Handleiding softwareprogramma (simulator):
Mini windturbinepark simuleren i.c.m. waterstof

Handleiding: Dit is een handleiding (in het Engels) die te gebruiken is in het onderwijs als het gaat om **systeem integratie van groene elektronen en groene waterstof.**

Ontwikkeld door: Practor Yme Dikkerboom
Practoraat Energietransitie & Smart Industry (STC)

The hydrogen ecosystem (HyEcoSys) is a simulator of a small wind park in the North Sea, combined with hydrogen as an energy carrier. This simulator is designed to give students a better understanding of the system integration of hydrogen with wind turbines, as well as the dynamics of changing energy demand and production.

The idea for this software originated out of frustration (and programming fun) in April 2023 because most teaching materials focus on the individual components of such a system. With this simulation-tool, everything fits together.

A short explanation of the hydrogen ecosystem (HyEcoSys):

- If the wind park produces more electrical energy than is demanded, the surplus energy is converted into hydrogen gas using an electrolyzer.
- This hydrogen is then compressed with a hydrogen pump and stored in a tank.
- When there is insufficient electrical energy and there is compressed hydrogen in the tank, fuel cells convert the stored hydrogen back into electrical energy to cover the deficit.
- A blackout occurs when there is no hydrogen and insufficient electrical energy produced by the wind park.

Each month, you can view the production and demand data in the table. Just click on the white months to walk through a year.

This is not a simulator with scientifically substantiated calculations. It is based on ‘straight to the point’ calculations, just to properly understand the system and play with the parameters.

Adjustable parameters are:

1. The number of wind turbines (10-30);
2. The power of the wind turbines (2-5 MW);
3. The demand in house equivalents (100,000-150,000);
4. The tank pressure.

The charts of monthly demand and production are based on the Dutch situation and North Sea wind profiles. I hope this simulation will give the user a better understanding of system integration with hydrogen.
Have fun and learn a lot with this software!

Yme Dikkerboom, September 2024

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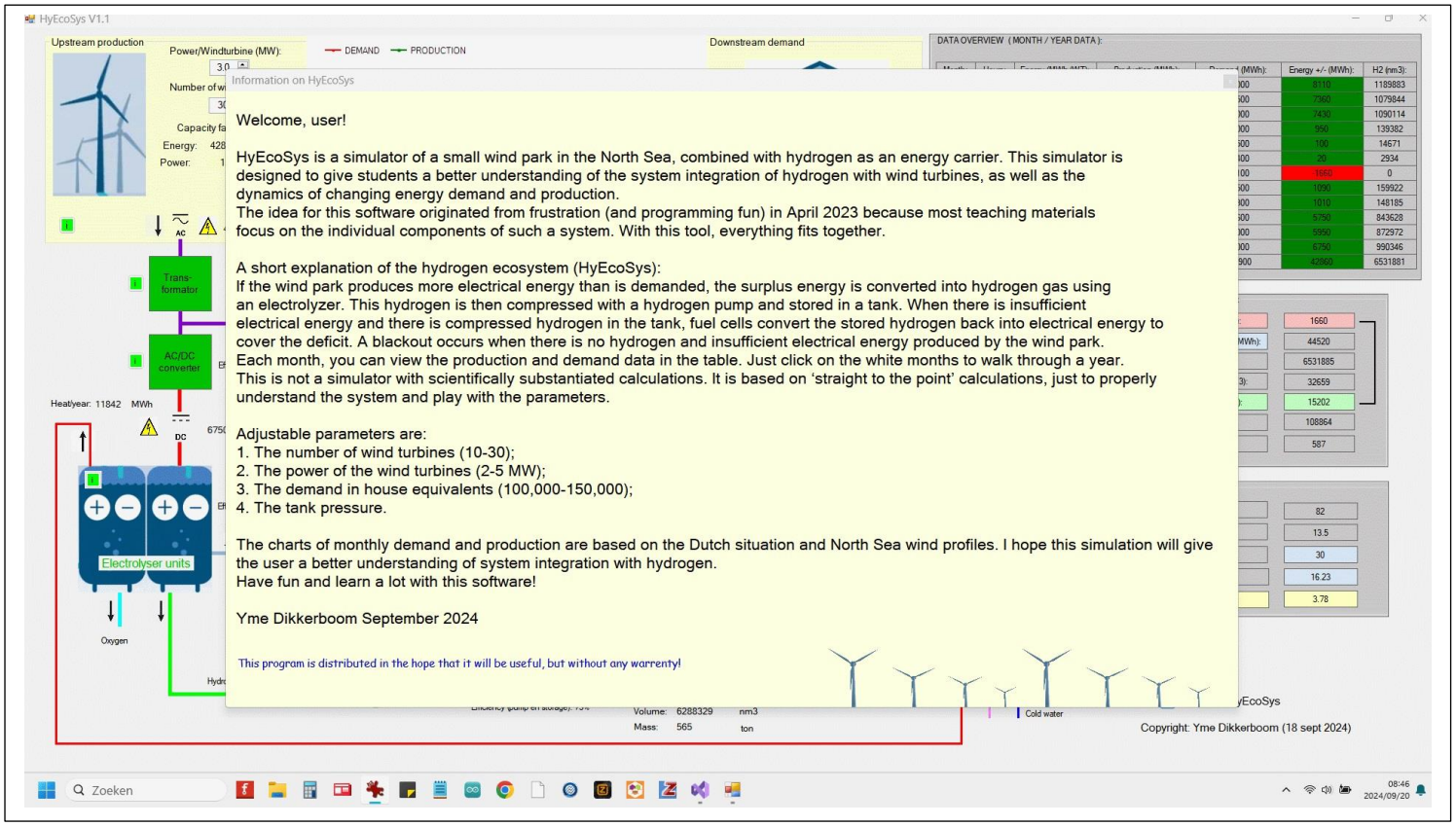
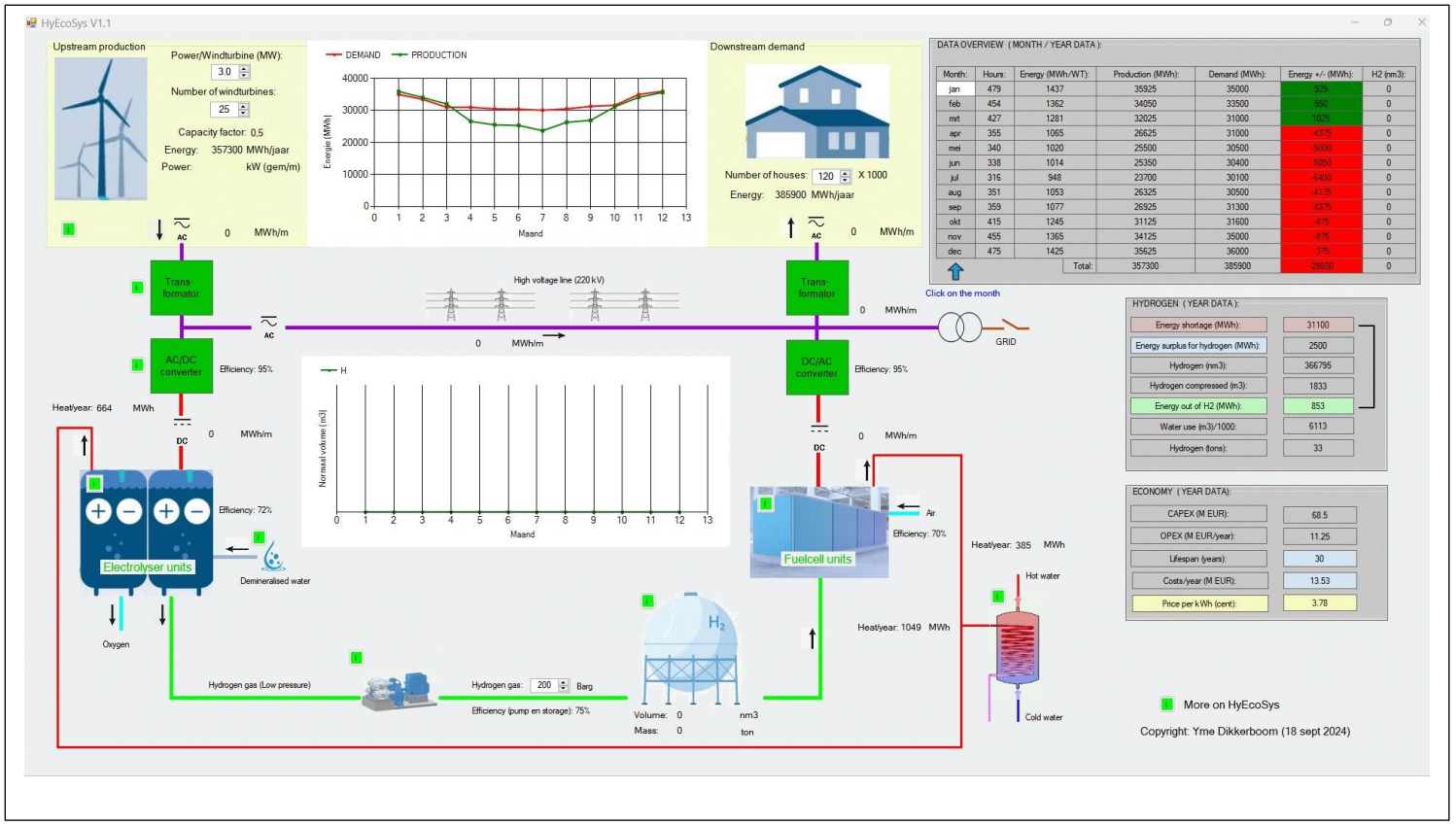
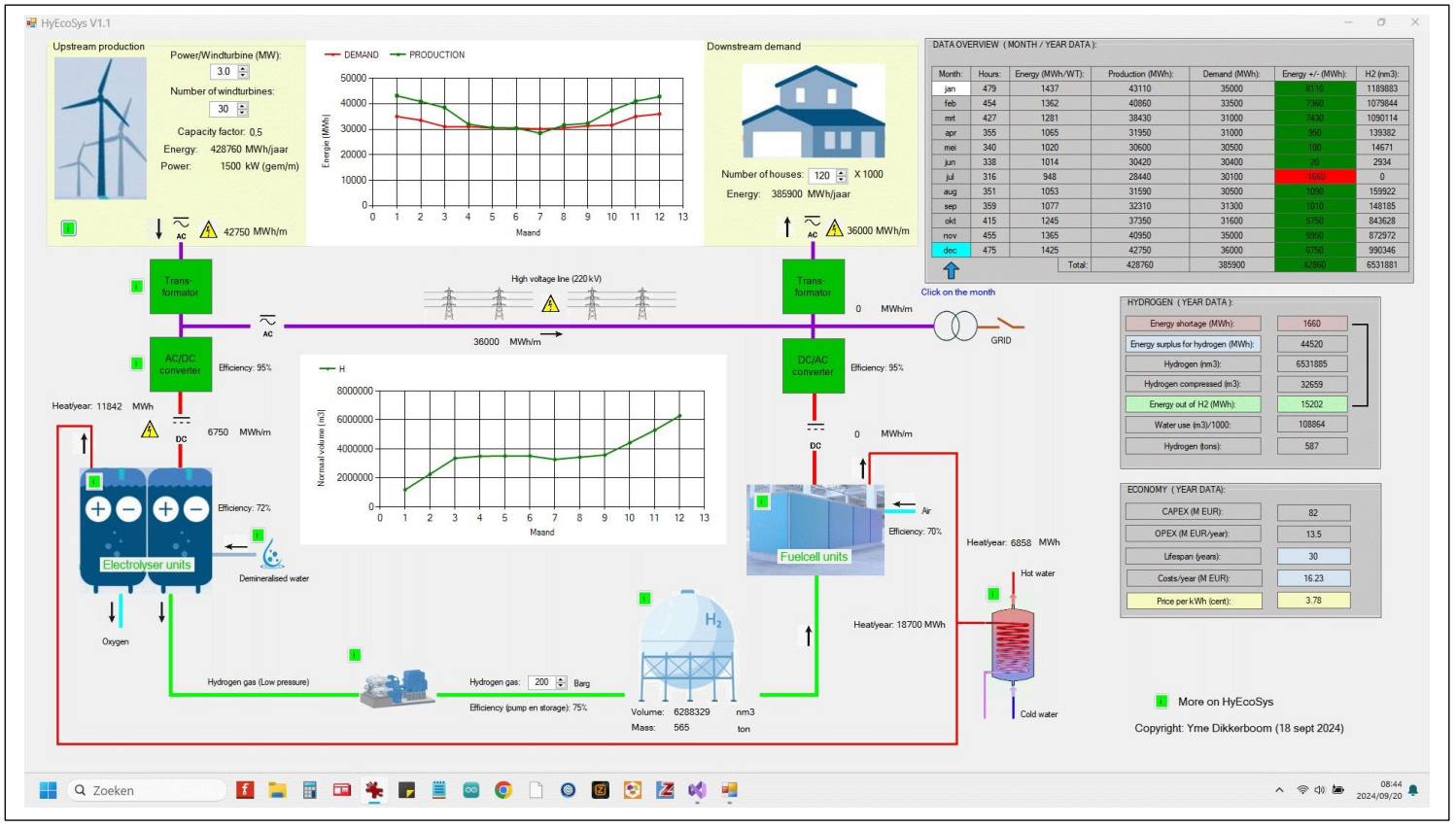



HyEcoSys V1.1
Upstream production
Power/Windturbine (MW):
3.0
Number of windturbines:
25
Capacity factor: 0,5
Energy: 357300 MWh/jaar
Power: kW (gem/m)
DEMAND
PRODUCTION
Energie (MWh)
Maand
Downstream demand
Number of houses: 120 X 1000
Energy: 385900 MWh/jaar
DATA OVERVIEW (MONTH / YEAR DATA):
Month: Hours: Energy (MWh/WT): Production (MWh): Demand (MWh): Energy +/- (MWh): H2 (nm3):
jan 479 1437 35925 35000 925 0
feb 454 1362 34050 33500 550 0
mrt 427 1281 32025 31000 1025 0
apr 355 1065 26625 31000 -4375 0
mei 340 1020 25500 30500 -5000 0
jun 338 1014 25350 30400 -5050 0
jul 316 948 23700 30100 -6400 0
aug 351 1053 26325 30500 -4175 0
sep 359 1077 26925 31300 -4375 0
okt 415 1245 31125 31600 -475 0
nov 455 1365 34125 35000 -875 0
dec 475 1425 35625 36000 -375 0
Total: 357300 385900 -28600 0
Click on the month
Trans-formator
AC/DC converter
Efficiency: 95%
Heat/year: 664 MWh
High voltage line (220 kV)
GRID
DC/AC converter
Normaal volume (m3)
Electrolyser units
Efficiency: 72%
Demineralised water
Oxygen
Hydrogen gas (Low pressure)
Hydrogen gas: 200 Barg
Efficiency (pump en storage): 75%
Volume: 0 nm3
Mass: 0 ton
Fuelcell units
Air
Efficiency: 70%
Heat/year: 385 MWh
Heat/year: 1049 MWh
Hot water
Cold water
HYDROGEN (YEAR DATA):
Energy shortage (MWh): 31100
Energy surplus for hydrogen (MWh): 2500
Hydrogen (nm3): 366795
Hydrogen compressed (m3): 1833
Energy out of H2 (MWh): 853
Water use (m3)/1000: 6113
Hydrogen (tons): 33
ECONOMY (YEAR DATA):
CAPEX (M EUR): 68.5
OPEX (M EUR/year): 11.25
Lifespan (years): 30
Costs/year (M EUR): 13.53
Price per kWh (cent): 3.78
More on HyEcoSys
Copyright: Yme Dikkerboom (18 sept 2024)


HyEcoSys V1.1
Upstream production
Power/Windturbine (MW):
3.0
Number of windturbines:
30
Capacity factor: 0,5
Energy: 428760 MWh/jaar
Power: 1500 kW (gem/m)
DEMAND
PRODUCTION
Energie (MWh)
Maand
Downstream demand
Number of houses: 120 X 1000
Energy: 385900 MWh/jaar
DATA OVERVIEW (MONTH / YEAR DATA):
Month: Hours: Energy (MWh/WT): Production (MWh): Demand (MWh): Energy +/- (MWh): H2 (nm3):
jan 479 1437 43110 35000 8110 1189883
feb 454 1362 40860 33500 7360 1079844
mrt 427 1281 38430 31000 7430 1090114
apr 355 1065 31950 31000 950 139382
mei 340 1020 30600 30500 100 14671
jun 338 1014 30420 30400 20 2934
jul 316 948 28440 30100 -1660 0
aug 351 1053 31590 30500 1090 159922
sep 359 1077 32310 31300 1010 148185
okt 415 1245 37350 31600 5750 843628
nov 455 1365 40950 35000 5950 872972
dec 475 1425 42750 36000 6750 990346
Total: 428760 385900 42860 6531881
Click on the month
Trans-formator
AC/DC converter
Efficiency: 95%
Heat/year: 11842 MWh
42750 MWh/m
36000 MWh/m
High voltage line (220 kV)
GRID
DC/AC converter
Normaal volume (m3)
Electrolyser units
Efficiency: 72%
Demineralised water
Oxygen
6750 MWh/m
Hydrogen gas (Low pressure)
Hydrogen gas: 200 Barg
Efficiency (pump en storage): 75%
Volume: 6288329 nm3
Mass: 565 ton
Fuelcell units
Air
Efficiency: 70%
Heat/year: 6858 MWh
Heat/year: 18700 MWh
Hot water
Cold water
HYDROGEN (YEAR DATA):
Energy shortage (MWh): 1660
Energy surplus for hydrogen (MWh): 44520
Hydrogen (nm3): 6531885
Hydrogen compressed (m3): 32659
Energy out of H2 (MWh): 15202
Water use (m3)/1000: 108864
Hydrogen (tons): 587
ECONOMY (YEAR DATA):
CAPEX (M EUR): 82
OPEX (M EUR/year): 13.5
Lifespan (years): 30
Costs/year (M EUR): 16.23
Price per kWh (cent): 3.78
More on HyEcoSys
Copyright: Yme Dikkerboom (18 sept 2024)
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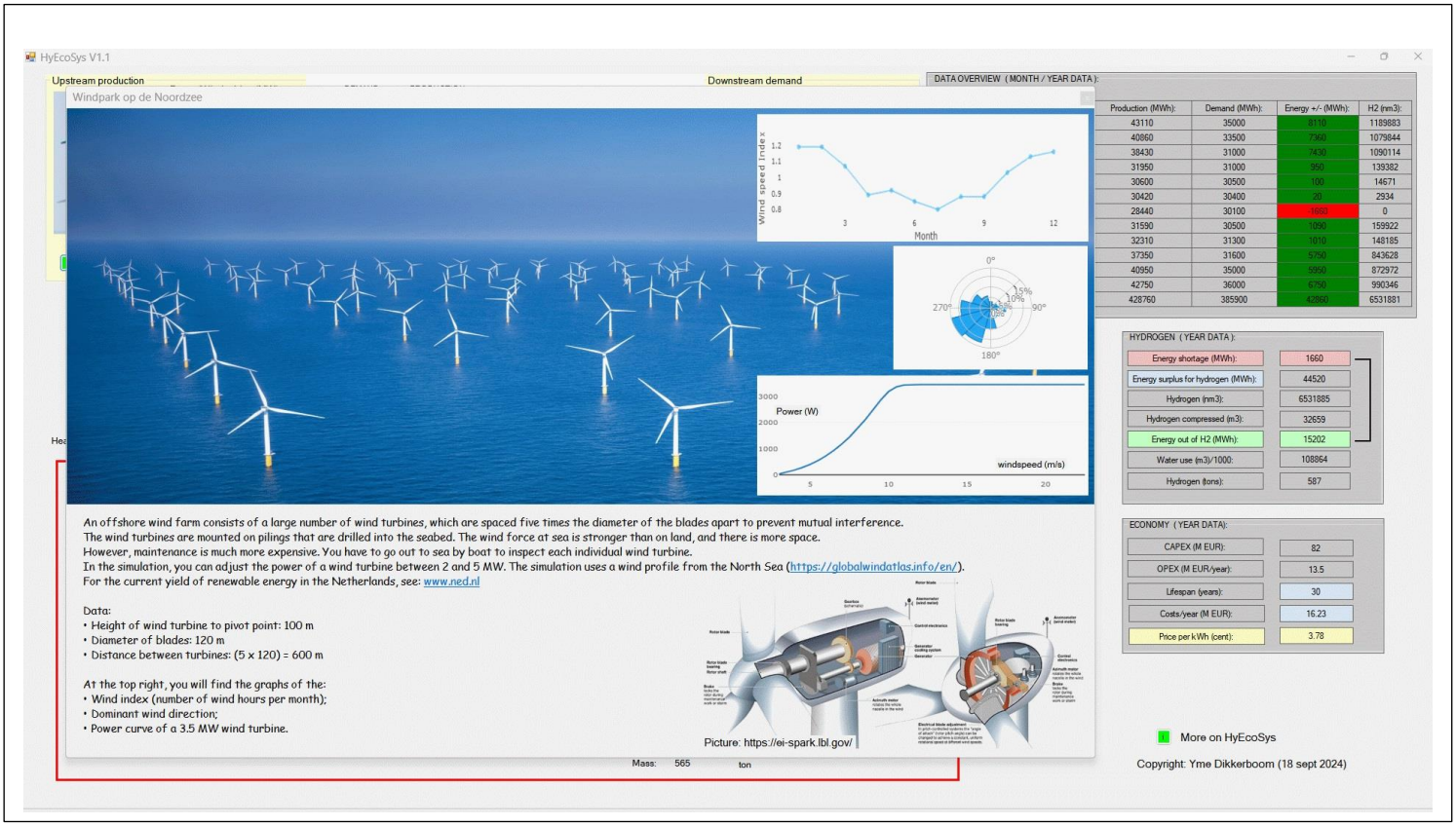

Production (MWh):	Demand (MWh):	Energy +/- (MWh):	H2 (nm3):
43110	35000	8110	1189883
40860	33500	7360	1079844
38430	31000	7430	1090114
31950	31000	950	139382
30600	30500	100	14671
30420	30400	20	2934
28440	30100	-1660	0
31590	30500	1090	159922
32310	31300	1010	148185
37350	31600	5750	843628
40950	35000	5950	872972
42750	36000	6750	990346
428760	385900	42860	6531881

HYDROGEN (YEAR DATA):	
Energy shortage (MWh):	1660
Energy surplus for hydrogen (MWh):	44520
Hydrogen (nm3):	6531885
Hydrogen compressed (m3):	32659
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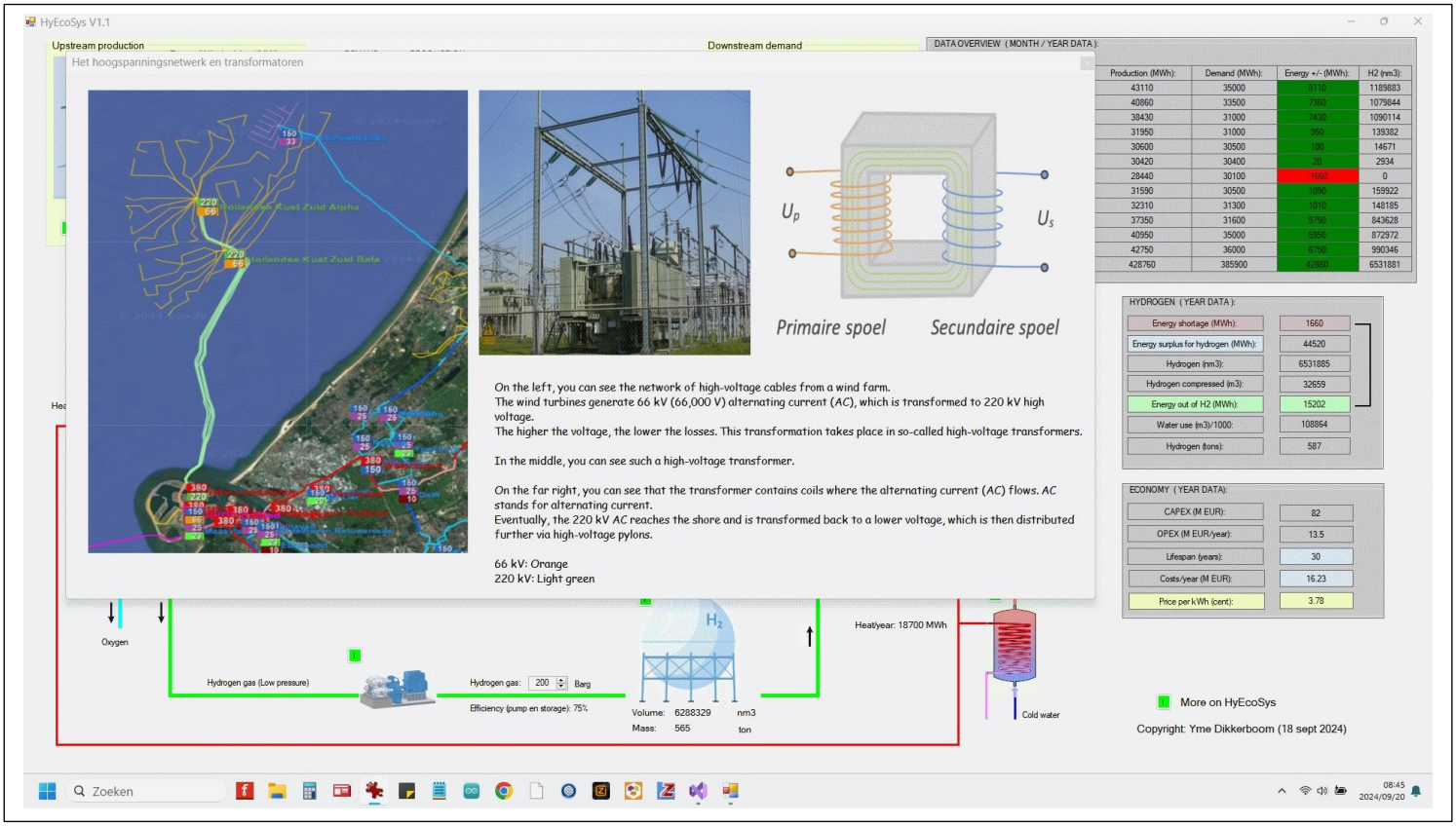

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