Company

Critical

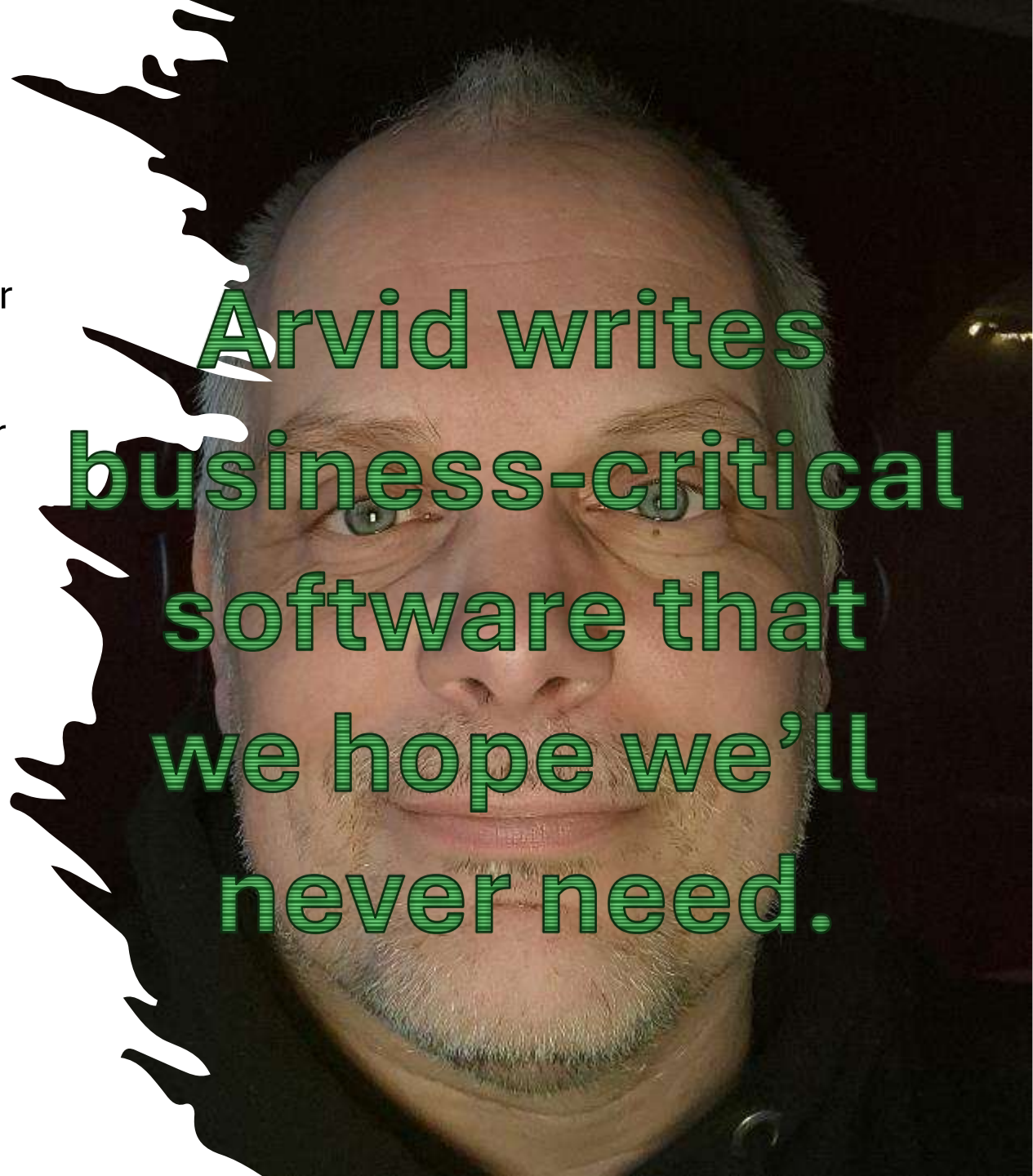
Code

Care

Arvid Claassen

- UA 1999 – Licentiaat Informatica
- 1999: ADReM + some tasks with prof. Demeyer
- 2001: Alcatel – Testing Engineer
- 2003: Aditel/Certipost – Solutions Coordinator
- 2005: CM – Test Coordinator
- 2006: Compuware – Test Tools Consultant
- 2007: Itineris Test Coordinator
- 2010: Eandis/Fluvius
  - Test Coordinator
  - Python Evangelist since 2017

- 1981: Board Game Geek
- 1985: Recorder player
- 2022: Bamboo flute builder



Fluvius is a grid operator.
We cover all Flemish
towns and municipalities.

We build and manage the public utility lines in the street that bring electricity, natural gas, sewerage and heat to our customers.

Fluvius also takes care of public lighting in all Flemish towns and municipalities.
We replace the lamps and
repair defects.

5 800
employees are ready to serve our customers

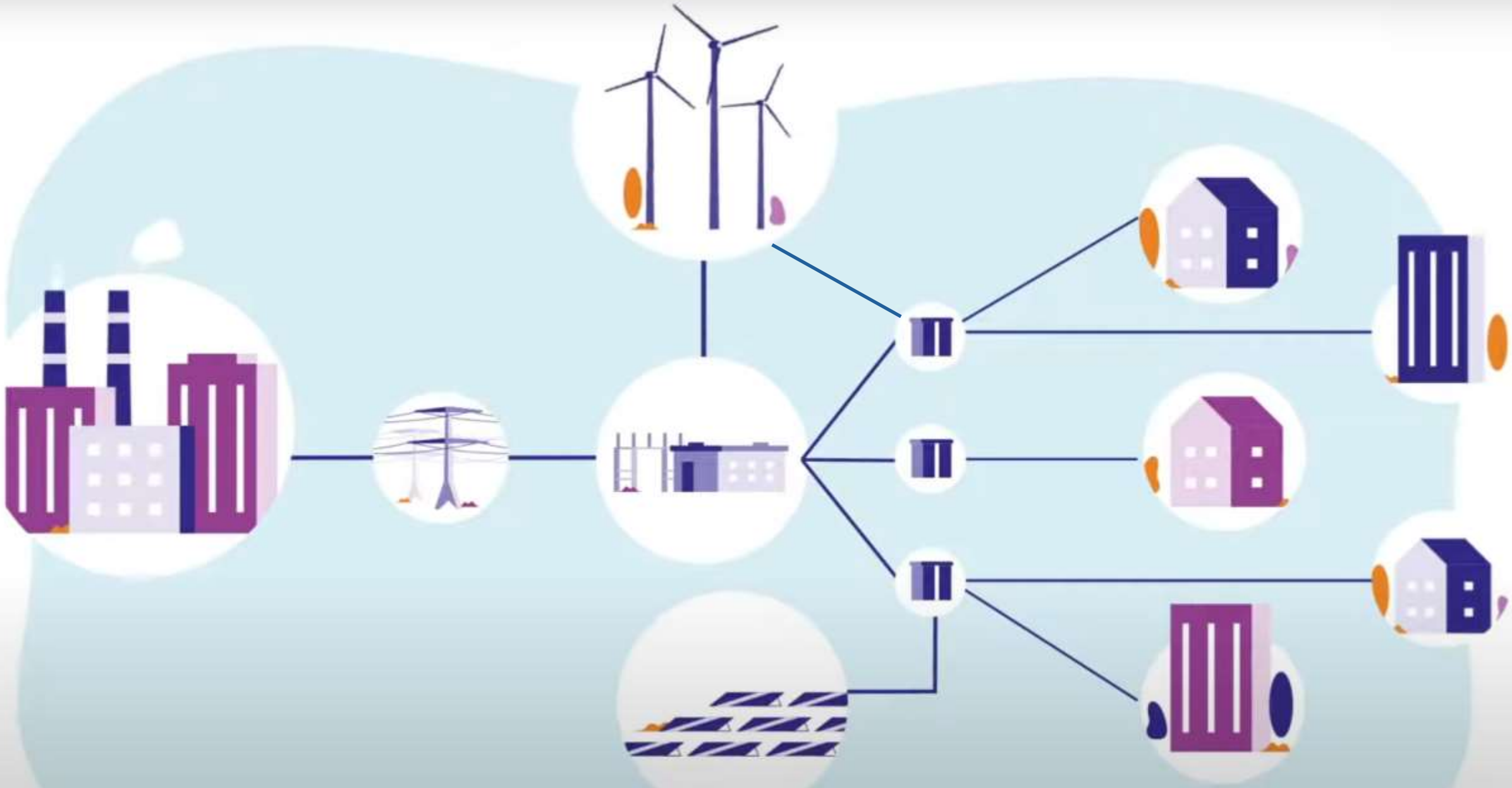
We manage
6.6 million
connections

We manage
1.2 million
street lights

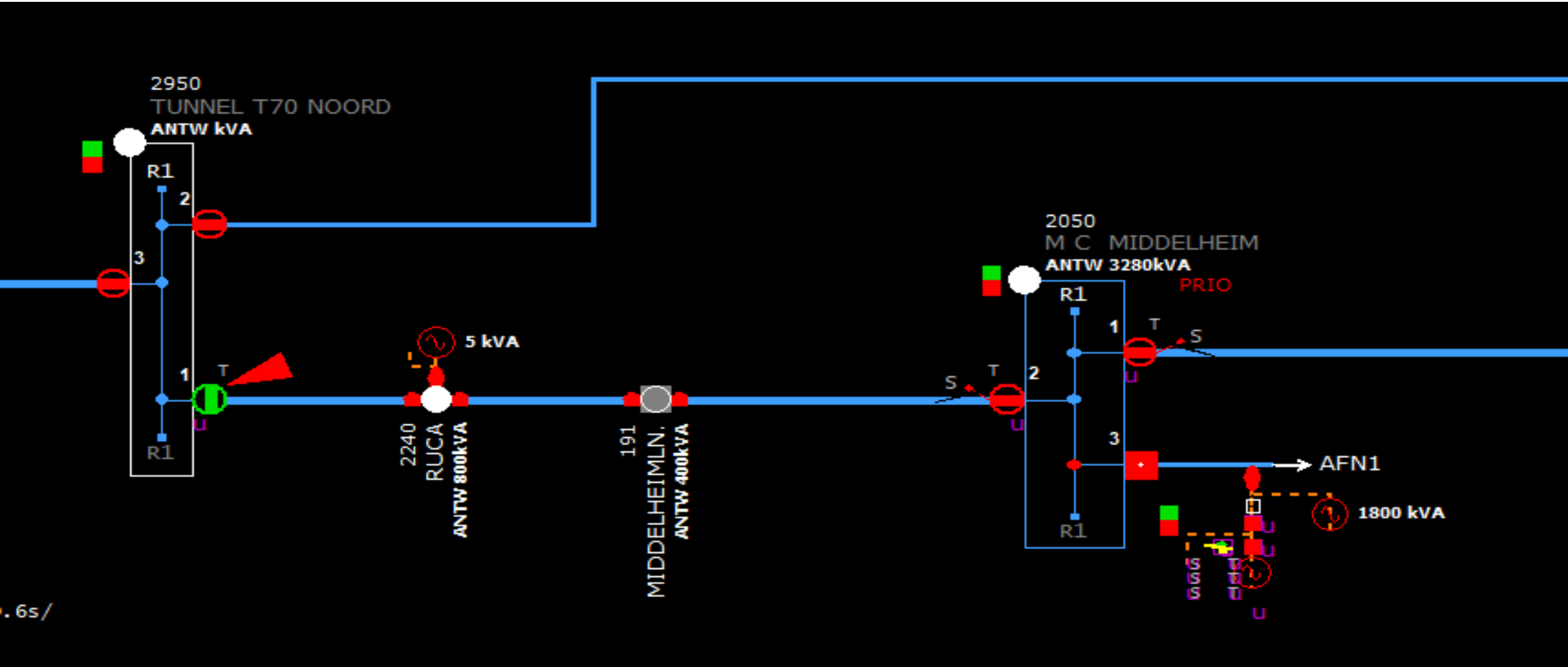
We invest
€ 1.2 billion
in our grids

Together, our networks add up to
>200 000
kilometers

START JE CARRIÈRE BIJ FLUVIUS

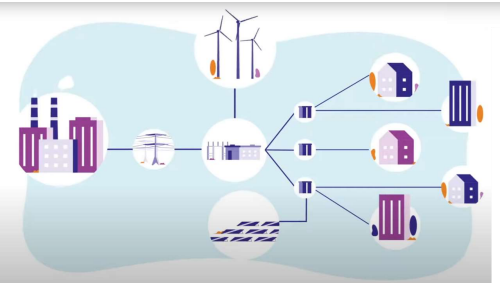


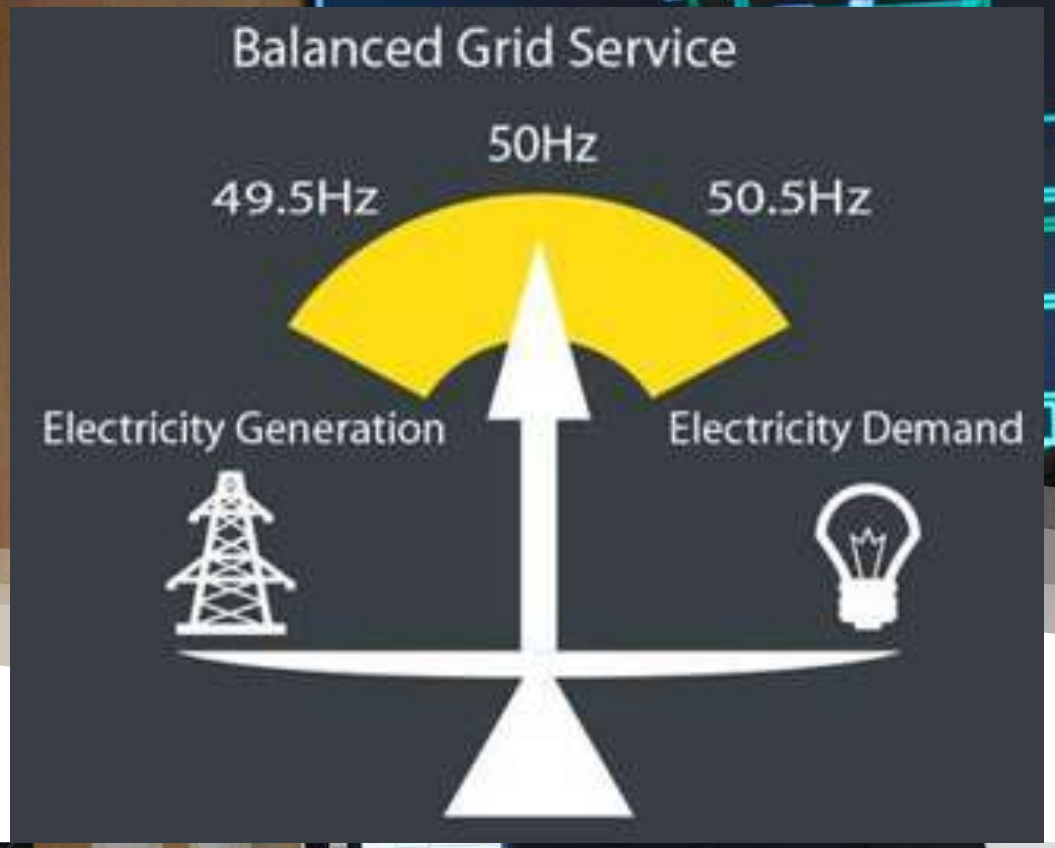
Distribution Management System

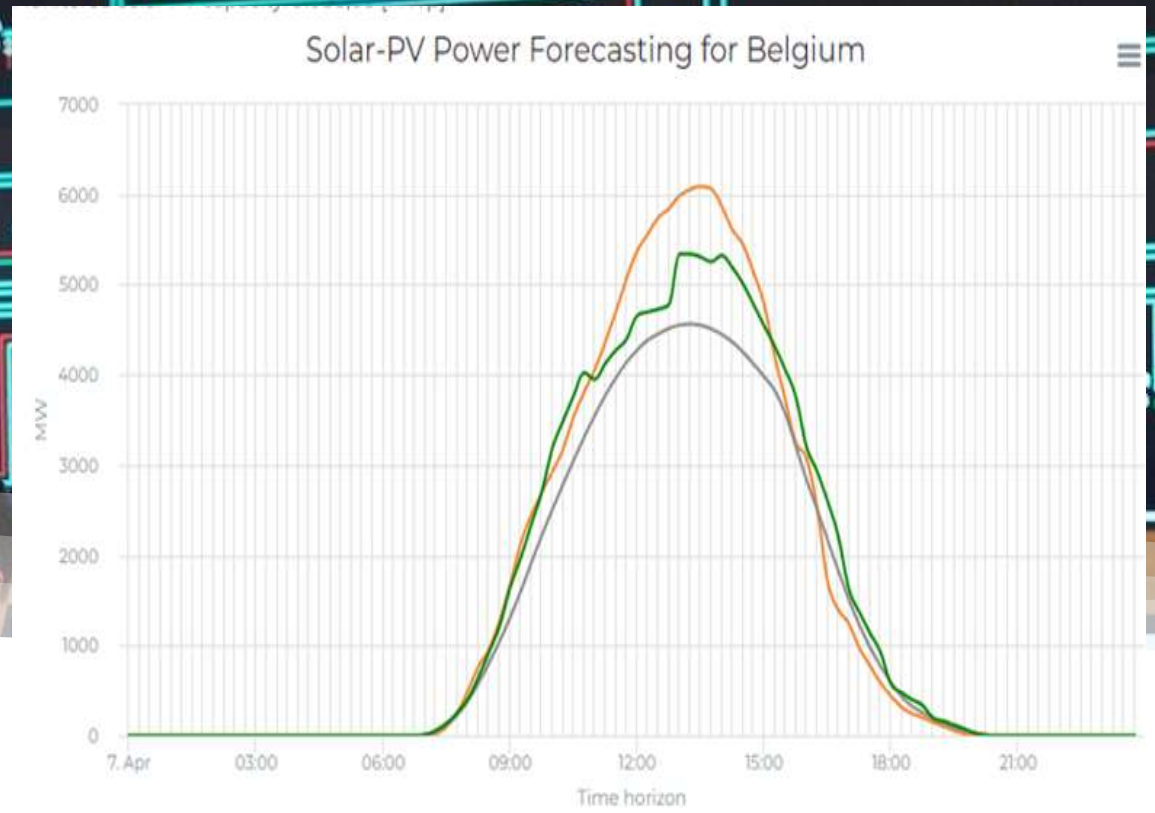


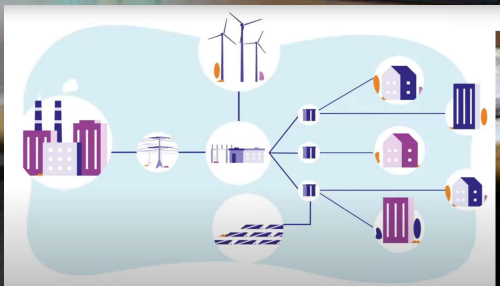
Operational Technology

- Isolated from WAN, LAN, Cloud, Internet
- Process Control driven
- “Oops” can cost a lot of money or even lives
- Major software upgrade postponed because of stormy weather
- 100% uptime since 2016, even during major upgrades
- Keep-it-running is prio 1, Compliance 2, Everything Else 3
- Common software might not be available




Balanced Grid Service
50Hz
49.5Hz
50.5Hz
Electricity Generation
Electricity Demand


Solar-PV Power Forecasting for Belgium
7000
6000
5000
4000
3000
2000
1000
0
MW
7. Apr
03:00
06:00
09:00
12:00
15:00
18:00
21:00
Time horizon



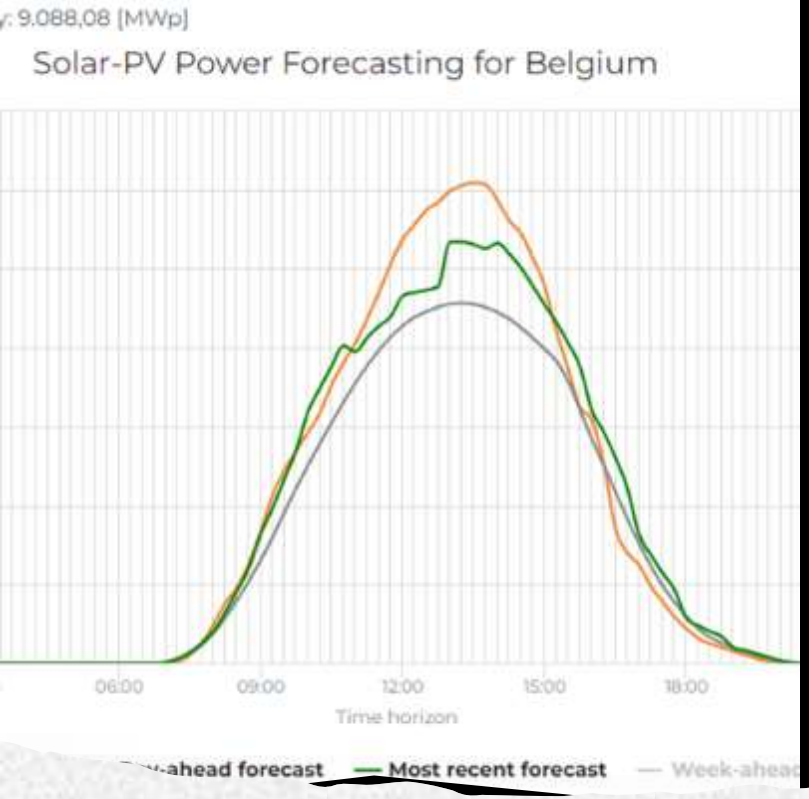
Balance Tools

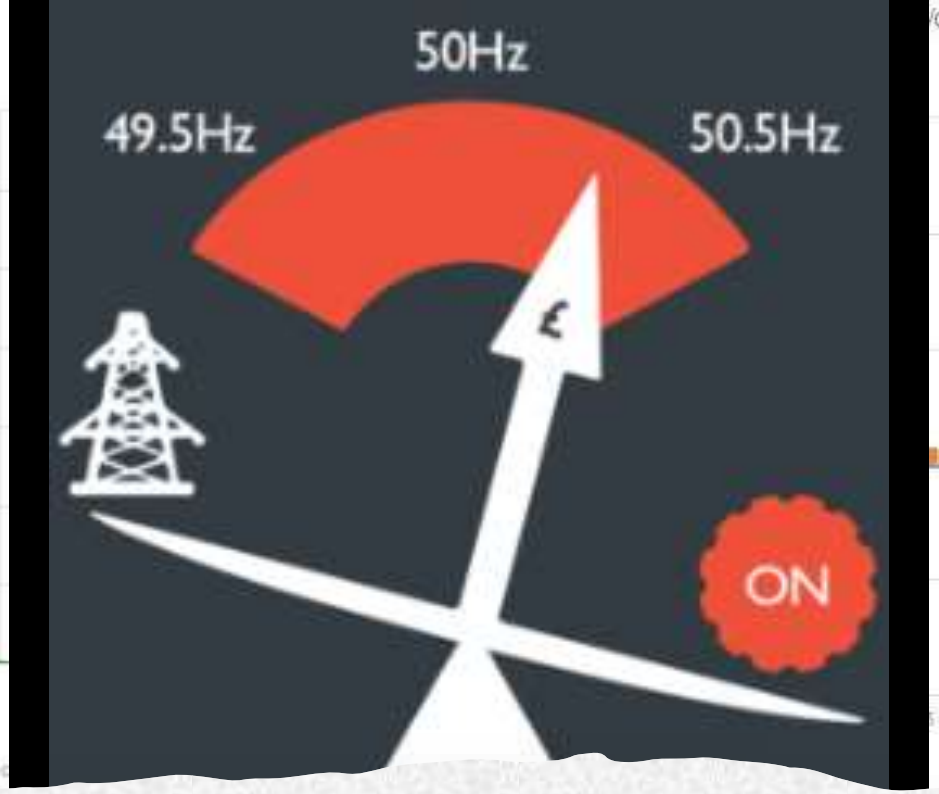
- International Import/Export
- Limit Generation
- Price Variation
- Limit Demand
- Emergency Generation or Demand
- Disconnect power plant / Black-out

We krijgen zondag vaak droog weer, met soms opklaringen. In de namiddag komen er meer wolken opzetten en neemt de kans op een bui geleidelijk toe. Het blijft zacht met maxima tussen 17 en 20 graden, meldt het KMI.

Due to desert sand dust in the air, solar panels will produce less.

Me @ April 7th 2024


9.088,08 [MWp]
Solar-PV Power Forecasting for Belgium
06:00
09:00
12:00
15:00
18:00
Time horizon
Most recent forecast


50Hz
49.5Hz
50.5Hz
£
ON


Imbalance prices on 07/04/2024
Hours
Price (€/MWh)


APRIL
7


PANIC

Aan: Claassen Arvid <Arvid.Claassen@fluvius.be>
Onderwerp: Noodknop

Dag Arvid,

Gelieve je agenda vanaf 3 juni vrij te maken voor een dringende ontwikkeling (script) van een noodknop om recent opgedoken netproblemen te kunnen opvangen. Indien ons MC dit volgende week bekrachtigt, heeft dit prioriteit over je andere activiteiten inclusief flex voor de maand juni.

Tine is de logica aan het voorbereiden en zal op 3 juni met je afstemmen over de inhoud.

Mocht je vragen hebben kunnen we hier volgende week over hebben.

Mvg

On-the-fly Requirements

‘invented’ during 10 looooong working days of coding

Reduce By x MW

Restore Everything

```
def execute(self) → None:
    """
    Core part of the script
    """
    try:
        self.prepare()
        self.warning("Script Noodcompressie")
        self.warning(f"       Start mode : {self.start_mode.name}")
        if self.in_regelmode():
            self.mention(f"          Congestie : {self.cp.get_alias()}",
                         log_method=self.warning)
            self.mention(f"      Doel vermogen : {self.target_p}",
                         log_method=self.warning)
            self.mention(f"  Minimale injectie : {self.config.minimale_injectie}",
                         log_method=self.warning)
```

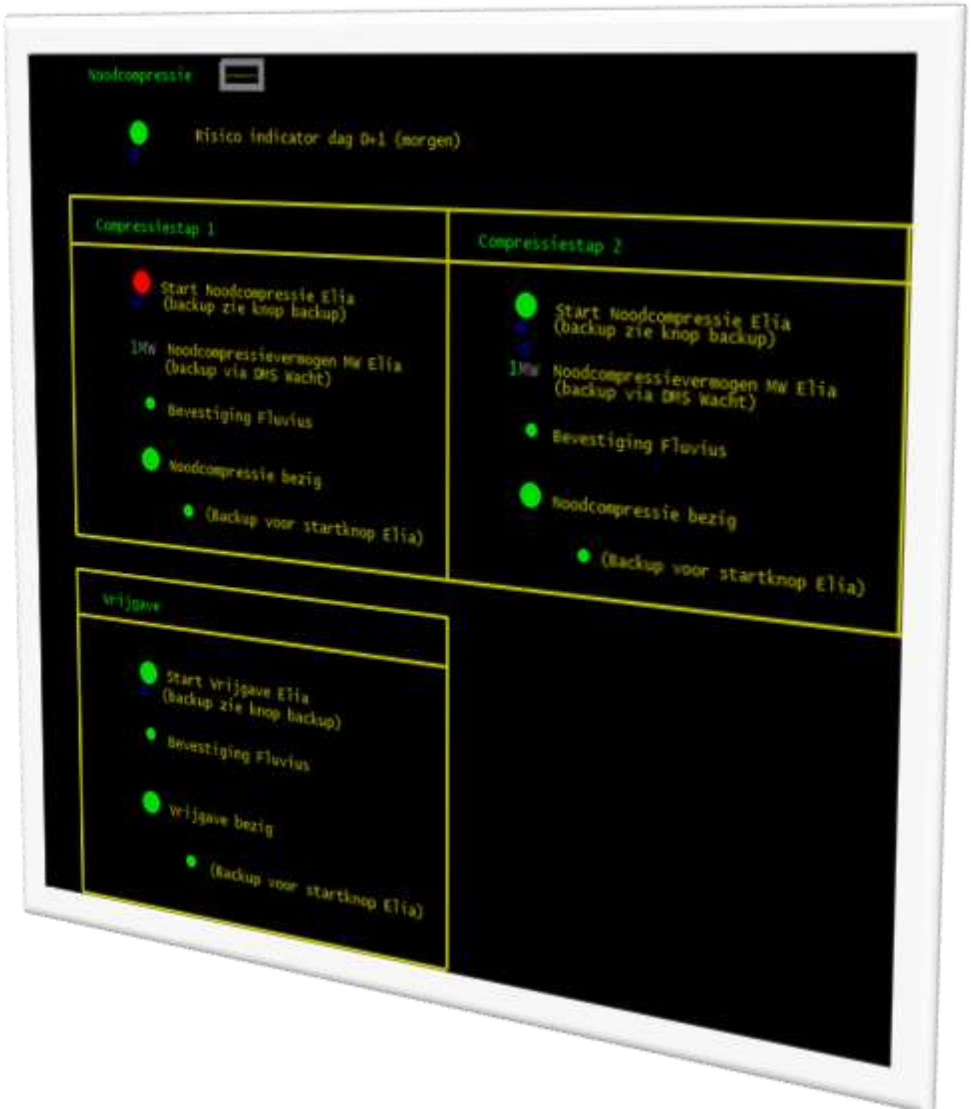
n Reductions / Restores

Manual shell script

Emergency Compression

“When Elia Balancing has been exhausted”

D-1	• Optional: Elia sends warning
T-2m	• Elia sends ‘Target Volume MW’ • Elia sends ‘Start’
T-1	• Fluvius Operator calls Elia for Confirmation
T	• Fluvius operator initiates Reduction
T+1s	• Emergency Script Run
T+x m	• *Slow* Reduction of Solar and Wind Production



‘Secret Code’

- First time right, no open ends
- Focus on reusing code
- Focus on maintainability
- Rule violation: Dutch variable names
- As many fallbacks as possible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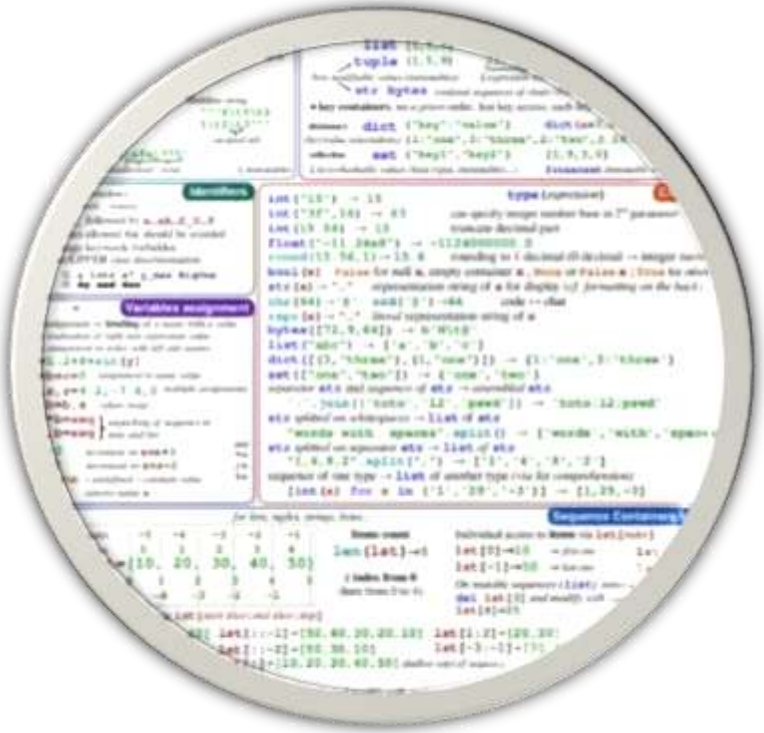
```

Unit Testing



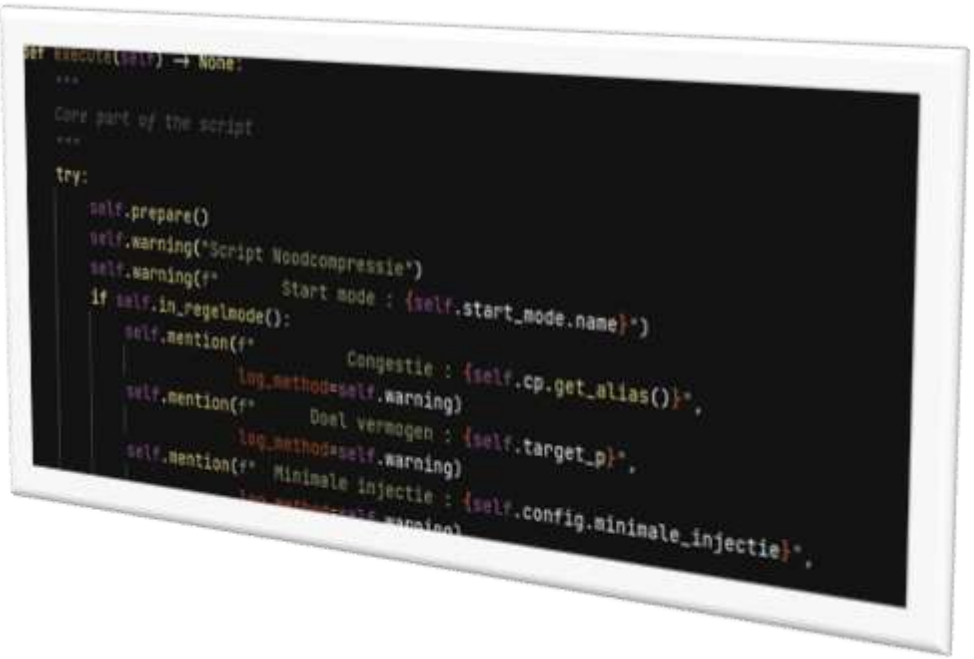
Test OS and python as much as possible

- OS settings
- Python environment
- 3rd party libraries
- Fluvius framework

	Critical	High	Medium	Low	Don't care
Python Specific	2	0	0	0	2
3rd Party	1	0	0	0	0
Framework	1	2	15	0	4

Unit Testing Script

- Python unit test framework
- 900000 different possible configs sliced into 1500 combinations
- Generated programmatically and by AI
- Tested automatically
- Tested daily on acceptance, monthly on production



Does the code work on every flavor of LP?
What if all LP's are disconnected?
How does LP react on values outside [0-100]%?

System Test

Try to bypass every safety guard
Garbage in, … out
Parallel runs
Messed-up process order

- Scenario Driven - Code as black-box
- Coded programmatically
- Tested automatically
- Tested after every script change or framework change

Integration test

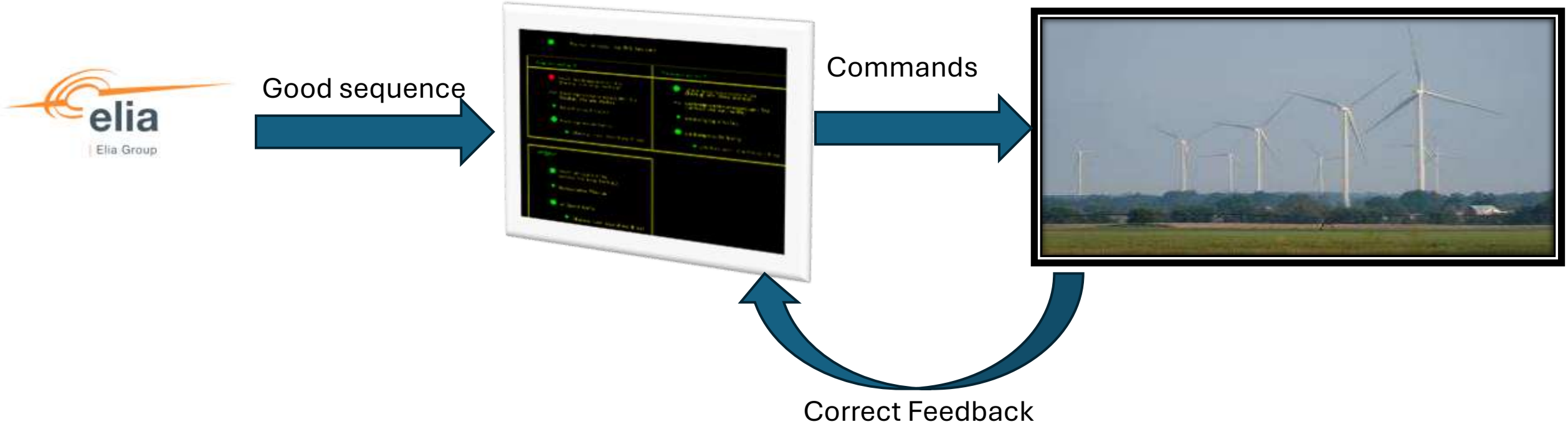
Good sequence

Good script call

Correct commands

End-To-End

System Of Systems



End-To-End Testing

Quality

- Full cycle of real of emergency compression
- Very Limited number of customers (max 6)
- Not at sunny/windy moments

Time

- At least once per year before the Spring
- After every major change by Fluvius or Elia
- ½ day

Cost

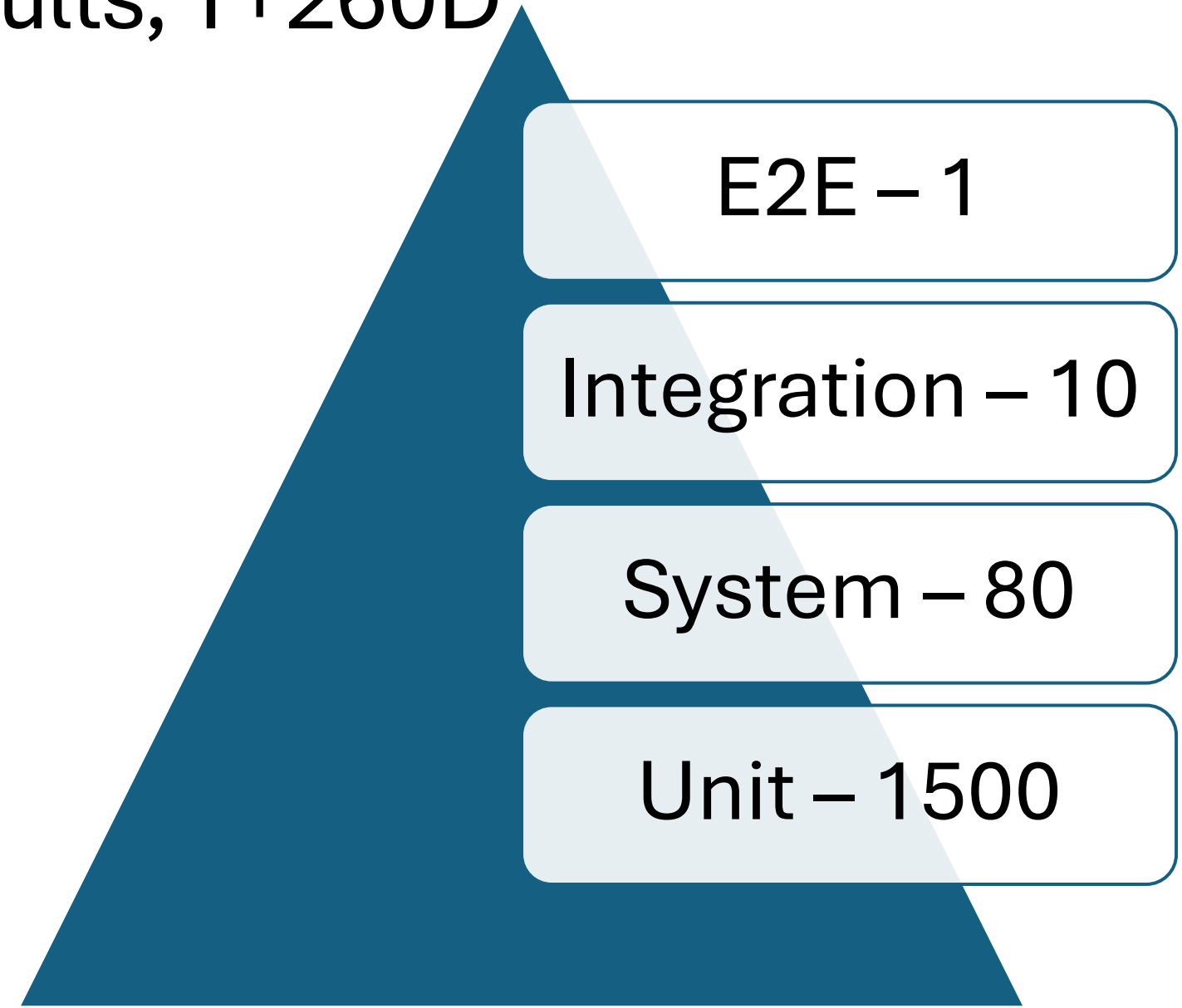
- Fluvius: 2 Operators, 2 IT Specialist, 4 Grid Experts
- Elia: 1 Operator, 1 IT Specialist, 1 Grid Expert
- Per Customer: 1 SPOC
- Down-time compensation per customer

Slow but sure

Expected: 100 reductions in real life Emergency Compression
The effect on DMS, network and intermediate components is
- Untestable
- Unpredictable
- Unsimulable

Experts say 10 reduction per second is safe
We chose::
- 1 every 2 seconds
- turn it 1 notch quicker every run

Test results, T+260D



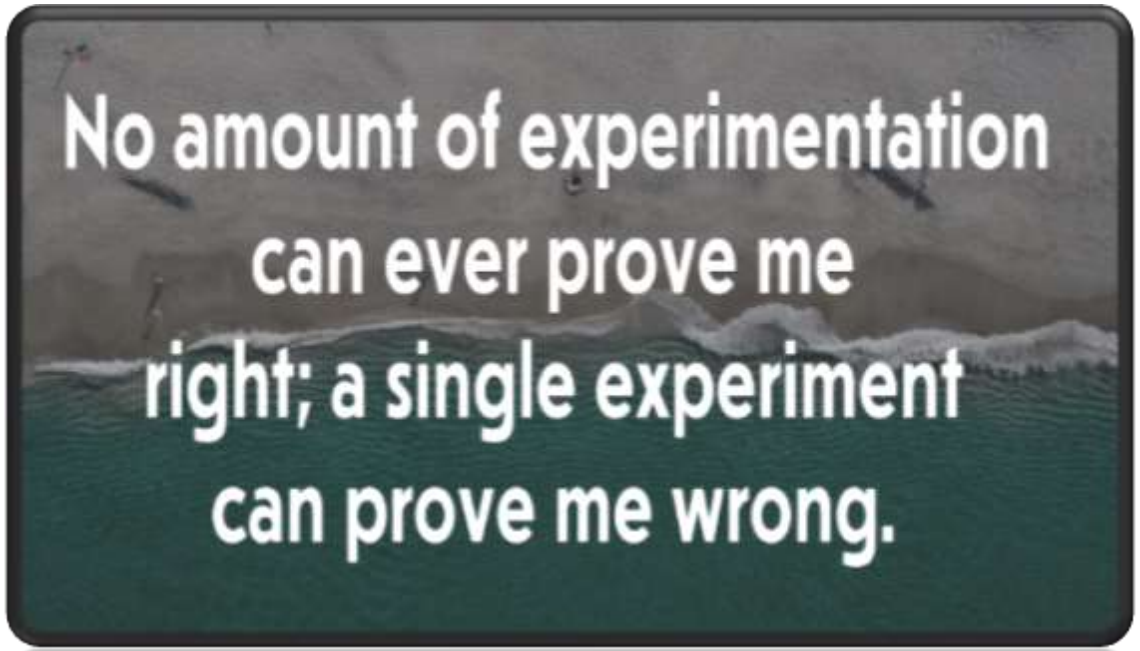
Statistics

- 2000 lines of script code excluding comments
- 15000 lines of test code

- 1200 Unit Test Runs
- 350 System Test Runs

- 100% Script Code Coverage & Path Coverage (low cyclomatic complexity)
- 78% Configuration Coverage (98% Weighted coverage)

- 5 Production Tests with real (limited) grid controls
- 0 Real Life Runs. (Let’s keep it that way)


No amount of experimentation
can ever prove me
right; a single experiment
can prove me wrong.


Beware of bugs in the above
code; I have only proved it
correct, not tried it.
Donald Knuth