization vs. reruralization**
- **Energy from Biomass vs. Power-to-X**
- **On which latitudes is a high-voltage grid an advantage or a burden?**

We designed our GEMINI next Generation house and energy-optimized settlements for maximum cost optimization and for worldwide use. At our research, what could our project do for the energy transition?

We encountered many points where profitability transitions had taken place without being noticed. Some are so big that they can be called paradigm shifts.



We got our mobility and transport system not by decreasing the costs of horse breeding.
The change from horses to cars is an example of a profitability transition everybody knows.

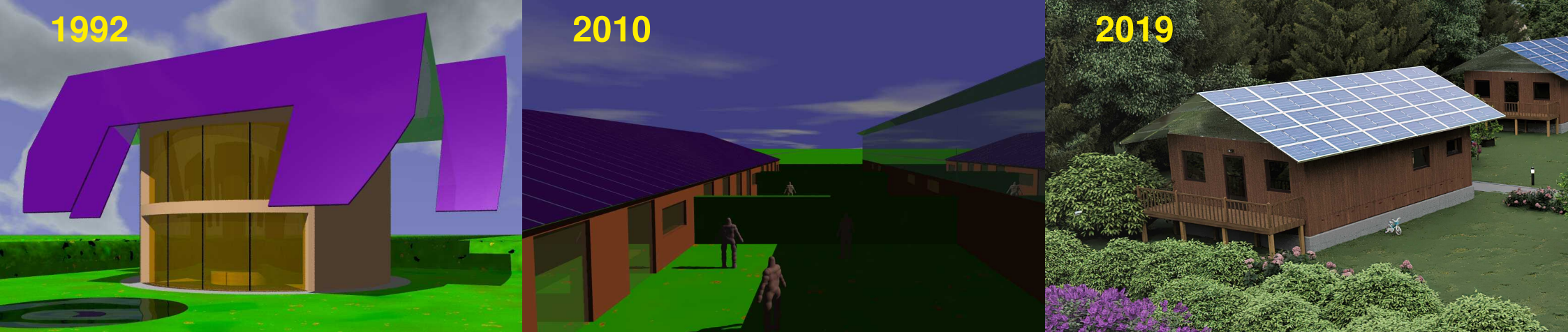


Who could afford a horse for their everyday mobility needs today? It's now an expensive lifestyle item. Big cars now pull horse trailers to events.

Take my lecture as something like a prediction: “Horses will be only for rich people, and rich people will pull their horses in trailers with their cars to distant events.” Unimaginable in 1900, but it happened.

**Many imaginations about our future
had been created in the past with
completely different parameters.**

**Unchecked conclusions from the past
endanger our future with unbearable costs.**



My personal experience with a profitability transition

I designed the GEMINI next Generation house in February 2019 and tried to figure out in March 2019 why it looks so different from my design in 1992. The design target was in 1992 30 MWh yearly yield in Austria.

This can be done with 30 kW peak south-oriented photovoltaic or 23 kW peak horizontally tracking the sun photovoltaic.

Photovoltaics were priced at 7 €/Watt. $30,000 \times 7 \text{ €/W peak} = 210,000 \text{ €}$ but $23,000 \times 7 \text{ €/W peak} + 5,000 \text{ €}$ for turning the house is only 166,000 €.

In 2019, photovoltaics were already so cheap that 30 MWh/a could be best done by 36 kW peak east-west oriented. Now I tried to figure out in what year the profitability transition took place.

It was 2010 and without knowing about the term “profitability transition”, I designed exactly in this year low-rise row houses with south-facing photovoltaic panels.

The equation had changed to $30,000 \times 1 \text{ €/W peak} = 30,000 \text{ €}$ and $23,000 \times 1 \text{ €/W peak} + 7,000$ for turning the house is also 30,000 €.

400 MW CCGT designed for fast load change

800 million € in Germany

no batteries

Can ramp 50 MW/min

60% LHV top efficiency

53% LHV average efficiency

400 MW CCGT designed for highest efficiency

600 million € in Germany

120 million € for 1,000 MWh sodium batteries

Ramp speed only limited by grid compliance

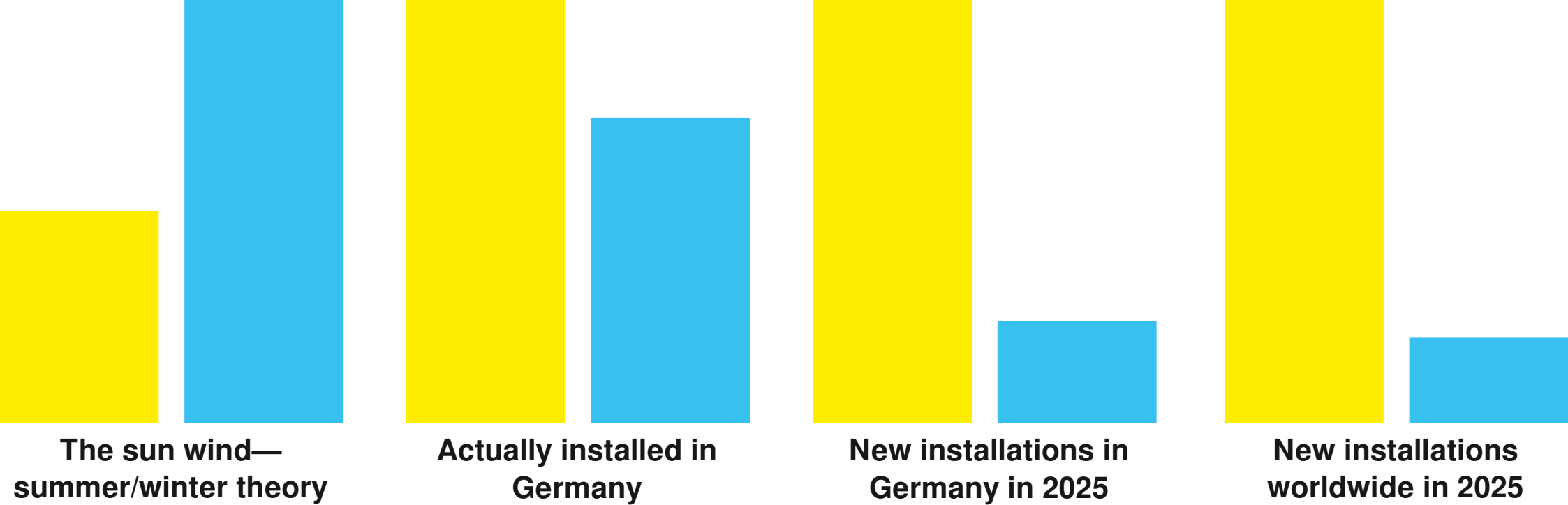
64% LHV top efficiency

59% LHV average efficiency

24-electricity is a cooperation between renewable energy and caloric power plants. There is a weather and demand forecast: the next day we split production on 80% renewable and 20% caloric power plants.

When there are 10 caloric power plants, let just 2 of them run with the highest efficiency.

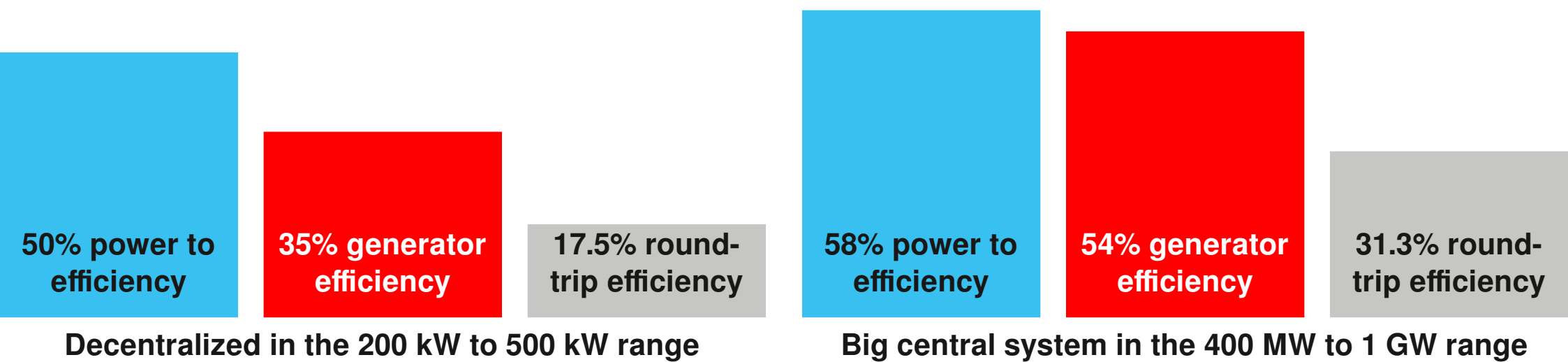
All the different yields of photovoltaic and wind power during the day are flattened by batteries. Surprise, the demand for fast load changes at power plants is gone. The batteries make such a slow load change possible that even the slowest-changing base load power plant can follow.



How to refine 24-electricity to 24×365 electricity? There had been the sun-wind theory for three decades: the sun delivers more in the summer, and wind delivers more in the winter.

This would require, on average, in Europe, 2 kW wind systems for every kW photovoltaic.

Just right now in Germany, 0.72 kW wind for 1 kW photovoltaic, and the gap widens fast: 0.24 in Germany, 0.2 in the EU and worldwide at new installations in 2024 and 2025.



The high-voltage grid is used to transport electricity over long distances. There are three reasons for this:

- Geographical features for wind energy systems and hydropower plants
- Very efficient central large-scale technology
- Minimum and optimal size requirements from energy-intensive industries

There is more wind in the North Sea than in Bavaria. Austria generates about twice as much electricity from hydropower as Germany, which is much larger.

In the past, the centralized large-scale technology counted on the rail connection to bring two freight trains full of coal to the coal-fired power plant every day.

To answer the question, we added to the simulation high-efficiency central systems with 58% at power-to and 54% at generation, grid losses already in the efficiency.

Modules East 25	560
Modules West 25	560
Modules East 8	484
Modules West 8	484
Modules South 5	0
Modules North 5	1,200
Modules Total	3,288
Watt per modul	610
Total Watt PV	2,005,680

Sodium battery efficiency	0.93
Generator Watt	800,000
Generator efficiency	0.35
Generator start penalty hours	0.10
Power to efficiency	0.50
Maintenance	0.02
Methanol buy/sell ratio	0.30

Price fast charging kWh	0.12
Price Photovoltaic per kW	300
Price Sodium battery per kWh	40
Price Generator	60,000

Jump to diagrams with years / methanol price:				
8 / 0.10	12 / 0.10	16 / 0.10	20 / 0.10	
8 / 0.15	12 / 0.15	16 / 0.15	20 / 0.15	
8 / 0.20	12 / 0.20	16 / 0.20	20 / 0.20	
8 / 0.25	12 / 0.25	16 / 0.25	20 / 0.25	

Modules East 25: East-facing modules with a 25° slope.

Generator Watt: Why 800,000 W? The average load is tested up to 400 kW, and the daily load profile has 2 hours with twice the average. To keep the simulation simple and avoid complicated ahead planning, we assumed the maximum possible load as the generator size. 200 kW would be the minimum reasonable size.

Generator start penalty hours: The cold start requires additional fuel.

Maintenance: The maintenance costs each year are $0.02 \times \text{CAPEX}$.

Price fast charging kWh: The off-grid fast charging settlement sells fast charging at this price.

Methanol buy/sell ratio: You cannot sell for the same price as you buy. At 20 cents/kWh HHV, 0.3 means you sell for $20 \text{ cents} \times 0.3$ buy/sell ratio makes 6 cents/kWh HHV.

Jump to diagrams with years / methanol price: The price per kWh and the balance are calculated with 8, 12, 16, and 20 years of depreciation and 10, 15, 20, and 25 cents/kWh HHV methanol price.

Diagram depreciation 20 years methanol 0.20 €/kWh HHV — price per kWh

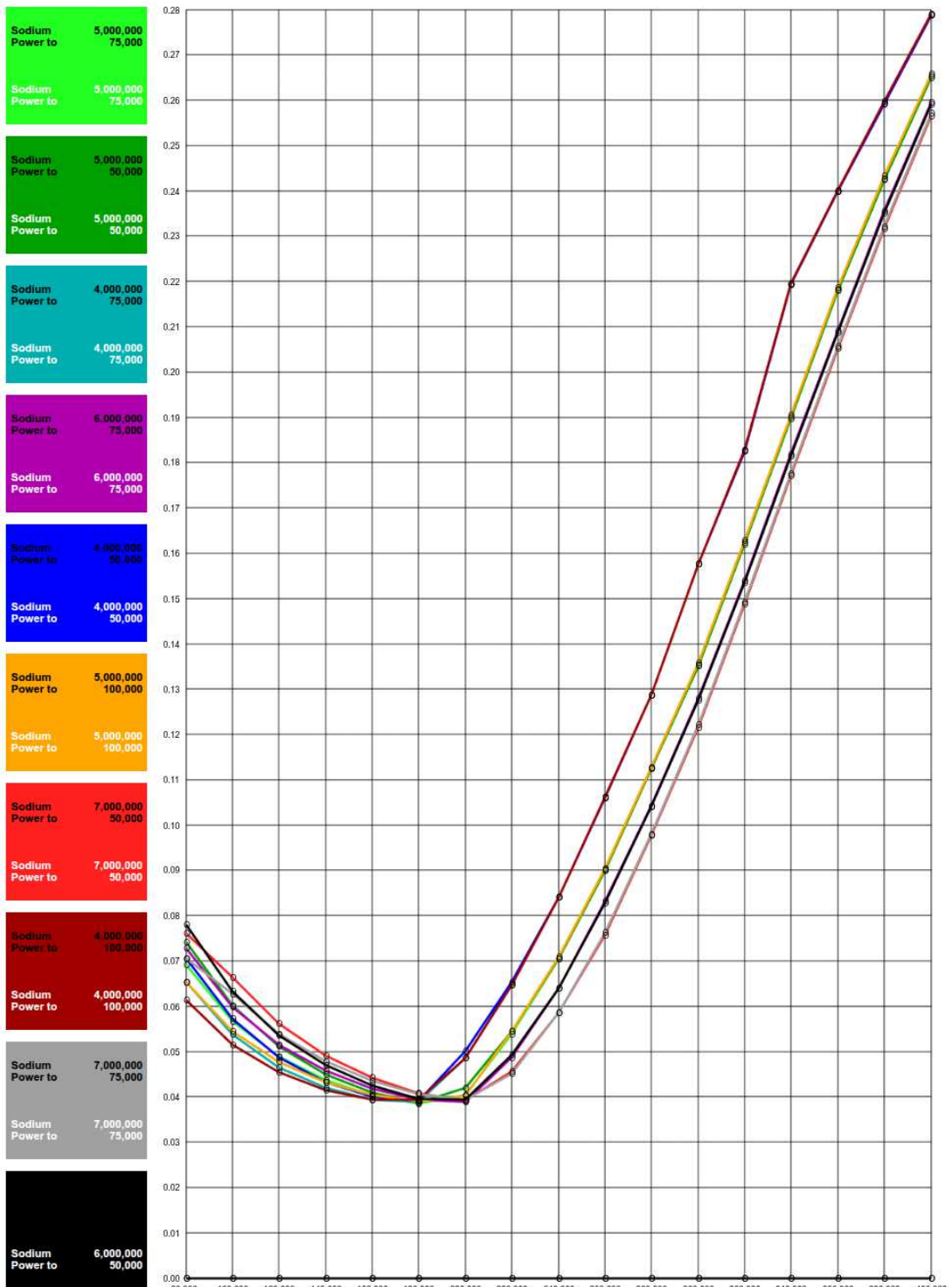
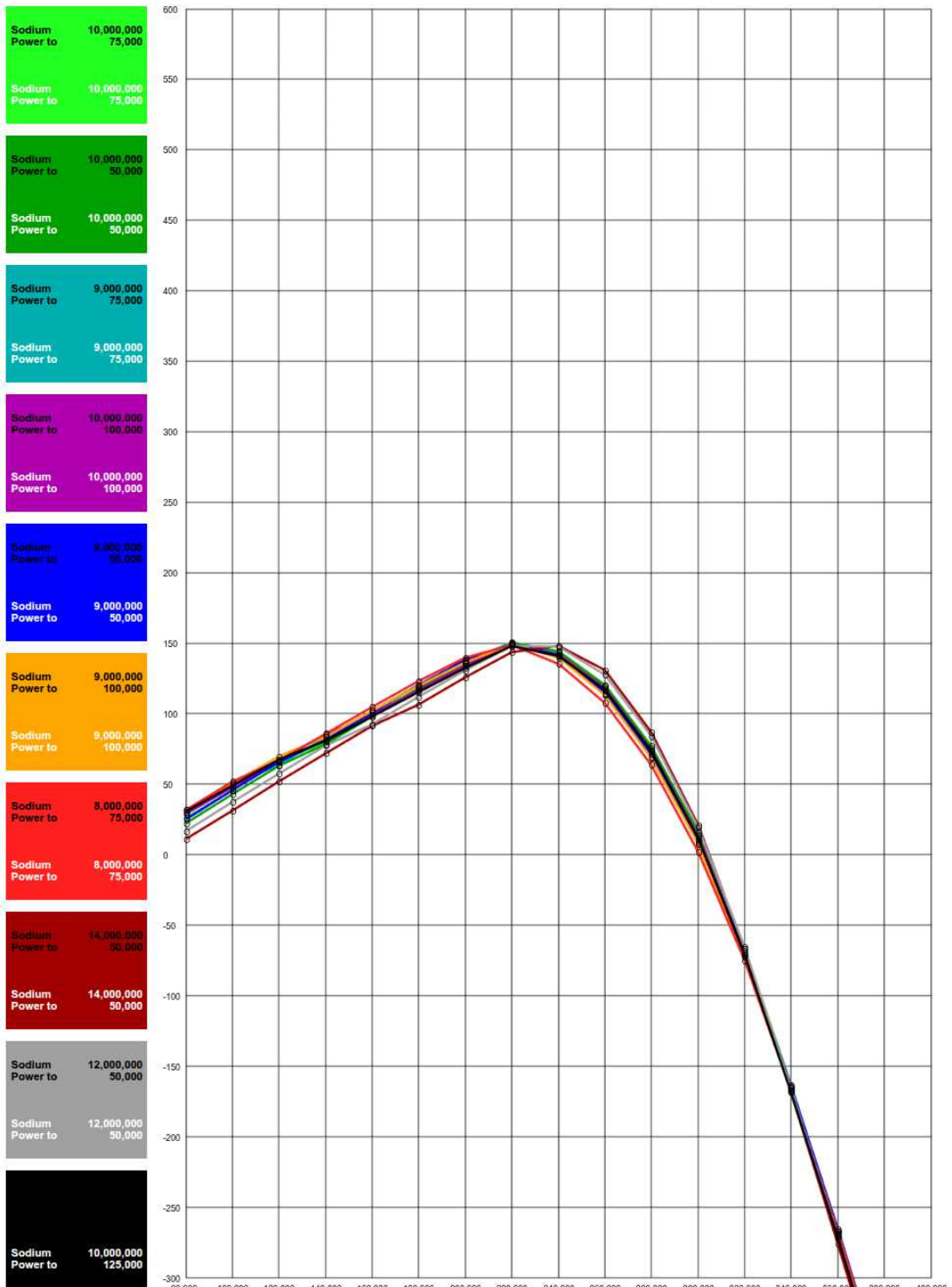


Diagram depreciation 20 years methanol 0.20 €/kWh HHV — balance in 1000 €



Average load: 220,000 W
Sodium batteries: 10,000,000 Wh
Power to methanol: 100,000 W
Price power to: 110,000 €

Methanol kWh	0.10 €	0.15 €	0.20 €	0.25 €
8 years	0.0881 €	0.0881 €	0.0880 €	0.0880 €
12 years	0.0628 €	0.0627 €	0.0627 €	0.0627 €
16 years	0.0501 €	0.0501 €	0.0500 €	0.0500 €
20 years	0.0425 €	0.0425 €	0.0424 €	0.0424 €

Less load **More load**

PV total	2,732,774,438
PV direct used	1,110,366,505
PV to sodium battery	1,103,142,700
PV to power to methanol	105,907,054
PV unused production	413,358,179
PV unused hours	894
Sodium battery total	987,684,817
Sodium battery charge hours	2,991
Sodium battery discharge hours	5,775
Sodium cycles	99
Generator starts	6.44
Generator usage hours	33.56
Generator direct used	5,781,875
Generator to sodium battery	21,068,125
Total price investment	1,171,704 €

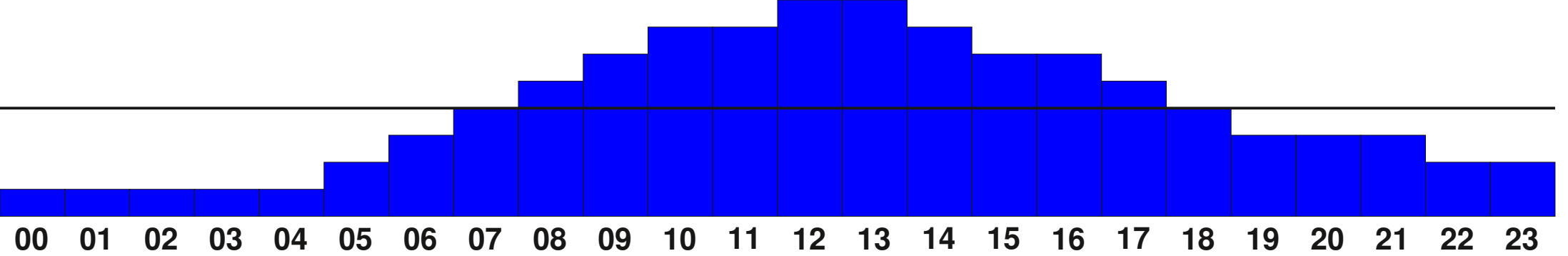
Power to usage hours		1,657
Power to usage hours > 90%		1,578
Methanol produced I/Wh	16,374	81,869,152
Methanol sold I/Wh	737	3,683,438
Methanol purchased I/Wh	0	0

Methanol	0.10 €	0.15 €	0.20 €	0.25 €
8 years	61,477	61,533	61,588	61,643
12 years	110,298	110,354	110,409	110,464
16 years	134,709	134,764	134,819	134,875
20 years	149,355	149,410	149,466	149,521

For each battery, power to methanol and load combination is such a statistic: 1,700 statistics for one location.

PV unused production: The batteries are fully charged, and power to methanol runs at maximum power. Sure, it would be possible to reduce the unused production by much more batteries and a much stronger power-to-methanol system.

All the simulations show that reducing unused production to nearly zero increases costs per kWh.



Daily load profile is a fast charging station

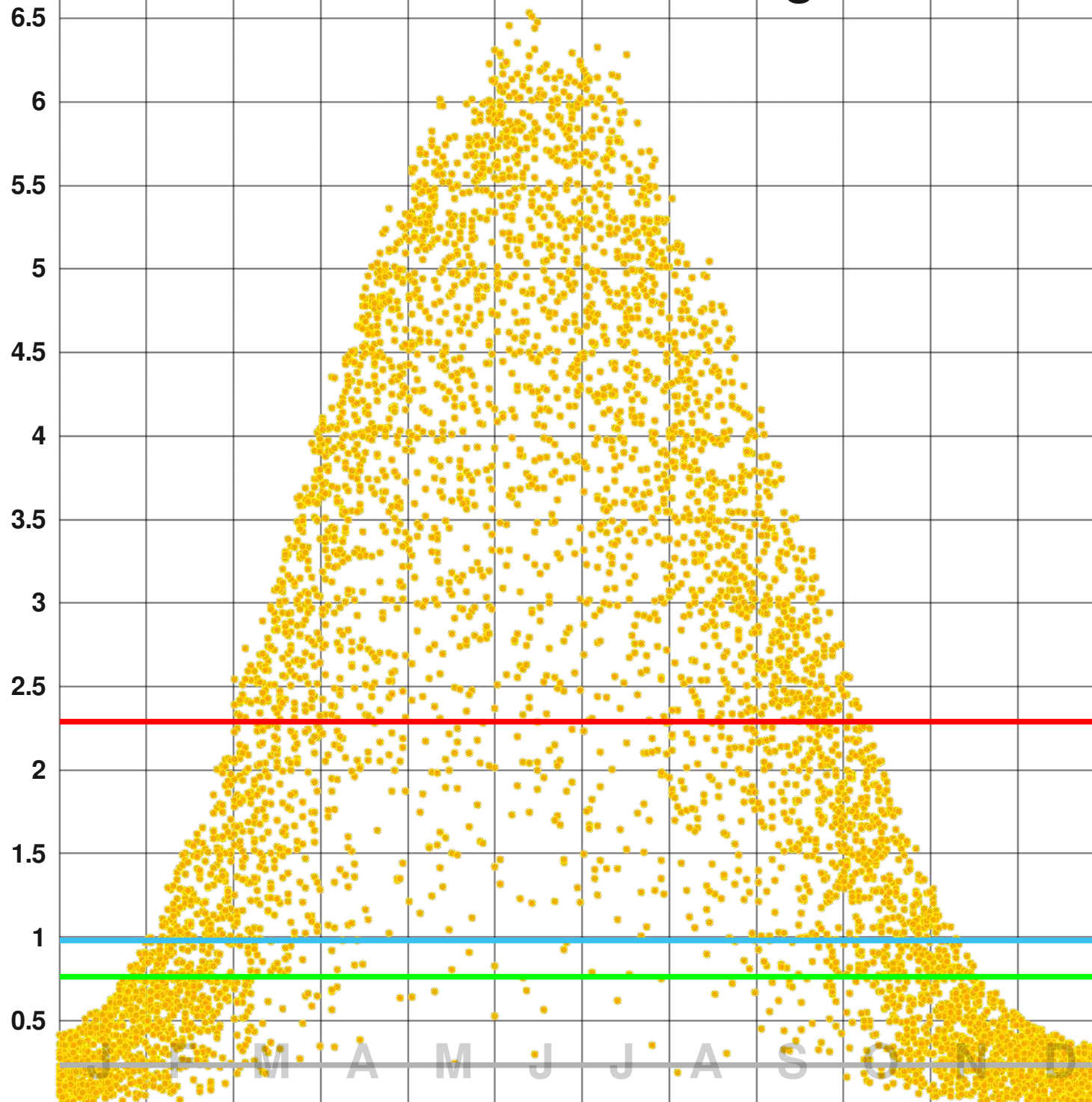
The simulation was created in April 2024 to research the possibility of off-grid fast-charging settlements in Africa. Future versions will have new possibilities to simulate different load profiles.

Industry with variable production: It will be possible to set a minimum percent of production rate. So the industry will throttle down in low solar yield situations.

Old town buildings: Old buildings usually have bad thermal insulation. They need much heating in winter and much cooling in summer.

Greenhouse: Growing plants in a greenhouse has several advantages but requires heating or cooling.

Denmark — Aalborg



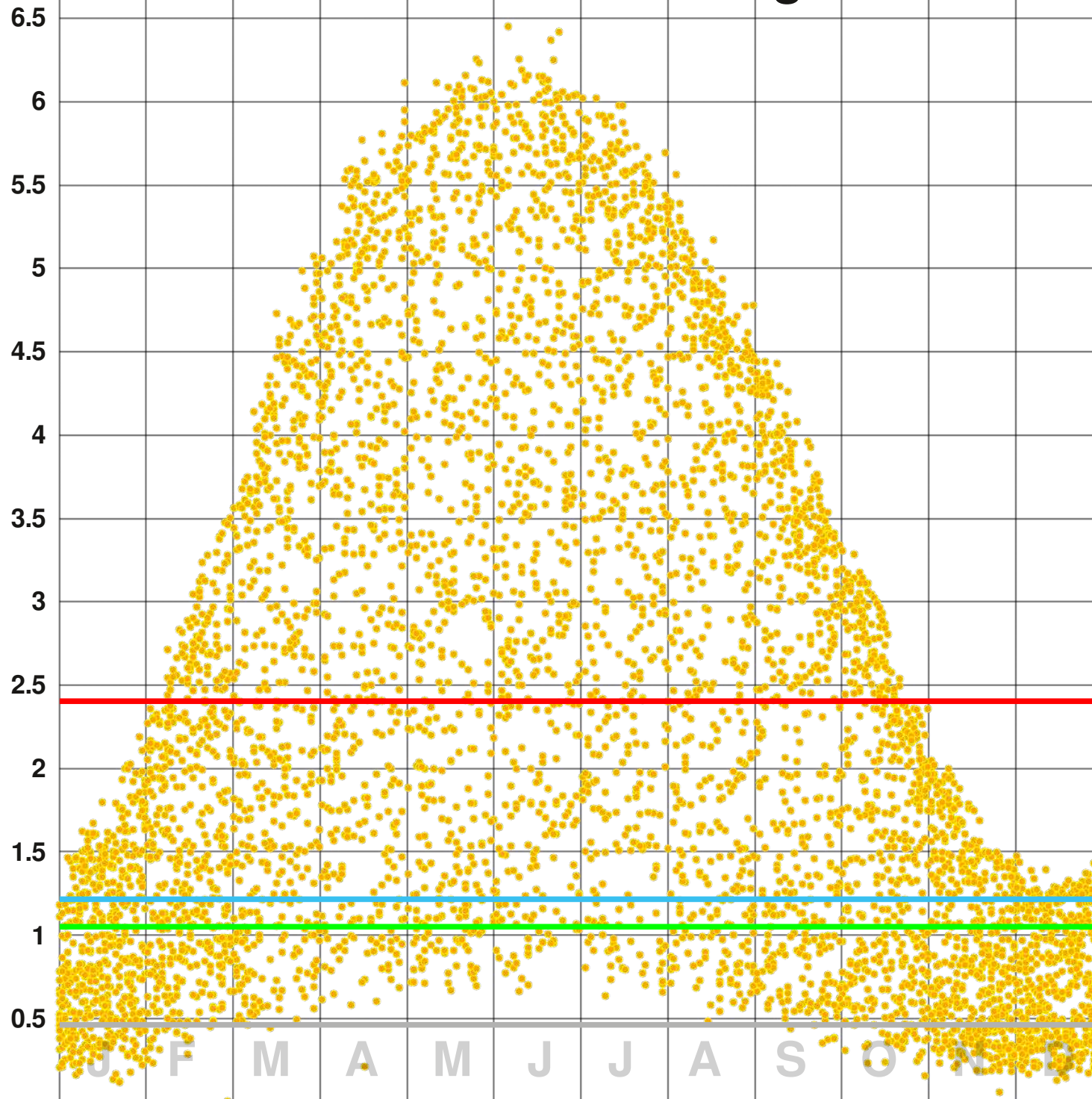
per kW peak photovoltaic:	
battery	2 kWh
power to X	125 W
total yearly yield	837 kWh
after conversion to 24×365	
central with grid	359 kWh
	42.9 %
decentral no grid	280 kWh
	33.4 %
gain by central	79 kWh
	28.3 %
grid cost allowance	151 €

just to study the effect:

Here are 3 battery-only scenarios with the same costs, 3 times the costs, and 10 times the costs.

5.5 kWh battery	87 kWh
	10.4 %
30 kWh battery	193 kWh
	23.0 %
120 kWh battery	283 kWh
	33.8 %

Austria — Salzburg



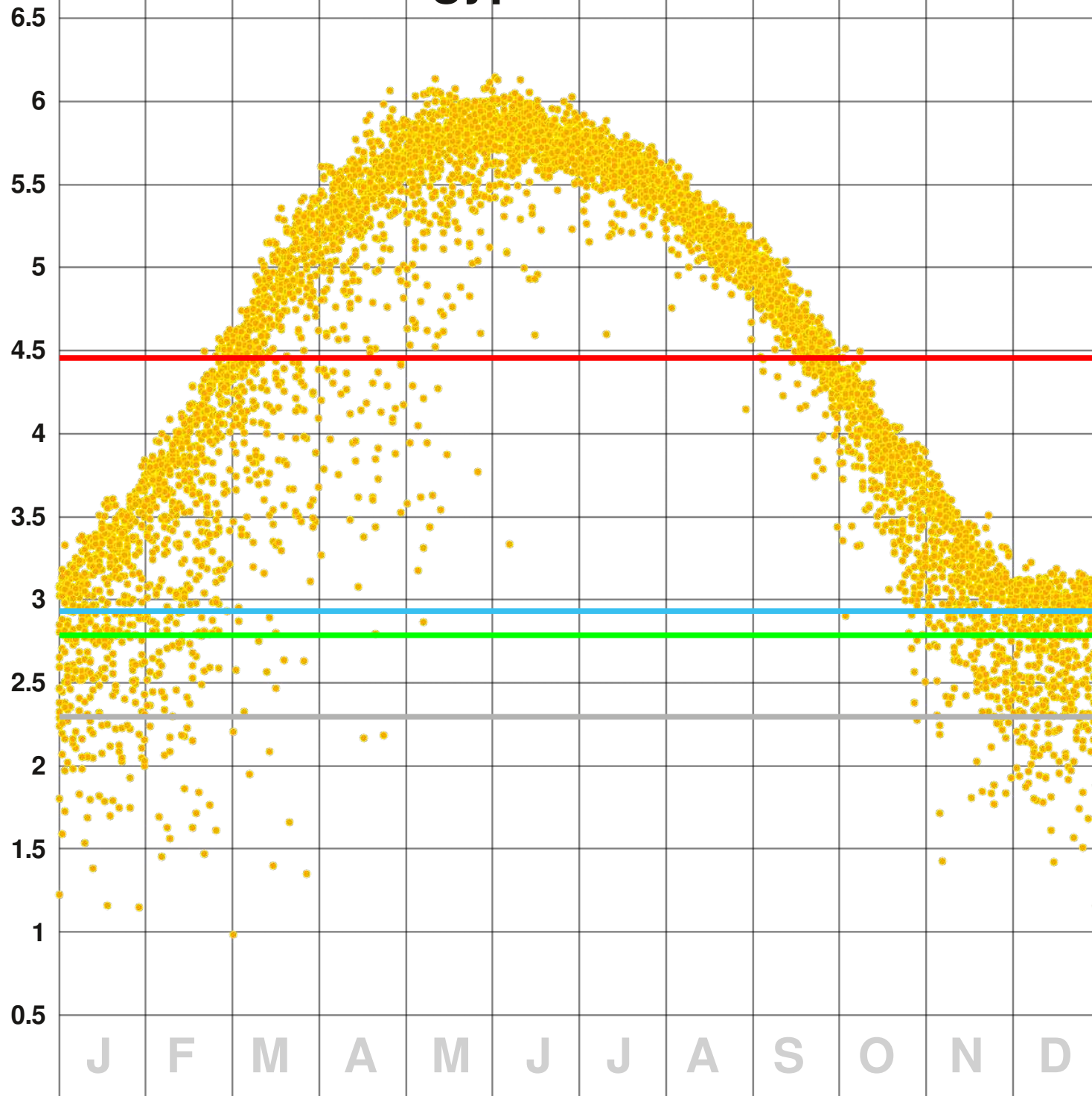
per kW peak photovoltaic:	
battery	2.5 kWh
power to X	75 W
total yearly yield	879 kWh
after conversion to 24×365	
central with grid	445 kWh
	50.7 %
decentral no grid	385 kWh
	43.8 %
gain by central	80 kWh
	15.6 %
grid cost allowance	80 €

just to study the effect:

Here are 3 battery-only scenarios with the same costs, 3 times the costs, and 10 times the costs.

5.5 kWh battery	170 kWh
	19.4 %
30 kWh battery	338 kWh
	38.5 %
120 kWh battery	523 kWh
	59.5 %

Egypt — Cairo



per kW peak photovoltaic:

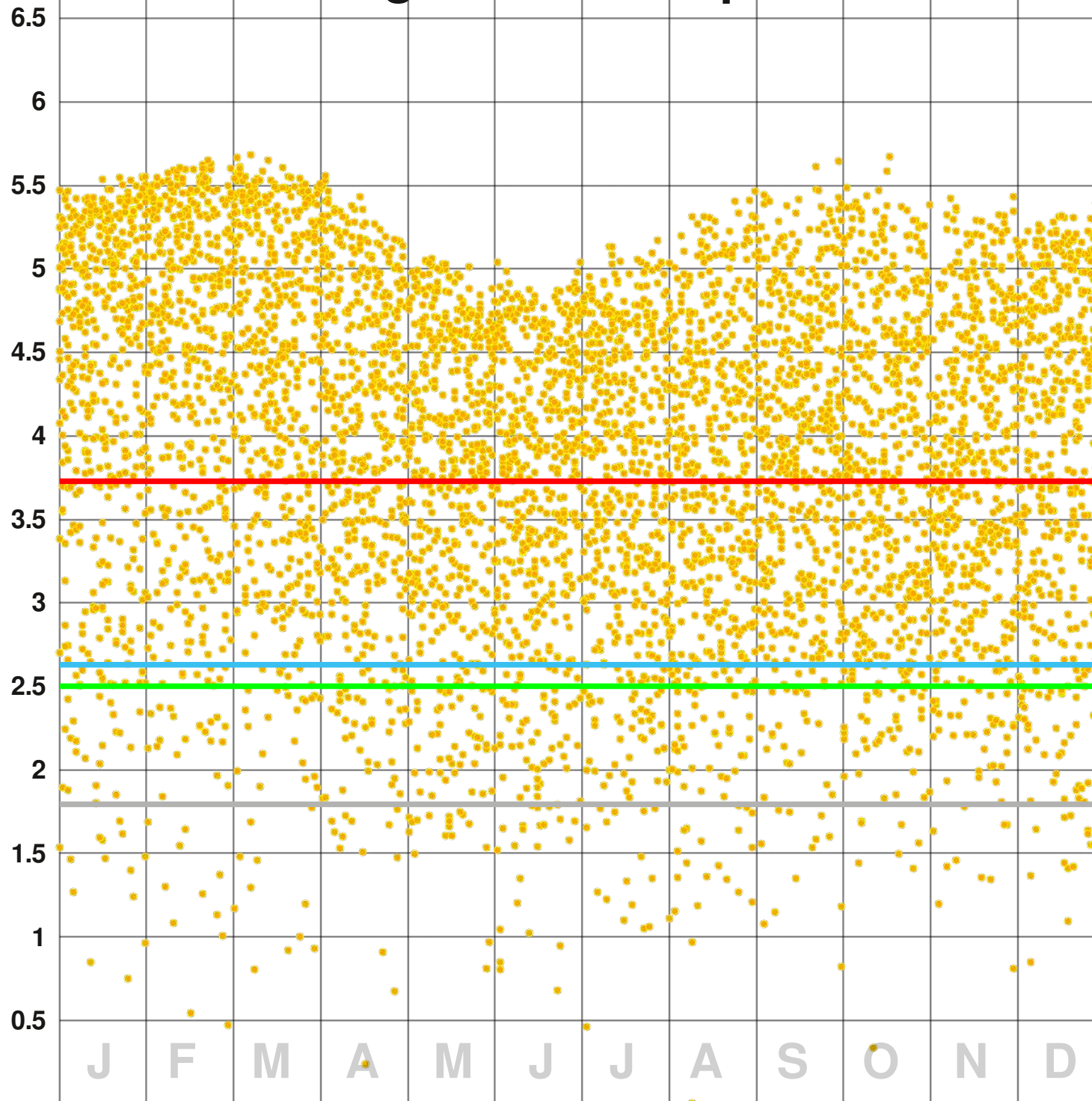
battery	2.5 kWh
power to X	75 W
total yearly yield	1,628 kWh
after conversion to 24×365	
central with grid	1,072 kWh
	65.8 %
decentral no grid	1,019 kWh
	62.6 %
gain by central	53 kWh
	5.2 %
grid cost allowance	27 €

just to study the effect:

Here are 3 battery-only scenarios with the same costs, 3 times the costs, and 10 times the costs.

5.5 kWh battery	839 kWh
	51.6 %
30 kWh battery	1,026 kWh
	63.0 %
120 kWh battery	1,242 kWh
	76.3 %

Uganda — Kampala



per kW peak photovoltaic:

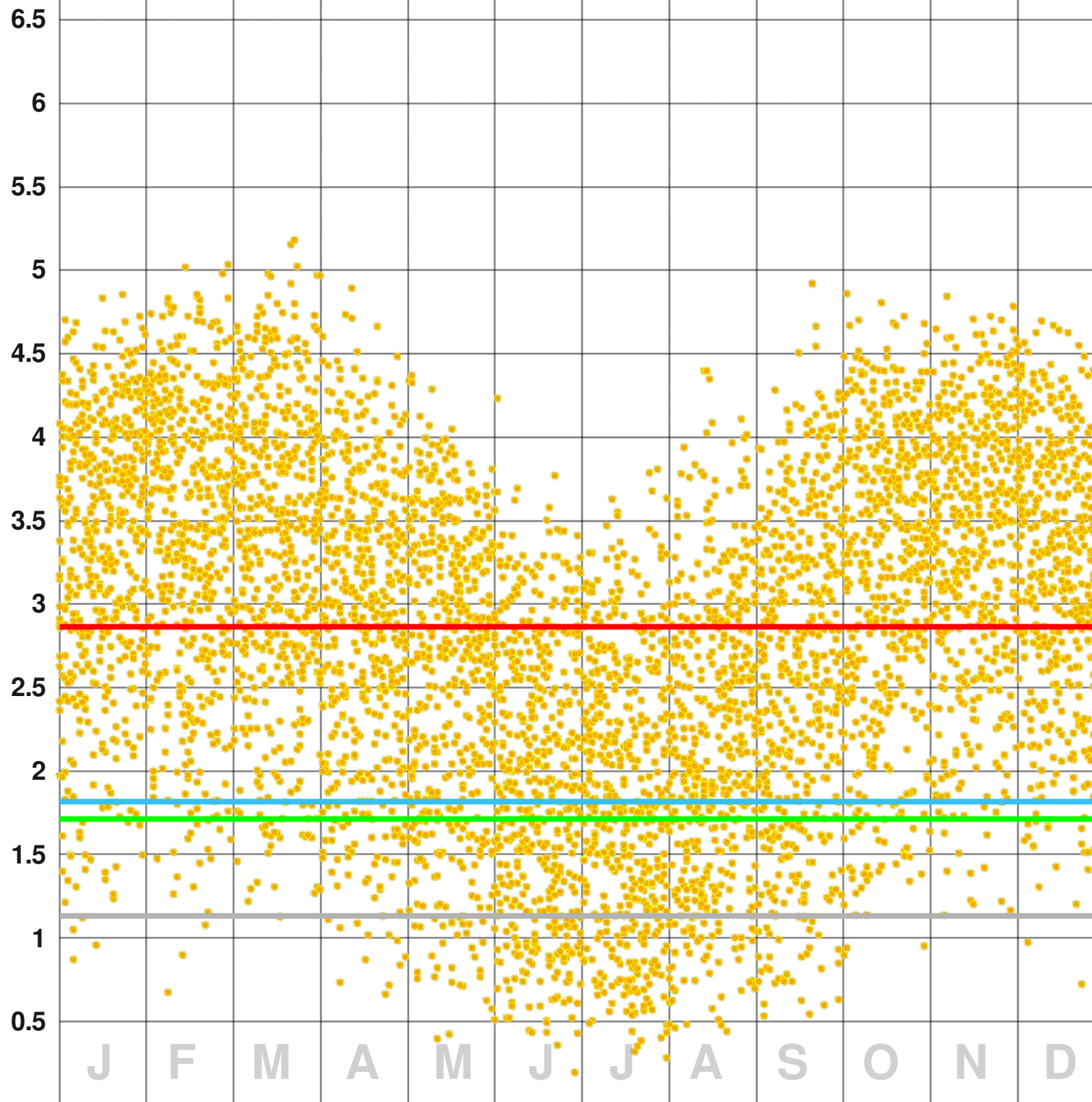
battery	4 kWh
power to X	50 W
total yearly yield	1,363 kWh
after conversion to 24×365	
central with grid	961 kWh
	70.6 %
decentral no grid	915 kWh
	67.0 %
gain by central	47 kWh
	5.1 %
grid cost allowance	27 €

just to study the effect:

Here are 3 battery-only scenarios with the same costs, 3 times the costs, and 10 times the costs.

5.5 kWh battery	656 kWh
	48.2 %
30 kWh battery	1,131 kWh
	83.1 %
120 kWh battery	1,192 kWh
	87.5 %

Indonesia — Timika



per kW peak photovoltaic:

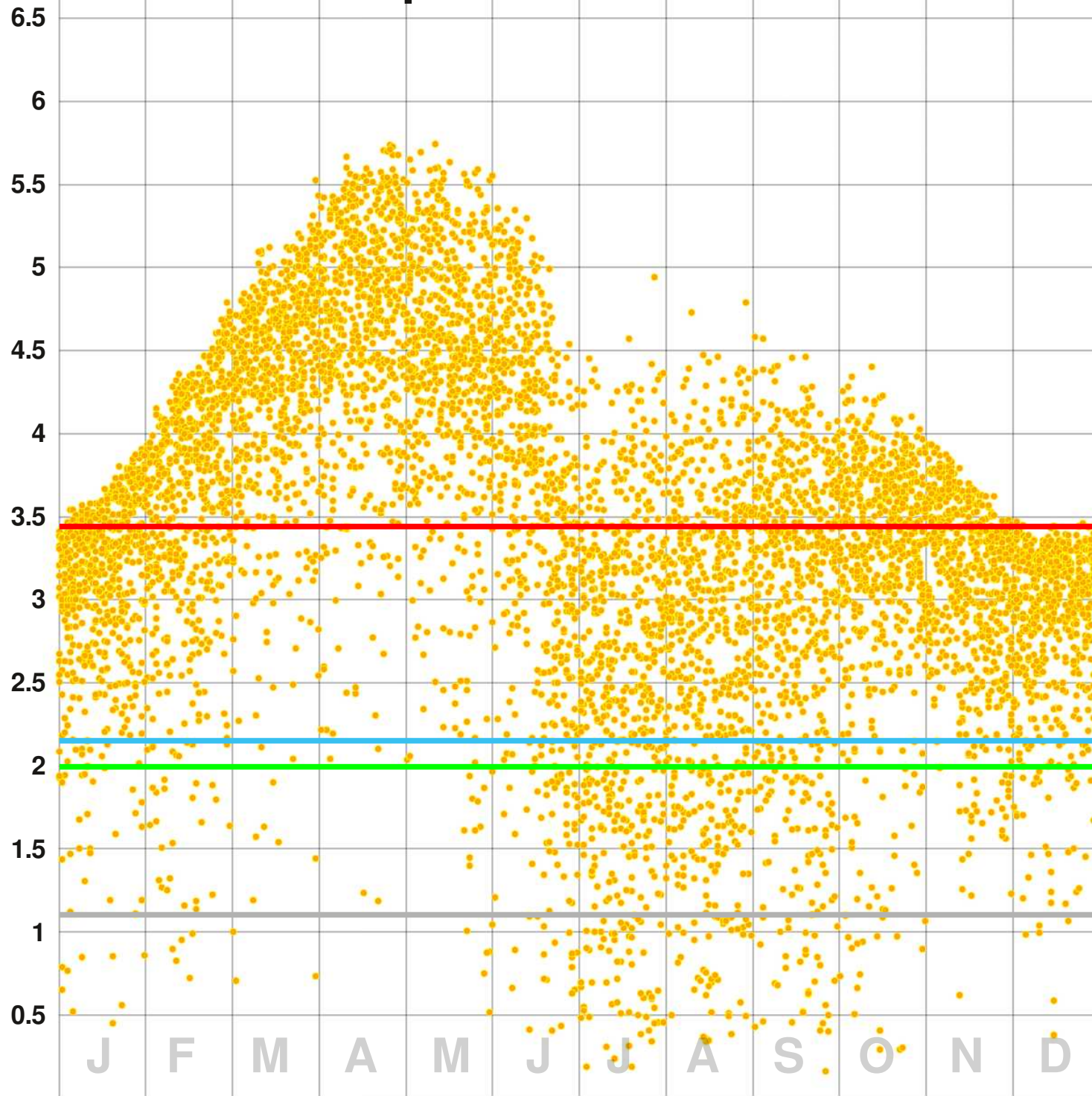
battery	4 kWh
power to X	50 W
total yearly yield	1,047 kWh
after conversion to 24×365	
central with grid	665 kWh
	63.5 %
decentral no grid	627 kWh
	59.9 %
gain by central	38 kWh
	6.1 %
grid cost allowance	32 €

just to study the effect:

Here are 3 battery-only scenarios with the same costs, 3 times the costs, and 10 times the costs.

5.5 kWh battery	415 kWh
	39.7 %
30 kWh battery	686 kWh
	65.5 %
120 kWh battery	940 kWh
	89.8 %

Nepal — Kathmandu



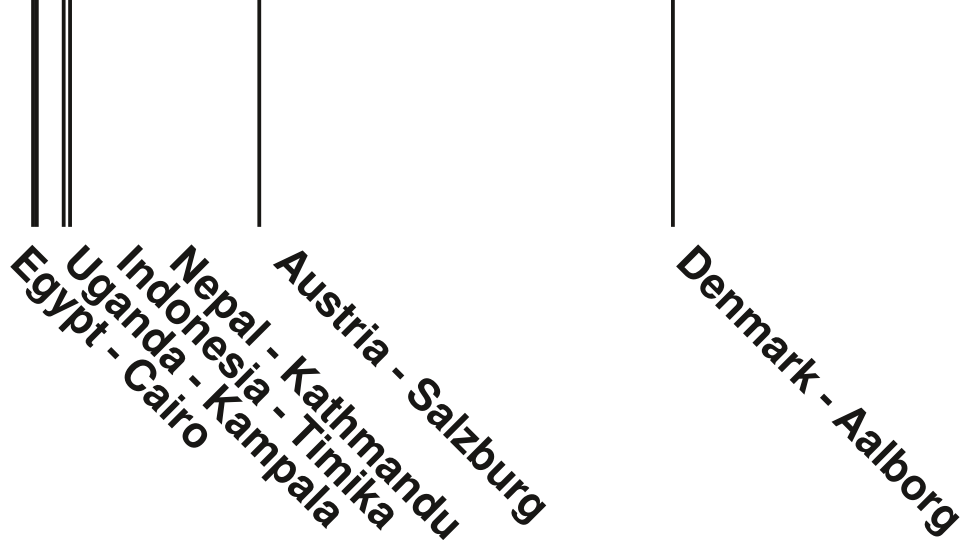
per kW peak photovoltaic:

battery	4 kWh
power to X	50 W
total yearly yield	1,258 kWh
after conversion to 24×365	
central with grid	787 kWh
	62.6 %
decentral no grid	730 kWh
	58.0 %
gain by central	57 kWh
	7.9 %
grid cost allowance	41 €

just to study the effect:

Here are 3 battery-only scenarios with the same costs, 3 times the costs, and 10 times the costs.

5.5 kWh battery	404 kWh
	32.2 %
30 kWh battery	858 kWh
	68.3 %
120 kWh battery	1,044 kWh
	83.0 %



Break even range for a grid connection to supply 1 GWh/a in 1925 inflation corrected

Different time, different places, completely different outcome.

When one century and a location more close to the equator changes the high voltage grid from a “must-have” to an “unnecessary, too expensive”.

Assuming a small consumer, industry, or settlement with 1 GWh/a electricity demand, the grid cost allowance had been 1 to 1.8 million € inflation-corrected.

No question, grid expansion was a great idea. We just showed the range is 27 € to 151 € per kW photovoltaic.

For the assumed 1 GWh/a consumer, this translates to a range of 27 to 534 thousand €. Denmark and Austria are “we already have a great grid” countries. Without these 2 countries in the examples, the range is only 27 to 56 thousand €.

Same photovoltaic

Same batteries

Same generator

biomass

From where comes the fuel for the generator?

**power to methanol
from photovoltaic
surplus electricity**

This duel is for the biomass impossible to win. It is unavoidable that fuel generated from power-to-X from surplus solar electricity will expel biomass from the energy market.

The batteries are full; what to do with the surplus electricity? When you have nothing to use surplus electricity for, it is simple waste. Power to X becomes, in this situation, simple waste utilization.

Components like large storage of chemical energy and caloric power plants are necessary, regardless of the system.

So all the energy from biomass competes against only one component: the power to X system. All the other components are necessary, regardless of the usage of biomass.

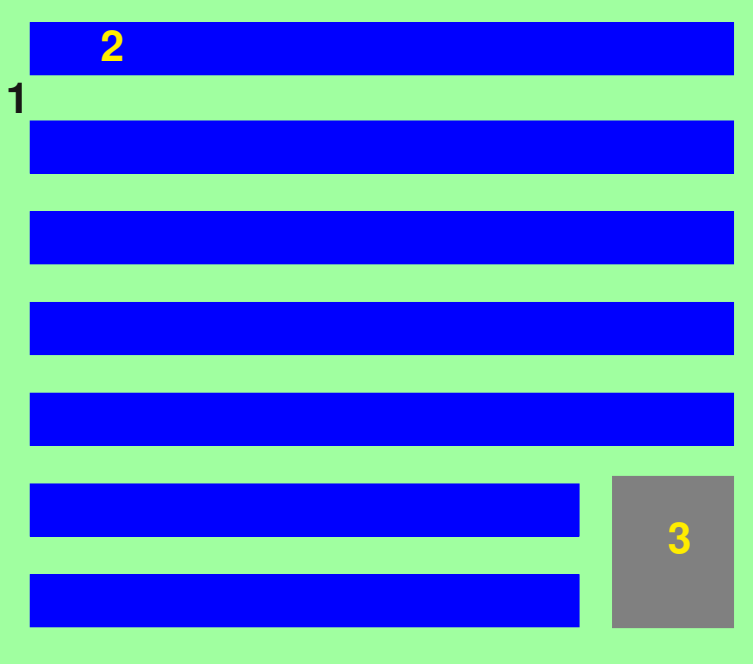
Range of typical single family homes in Germany		1960		2025	
Size		100 m ²	120 m ²	140 m ²	152 m ²
Heat demand per m ²		250 kWh	300 kWh	40 kWh	60 kWh
Heat demand total		25,000 kWh	36,000 kWh	5,600 kWh	9,120 kWh
Range of typical 16-apartment block					
Size		60 m ²	80 m ²	70 m ²	85 m ²
Heat demand per m ²		160 kWh	220 kWh	30 kWh	50 kWh
Heat demand total		9,600 kWh	17,600 kWh	2,100 kWh	4,250 kWh

Both apartments and single-family homes are now bigger but have improved much at lowering the heat demand.

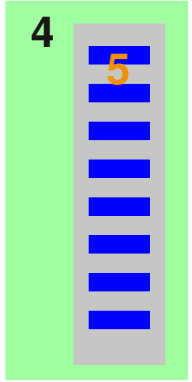
Houses built around 1960 in Germany had been a horror in nonexistent insulation. A typical 16-apartment block had been, at this time, between 160 and 220 kWh/a/m² heat demand and 60 to 80 m² per apartment.

On the other side had been a single-family house with 250 to 300 kWh/a/m² heat demand and between 100 and 120 m² living space.

So a family living in an apartment block had between 9,600 and 17,600 kWh heat demand, while the family in the single-family house had 25,000 kWh to 36,000 kWh heat demand.

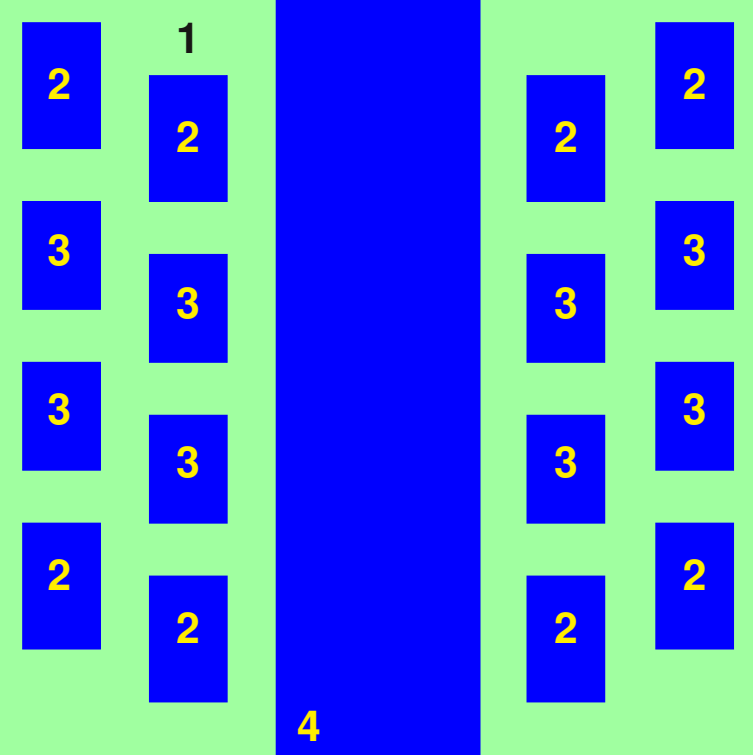


- 1: 0.88 ha of land, 100 m × 88 m for an open field photovoltaic
 - 2: 1,614 photovoltaic modules 1.134 m × 2.378 m
 - 3: Building for inverters, 3 MWh sodium batteries, and a 400 kVA medium-voltage transformer
 - 4: 0.12 ha of land, 24 m × 50 m for housing
 - 5: 16 apartment block, 12 m × 45 m with 8 rows of 7 photovoltaic modules on the roof
- Total 1,770 south oriented PV modules

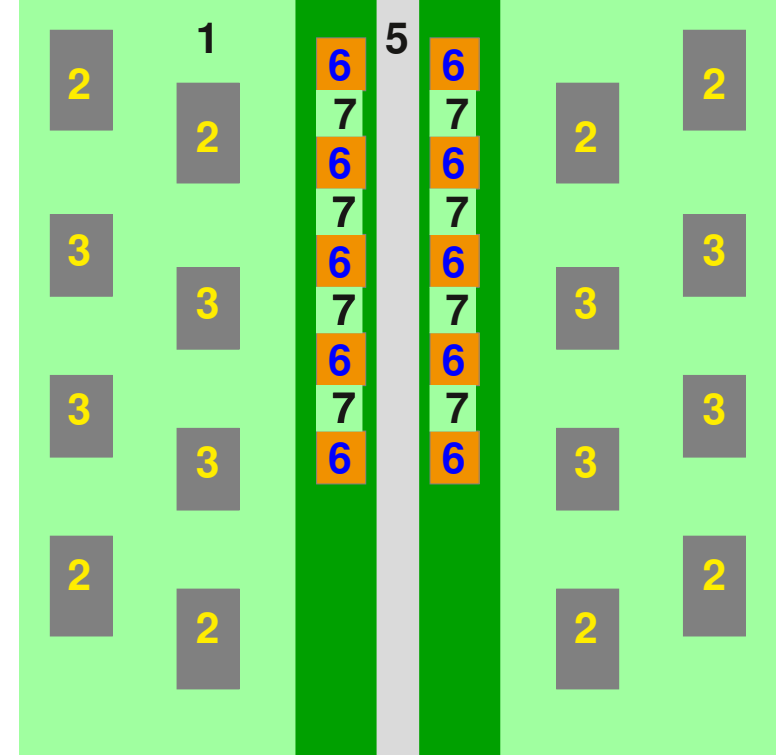


Conventional usage with housing and open field PV seperated

Let's put the 16 apartment block somewhere on 0.12 ha of land and somewhere else 0.88 ha of open-field photovoltaic systems. 1,670 south-oriented photovoltaic modules with 1.094 MW peak.



- 1: 1 ha double used land
 - 2: GEMINI 70 house 70 PV modules
 - 3: GEMINI 60 house 60 PV modules
 - 4: Central structure
1,008 PV modules
 - 5: Access road 5.5 m width
 - 6: Double garages
 - 7: Parking spaces
- Total 2,048 east west oriented PV modules



Left is seen all the photovoltaic from above; right is seen what is below all the photovoltaic.

Optimized usage for better housing, more energy, and fewer costs

Now let's compare this with an energy-optimized village like the one presented in my paper for CORP 2025.



The single-family home is dead; long live the new single-family home, which makes a major contribution to energy transition and climate protection.



Who would trade living here for the canyon-like streets of a big city?



For a complete energy transition, including the electrification of heavy industry, it is necessary for about one-third of the population to live in this way.



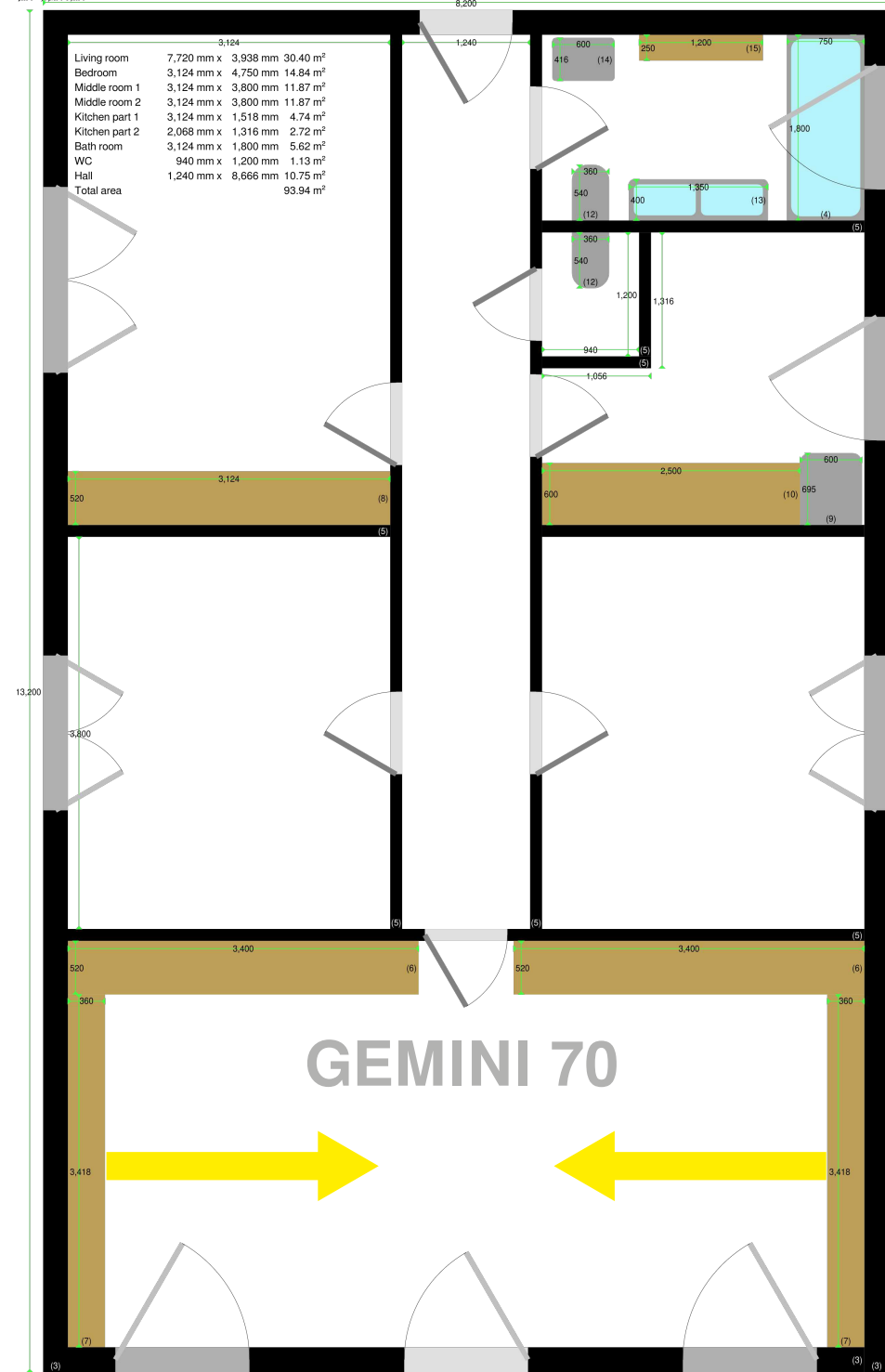
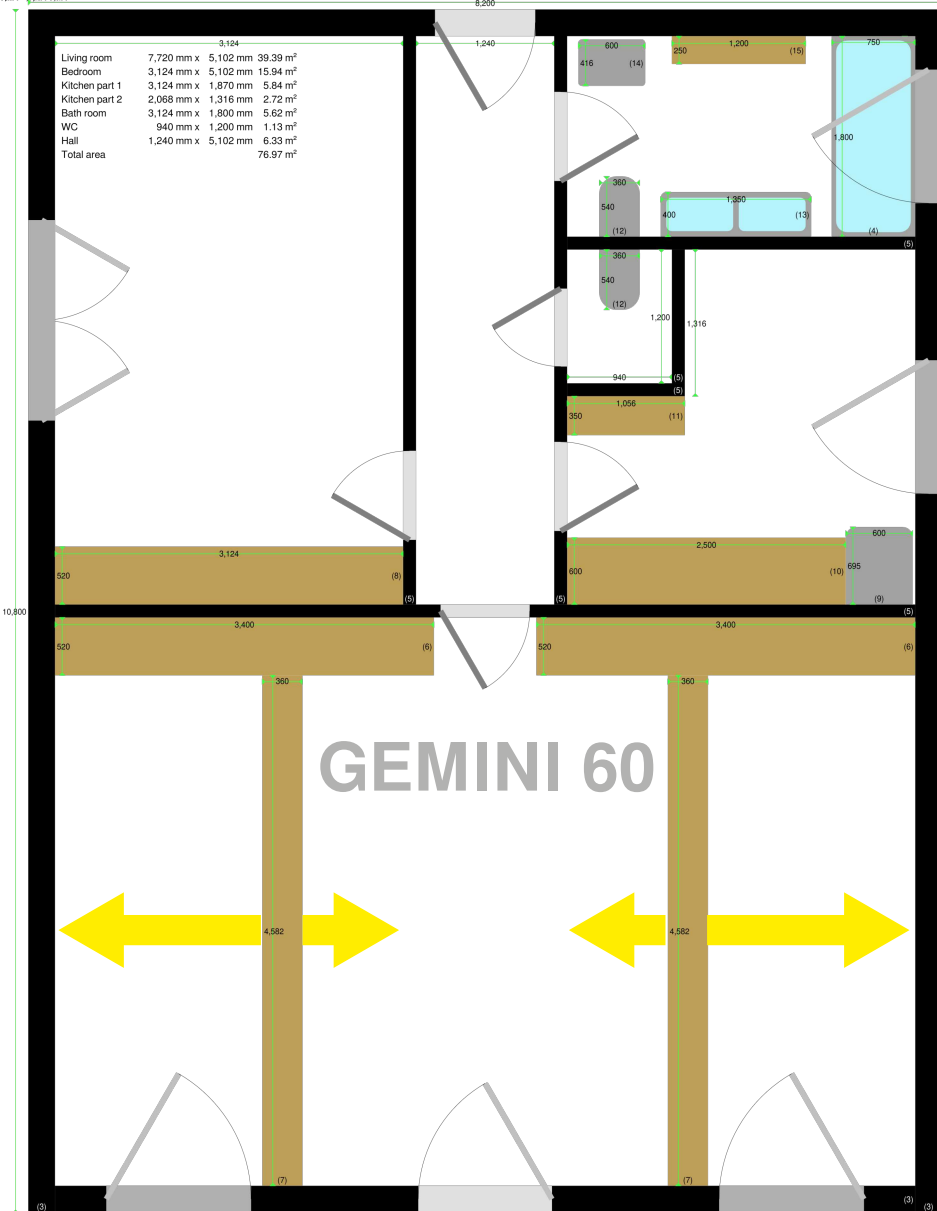
Anyone who generates so much electricity should also be able to use a small portion of it for luxury items: for example, using a swimming pool in Central Europe from April to October.



The area covered by photovoltaic panels is almost 27 m wide. That's enough for much more than just garages and parking spaces.



40% of the area protected from sun and rain by photovoltaics is communal space for sports, children's playgrounds, and shared activities.



Slideable wall/furniture elements for a variable usage as one big living room or a small living room and two additional rooms. We did cost optimization not only at the energy system. Affordability is a key point in every design decision.



We have shrunk the basement. Drawers that are within the thermal envelope of the house.

Perfect conditions for long-term storage.

Lots of space; perhaps a homeowner in financial difficulty might even consider renting out some of the drawers as storage space.



Biodiversity is only beautiful outside.

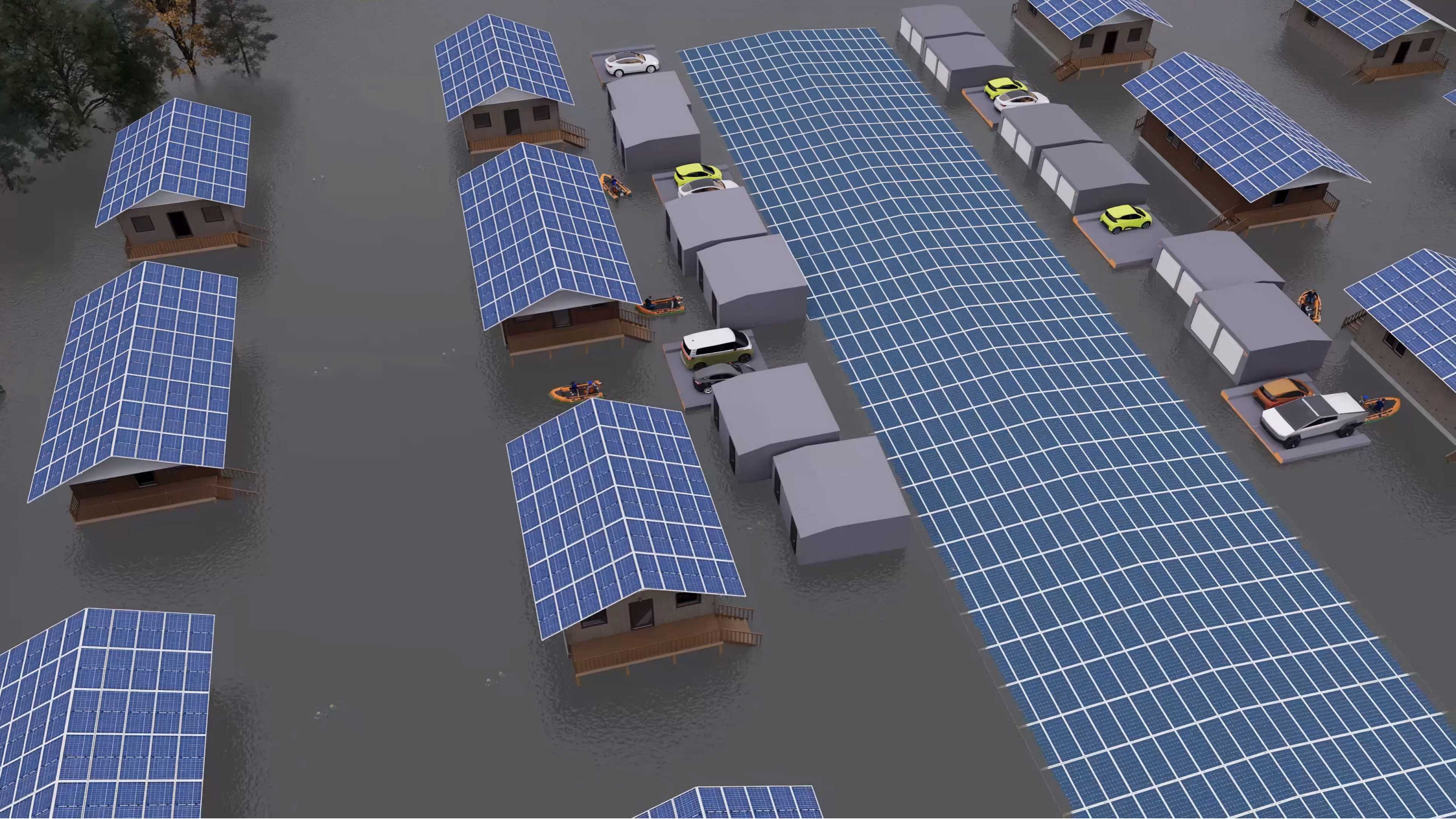
The ventilation system with heat and humidity recovery not only saves energy but also keeps unwanted intruders away. HEPA filters can also be used.



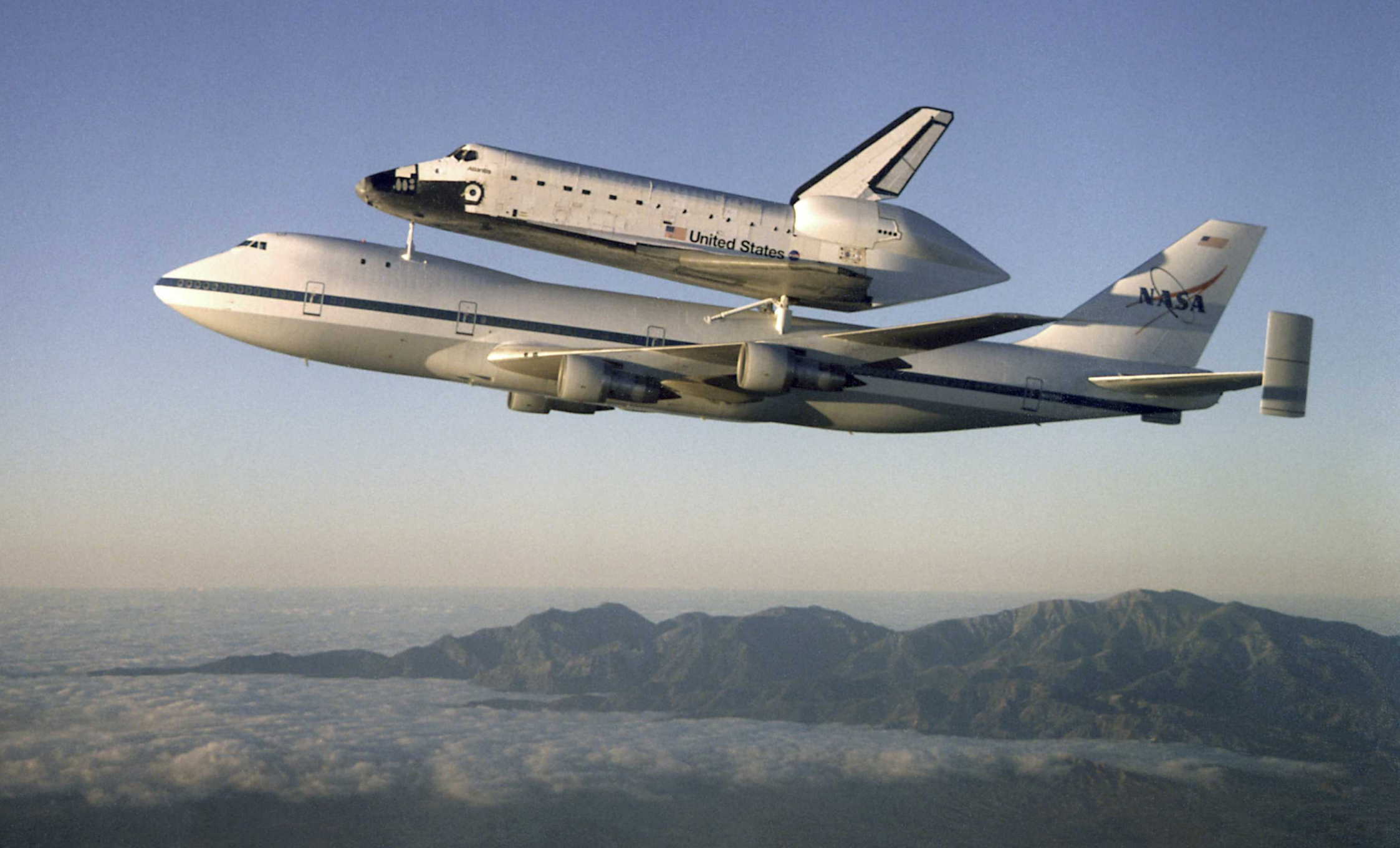
This machine can produce the frame of a GEMINI 60 house in 3 hours.



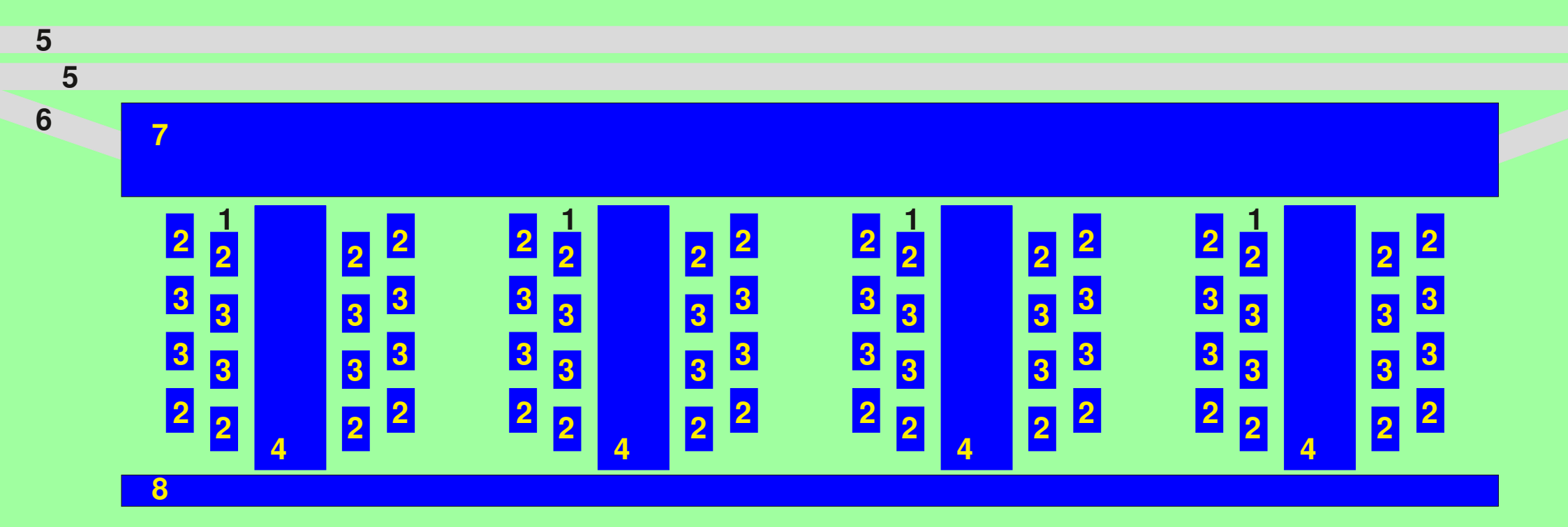
The steel comes from this coil.



The settlement, shown before, at 4.5 m flood. All houses swim. The central structure is fixed, so all garages and parking platforms had been brought outside to swim.



A Boeing 747 carrying a space shuttle makes 322 tons of takeoff weight. Or the weight of 5 Abrams M1 main battle tanks. An 100 m² apartment with 2 places in the underground garage can also be up to 322 tons of construction material.



Typical 24×365 capability for 80 trucks 300 kWh charging and 300 cars 30 kWh charging.

(1) 1 ha double used land

(2) GEMINI 70 house 70 PV modules × 32 = 2,240

(3) GEMINI 60 house 60 PV modules × 32 = 1,920

(4) Central structure 1,008 PV modules × 4 = 4,032

(5) Highway

(6) Street to the fast chargers

(7) 460 × 15 = 6,900 modules above fast charging and gastronomy

(8) 460 × 5 = 2,300 modules above a connection street behind the village

Total 17,392 modules with 11 MW peak. The inhabitants work in the gastronomy of the fast-charging station and as farmers to utilize the surrounding land.

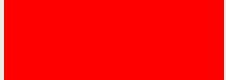
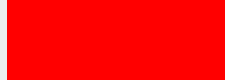


















At the hydropower plant Urstein at the Salzach is a sign: 120 GWh/a, we supply to 35,000 households.

Only 2.5 km distant is the cement factory LEUBE: 110 GWh electricity and 400 GWh heat for 600,000 t cement per year.



















Making a fire to bring the clinker to the required reaction temperature could be replaced by electric-only heating. The 400 GWh heat could be replaced by 250 GWh electricity.

So the cement factory would be with 360 GWh/a fully electric, and the shield at the hydropower plant should be reworded with: 120 GWh/a, we supply 90 workers in the energy-intensive industry.





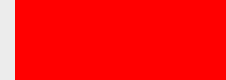













600 kWh per ton for electric only cement production	Aalborg Denmark	Salzburg Austria	Cairo Egypt	Kampala Uganda	Timika Indonesia	Kathmandu Nepal
Usual market price for 1 t	134 €	140 €	66 €	148 €	87 €	89 €
Electricity for the production of 100 € market price	448 kWh	429 kWh	909 kWh	405 kWh	690 kWh	674 kWh
If 70% of the price would be energy, this would be €/kWh	0.156	0.163	0.077	0.173	0.102	0.104
Constant production all the year aound						
Moderate production changes for cost optimization						
Runing only on 24-electricity to be competitive						

The energy subsidies in Egypt are running out. Electric-only cement production by photovoltaics is possible in all example locations.

What moderate production changes in Denmark and Austria? Simple 30 to 45 days break around the winter solstice.

2,000 kWh per ton for electric only mineral wool production	Aalborg Denmark	Salzburg Austria	Cairo Egypt	Kampala Uganda	Timika Indonesia	Kathmandu Nepal
Usual market price for 1 t	2,200 €	2,200 €	1,800 €	1,200 €	1,000 €	900 €
Electricity for the production of 100 € market price	91 kWh	91 kWh	111 kWh	167 kWh	200 kWh	222 kWh
If 70% of the price would be energy, this would be €/kWh	0.770	0.770	0.630	0.420	0.350	0.315
Constant production all the year aound						
Moderate production changes for cost optimization						
Runing only on 24-electricity to be competitive						

I kept hearing from building biologists about the energy required for production, but now it turns out that this is completely uncritical.

450 kWh per ton for electric only scrap to steel recycling	Aalborg Denmark	Salzburg Austria	Cairo Egypt	Kampala Uganda	Timika Indonesia	Kathmandu Nepal
Usual value change for 1 t	250 €	250 €	280 €	160 €	50 €	100 €
Electricity for 100 € market price gain from scrap to steel	180 kWh	180 kWh	161 kWh	281 kWh	900 kWh	450 kWh
If 70% of the price would be energy, this would be €/kWh	0.389	0.389	0.436	0.249	0.078	0.156
Constant production all the year aound						
Moderate production changes for cost optimization						
Runing only on 24-electricity to be competitive						

Seems there is a price anomaly in Timika.

Approximately 29% of global crude steel production is made via electric arc furnace (EAF) melting, which is the primary method for recycling steel scrap (electric melting).

So this is an established technology.

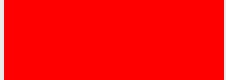
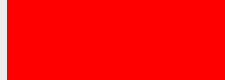


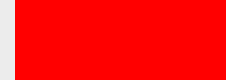
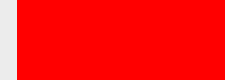












Type	— PEM —		— AEL —			
	Year	2010	2030	2010	2030	
Photovoltaic	1 kW	1,500 €	300 €	1.2 kW	1,800 €	360 €
Batteries				3.6 kWh	1,800 €	144 €
Electrolyser	0.8 kW	1,600 €	1,600 €	0.25 kW	200 €	200 €
Total		3,100 €	1,900 €		3,800 €	704 €

Surprise, we have again detected a missed profitability transition.

There had been a time when photovoltaics and batteries had been extremely expensive.

No batteries are necessary at a PEM electrolyzer, making the best usage of the expensive photovoltaic. In this scenario, the high price per kW of PEM electrolyzers did not matter. In this scenario, the scarcity of iridium did not matter.



















But here again, we have a missed profitability transition. How can this happen so often in the area of the energy transition?

4,000 kWh per ton for electric only steel production from ore	Aalborg Denmark	Salzburg Austria	Cairo Egypt	Kampala Uganda	Timika Indonesia	Kathmandu Nepal
Usual market price for 1 t	650 €	650 €	670 €	550 €	450 €	500 €
Electricity for the production of 100 € market price	615 kWh	615 kWh	597 kWh	727 kWh	889 kWh	800 kWh
If 70% of the price would be energy, this would be €/kWh	0.114	0.114	0.117	0.096	0.079	0.088
Constant production all the year aound						
Moderate production changes for cost optimization						
Runing only on 24-electricity to be competitive						

Changing the production of steel by ore: 2 kWh of electricity replaces 1 kg of CO2 emissions.

If you want iron, you first have to remove the oxygen. This can be done either with carbon or hydrogen.

With carbon, you get 2 kg of CO2 emissions per kg of iron, while with hydrogen you have to use about 4 kWh of electricity to produce the necessary hydrogen.

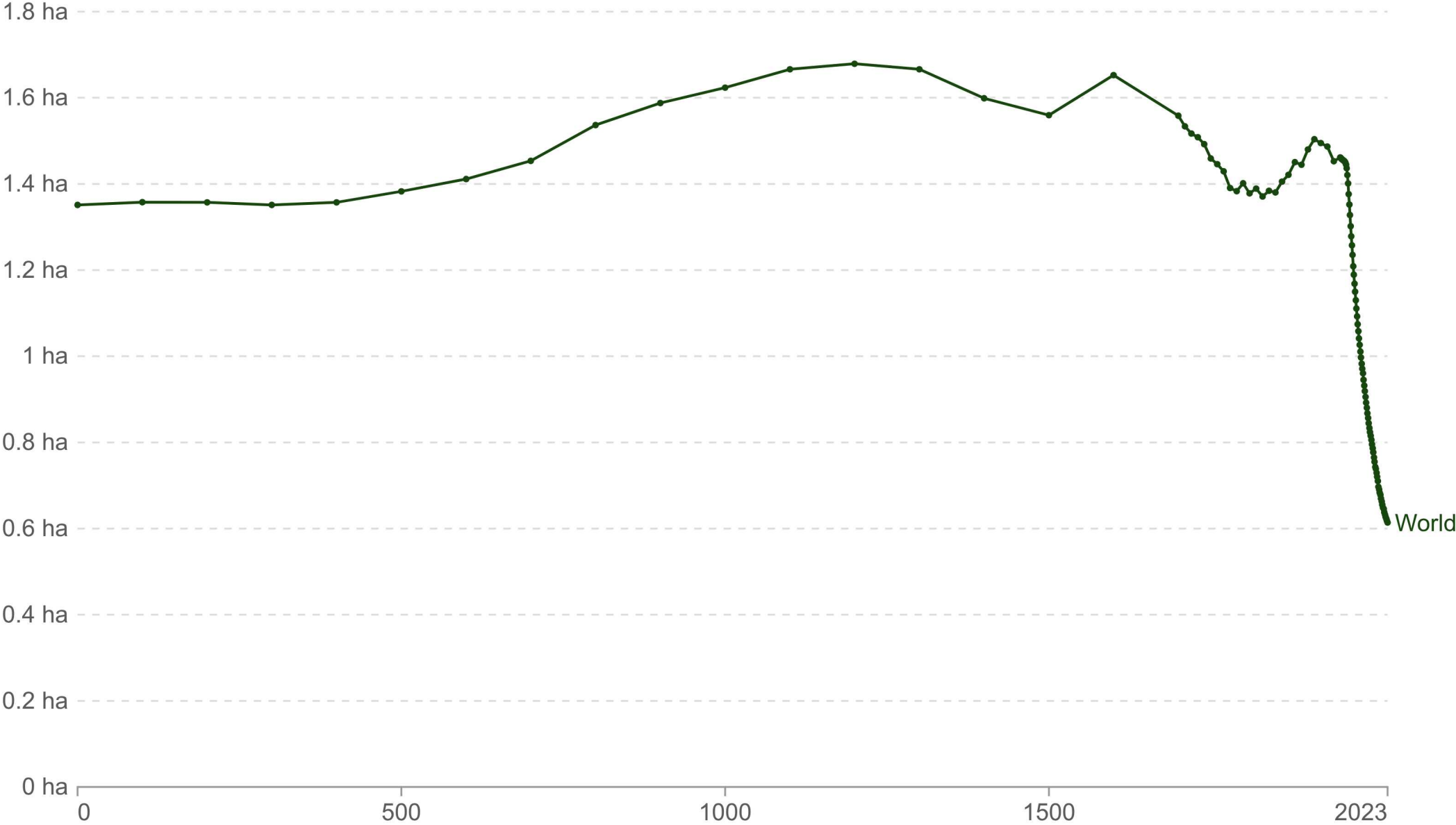
9,000 kWh per ton for electric fertilizer (urea) production	Aalborg Denmark	Salzburg Austria	Cairo Egypt	Kampala Uganda	Timika Indonesia	Kathmandu Nepal
Usual market price for 1 t	445 €	470 €	300 €	430 €	300 €	150 €
Electricity for the production of 100 € market price	2,022 kWh	1,915 kWh	3,000 kWh	2,093 kWh	3,000 kWh	6,000 kWh
If 70% of the price would be energy, this would be €/kWh	0.035	0.037	0.023	0.033	0.023	0.012
Constant production all the year aound						
Moderate production changes for cost optimization						
Runing only on 24-electricity to be competitive						

The greatest challenge: cheaper than steel but more than twice the electricity for production.

At least one green field in the “Run only 24-electricity” mode, but this is more than enough, because Cairo, Egypt stands for the Sahara, the Arabic peninsula and many more very sunny deserts.

Agricultural land use per person

This dataset is showing estimates of the total agricultural land area – which is the combination of cropland and grazing land – per person. It is measured in hectares per person.



Scenario: tomato production	Yield per m ²	Usage per m ²		Usage per kg	
		L water	kWh	L water	kWh
Open Field near Vienna	8	480	1.6	60	0.2
Open Field near Amman	6.8	476	2	70	0.3
Advanced Greenhouse in Vienna with LED light in winter	200	400	900	2	4.5
Advanced Greenhouse in Vienna without artificial light	140	280	650	2	4.6
Advanced Greenhouse in Amman	200	400	1,400	2	7.0

Jordan has approximately 61 cubic meters of renewable freshwater available per capita per year. This is far below the international threshold of 500 cubic meters per person per year, which defines absolute water scarcity.

To grow food, you need water. This limits Jordan's food production. It is possible to reduce water usage drastically by using much electricity.

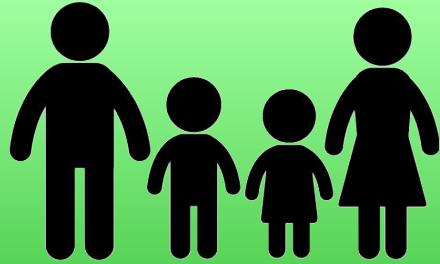
Advanced greenhouse: Very low air exchange.

The air exchange is controlled by holding the oxygen level below 25%.

At the air exchange, humidity recovery is used.

CO₂ is blown into the greenhouse to achieve the 800 ppm CO₂ optimal level for growing tomatoes.

The 1000 m² civilization



4000 m²

Streets
18,047
km²

Buildings
26,195 km²

Energy
27,000 km²

Food
36,740 km²

covered

100 % used

Meadow
100,200 km²

close to nature

Forest
114,000 km²

Germany

The 1000 square meter civilization would mean 83,500 km² of land usage in Germany and the rest more or less close to nature.

The easiest to resolve in Germany is the area wasting energy from biomass.

One hectare of maize for biogas creates only 17 MWh/a, while one hectare of energy-optimized settlement has, even after the 24×365 conversion, about 550 MWh.

With the new possibilities, there could be 50,000 km² more meadows and forests while having a very comfortable housing and living standard.