# Smart Distribution Sub-Stations
# an SME Perspective

Bausch Datacom

# Who Are We?

- Privately owned since 1997
- SME
- Staff 8-12 (engineering)
- Annual turn-over over the last 3 years: approx. 1,500,000
- Engineering in Belgium
- ISO 9001:2008 certified
- Production in Belgium (Connectronics, Demival)
- Production in Taiwan (> 10,000 units)
- More than 500,000 modems sold since 1995

# What do we Make?

- Communication for MV/LV substations & smart metering
- EV charging electronics
- Monitoring for MV/LV substations
  - Mobile communication GPRS/3G/LTE…
  - SCADA communication IEC 60870-5-104
  - Security
  - Monitoring PQ, FPI and controlling (street lights)
  - MV sensor cable electronics

# Our Market

- What
  - Electricity, water and gas meter reading
  - Electricity substation (MV/LV) monitoring
  - Electric vehicle charging infrastructure electronics
- Who
  - Integrators
  - DSOs
- Where
  - Europe
  - World-wide

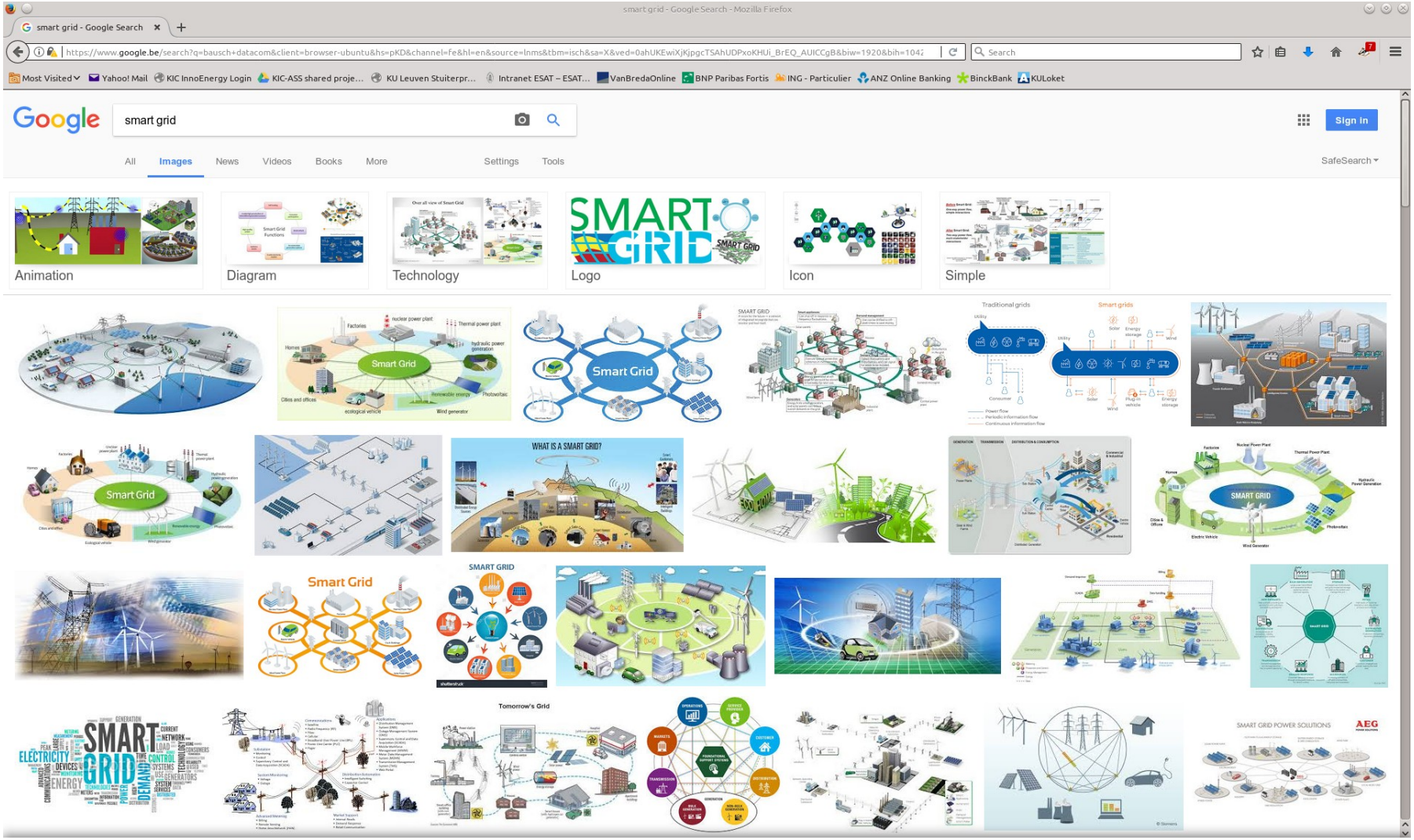
# Some Reference Projects

- 2003-2016 Belgium: Eandis, ORES, Sibelga
  **40,000** InduBox modems
- 2007-2016 Belgium: Infrax
  **6,000** RTUs
- 2007 Olivetti & DA Sistemi
  **130,000** PSTN socketmodems
- 2013-2014 Greece: Public Power Corporation
  **15,500** InduBox modems
- EV electronics eNovates
  **5,000** RTUs
- Mutual R&D with Eandis, Nexans and Bausch
  patented MV sensor

# Smart Grids, are they Real?

**NOTE**

This presentation considers only smart MV/LV secondary distribution sub-stations, not LV smart meters, nor HV/MV or MV/MV distribution




What is a smart grid? According to Google image search, mainly pictures of wind mills on Disc World and word clouds. It takes a **lot** of scrolling to see anything in the field… And even then it's often proof-of-concept toy projects.

# The Smart Grid Mirage

- The SME cardinal rule: there must be a paying customer
  aka ***It is only real if there is a tender***
- Grid observation and automation did exist before the smart-grid craze...
  - Specific sites with monitoring needs (e.g.: Bausch sold 6000 RTUs to Infrax)
- Smart grid projects were, until recently, mainly proof of concepts
  - Exploratory **models** of what might, one day, be…
    - Often overly ambitious vs justifiable/available budgets
    - More suitable for larger manufacturers who can afford it
  - Difficult for a small SME to participate
    - Large effort
    - Little, if any, return
    - High uncertainty
- As of the last year or two, the smart grid POC have become large-scale roll-out projects with economically-viable **tenders**
- The mirage has become **real** and **tangible**!

# The Smart Grid ~~Mirage~~ Reality

- The tender ambition is often less then the POC
  - Cost becomes an inhibitor
  - Bad experiences during the POC with practical issues, such as: compatibility, communication, DMS, knowledge of grid assets, ...
  - Awareness of the high complexities and short life-spans (smart equipment tends to do dumb things and die in dumb ways)
- *Focus shift: "what is possible" → "what gives the most core functionality for the Euro **and** gives the least stress"*
- This is a favourable arena for an SME!
  - Can cost-optimise through (semi)custom design
  - Can tailor the solution to the clients preferences
- How so? These are very large projects...
  By building co-operations between companies large and small

# The Need to Cooperate

- An SME can often not handle the complete project scope
- Preferred supplier biases are real
  - Credibility is everything
    (but a low price helps to make new best friends)
  - New kid on the block = suspicious
  - Better the devil you know (← works well for large corps)
- A credible system integrator partner is often needed
  - The integrator is often a local company and the local face to the utility
  - The integrator has often done business with the utility before
  - The integrator, as a partner, often lacks the technical solution (or has to source it from COTS parts, and then be non-competitive on price)
- The integrator is the “in” for many a project!

# An Example Cooperation: Enexis

- Enexis issued the Dali tender
- Bausch Datacom became aware thereof through its network
- Xemex, a trusted supplier of Enexis, was also aware of the tender
- Xemex did not have enough manpower available to enter the tender
- Xemex and Bausch Datacom have existing commercial links → both companies contacted each other
- Bausch Datacom could design the hardware, but did not have the software resources. Bausch Datacom sub-contracted to Altran
- Xemex entered the tender, with Bausch Datacom as the hardware partner, and Altran as a sub-contractor for Bausch Datacom
- The consortium made it to the last three of the selected offerings (The prototype was made from scratch in 40 days!)

# Smart Grids in Practice
# MV/LV Secondary Distribution Sub-Station Tenders

# Researcher Beware!

- DSO have different motivators then you might think! Cost is not what you think!
- It doesn’t matter how beautiful your algorithm is, what matter is reliability, CAPEX, OPEX and complexity (it must be intuitively understood), and “unmentionable” factors
- Also, real-world factors DSO have to deal with are often bizarre!
  - Many DSO don’t actually know their exact MV and LV grid topologies
  - People make mistakes. It is not because it is written that it is true (eg: tap setting on the MV/LV transformer, fuse rating on the LV feeder, location of cables on maps, type of cables actually in the ground, etc…)
  - Communication is expensive and occasionally reliable
    - Also: bandwidth and latency are two different things
  - Interactions between more and more control systems on all levels
    - LV: constant power load in an EV, PV disconnect control, electronic power supplies with PFC,...
    - MV: wind turbines, large PV installations, inverter-driven machines,…
  - Sub-contractors of the “It’s four ‘o clock. Slap it together and jam the lid shut” school
- DSO are often KPI driven (by law and stock holders). Thus, only those KPI will be addressed. Note that the compromise between two logical things is often anything but
- All this, combined with a 50 year time horizon, drives conservative behaviour

# Researcher Beware!

- Talk to people from DSOs, learn their actual concerns and restrictions, and why they have those (not always warranted, but don’t bet on that too quickly)
- Make sure you are talking to the right person! (← Super important)
- Keep in mind that people change around in large companies...
- Understand the true nature of costs
  - This is often not the physical thing itself, but the framework around it. (CAPEX vs OPEX, contracts and legal requirements. Customer minutes not served, for example.)
  - Needing a technician with a van to go configure and fix things costs over €100k/year
  - Cost must be seen in a holistic way
- Understand how the grid is operated. Company processes are hard to change, and take long to change. Try to make your solution a natural fit in this process, or at least offer a proper transition plan. Remember: the grid is in use, the plane is in flight. You can’t pull-over for a week to change something...

# Some Tenets

- Make it **quiet**
  Avoid algorithms that require constant communication
- Make it **smart enough**
  Avoid algorithms that can’t operate in a safe mode with local intelligence
- Make it **self-discovering**
  Avoid anything that requires exact grid topology information
- Make it **self-configuring**
  Avoid anything that needs configuration
- Make it **robust**
  Beware of control interactions and study them!
  Design for soft fail and integrate reliable health checks!
- Make it **boring**
  Rule of least surprise. Think of it as nuclear power: it should not be exciting
- Make **simple** that which is hard
  Avoid anything that needs four years of study to understand
  Rather, use your four years of study to make it intuitive and clear

# Smart Grid: What to Expect?

- The first tenders are out, from various countries
- The scope varies dramatically between DSOs
- The devices are supposed to last at least 15 years, tenders in blocks of 4-5 years
- Spoiler: don’t expect much from the feature set for research!
  - It is all about improving the reliability indices in system operation (which is the thing that costs money, also what a DSO is all about!)
  - It is not about generating terabytes of measurements
  - And it is definitely not about toying with the grid
- Some tenders do include basic self-healing automation on the MV loop (automatic RMU open-point re-configuration, using local intelligence)
- Data is usually logged in coarse intervals, but not communicated. Only out-of-bounds values are typically communicated.
  - “Don’t speak unless spoken to.” and “Don’t cry wolf.” DSO are pretty harsh parents…
  - The reality is that the SCADA/DMS can only handle so much
  - The other reality is that communicating this much data is not free, let alone storing it

# Example Tenders

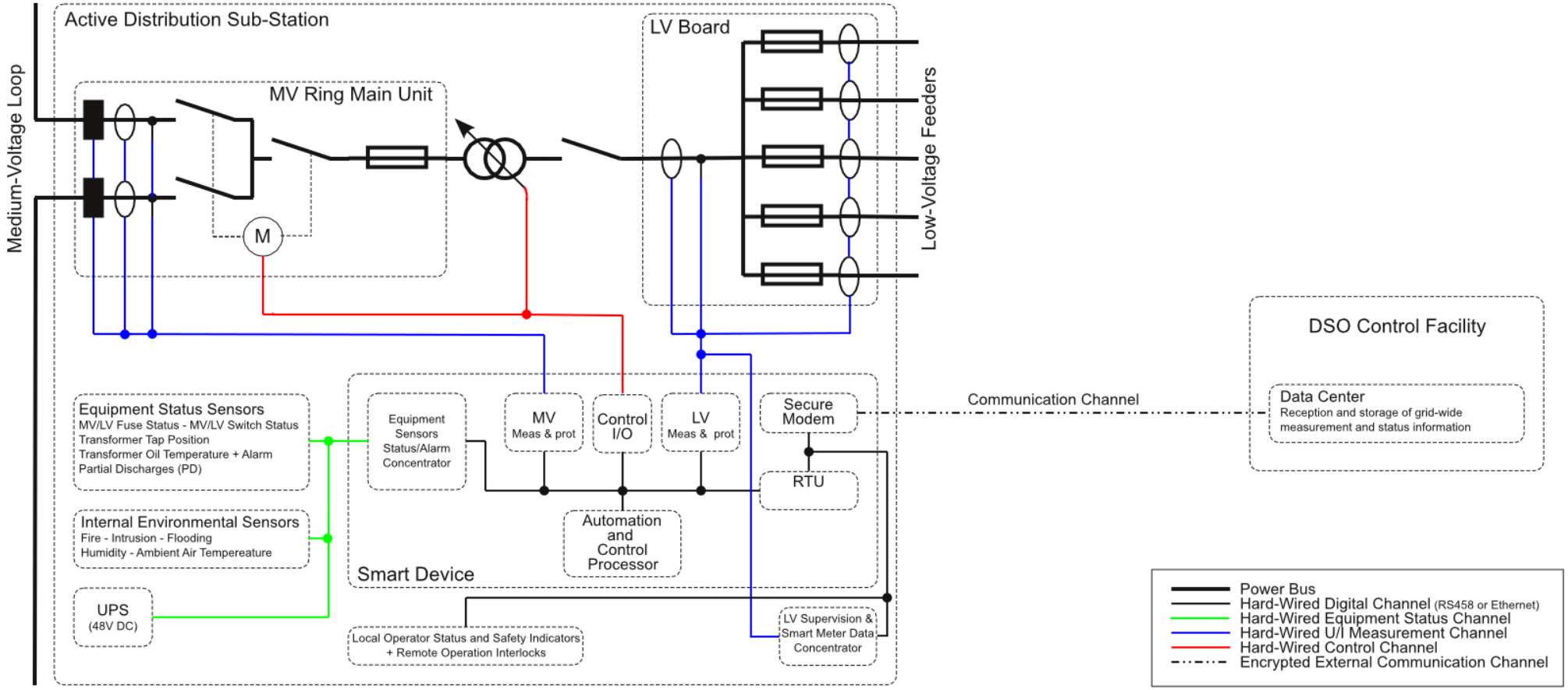
- We will compare the recent tenders from three DSOs
  - Note: different DSO in the same country can have very different tenders
    e.g.: the Stedin (NL) tender is conceptually much closer to Enedis (FR) EMIS then Enexis (NL) Dali
  - However, the core functionality is always similar.
  - The Enexis DALI project is beautifully transparent, also the POC results (but, all in Dutch)
    Google: “Enexis Dali”
- A good source for minimal specs is the EDSO SSS.Lite document
  http://www.edsoforsmartgrids.eu/minimum-functional-requirements-for-smart-secondary-substations-lite-technology-specification/

| **DSO** | Enexis | Sibelga | Enedis |
|---|---|---|---|
| **Country** | NL  | BE (Bru) | FR (95%) |
| **Scope** | Basic | Medium | Advanced |
| **Cost** | Low | Medium | High |

# MV/LV Distribution Sub-Stations

- First, a recap:
  - This is about secondary MV/LV distribution sub-stations
  - The MV network is radial, 3P 10kV – 15 kV
    - Actually a loop operated with an open point
    - Grounded or impedance grounded star point (implications for fault detection and fault current)
  - The LV network is radial, 3P 230V or 3P+N 400V
  - The transformer has an off-load tap changer
  - The RMU may or may not be motorized
  - Street lighting is an important aspect of automation
- Right now, there is little to nothing there in the way of monitoring and communication

# MV/LV Distribution Sub-Station



# Communication Protocols

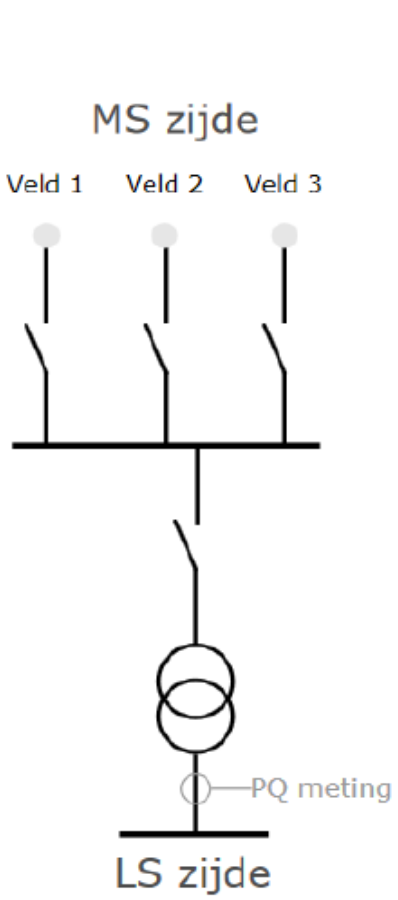
- The future is IEC61850… Eventually
  - Sub-sets of IEC61850 are now more common
    - MMS & GOOSE
    - Mainly talking to IEDs (protection and metering)
    - Still stays within the sub-station
- IEC60870-5-104 is still the standard toward SCADA/DMS
- In other markets: DNP3 (IEEE Std 1815-2012)
- Within the sub-station
  - ModBus (over RS485 and Ethernet)
  - Smart meters via a P1 port
  - DIO (mainly potential-free contacts)
- Security is through encrypted tunnels, VPN, and so on.

# Tenders at a Glance

| | MV Fault Detection | Self-Healing | MV measurements | Control of RMU | LV measurements | LV fuse detection | Street lights |
|---|---|---|---|---|---|---|---|
| Enexis | Yes, external | No | No | No (?) | Yes | No | Yes |
| Sibelga | Yes, external | No | No | Yes | Yes | Yes | No |
| Enedis | Yes, external and built-in | Automatic MV fault detection and RMU re-configuration | Yes, both fault detection and more accurate for voltage management | Yes | Yes | Yes | No |

- Each of these DSO have quite different operational areas
  - Enexis covers a diverse area, fairly populated, including cities. Also, each town has their own street light scheme.
  - Sibelga deals with a small, very densely populated, urban area with impossible traffic congestion.
  - Enedis deals with a geographically very diverse area, from extremely rural to large cities.
- These practical realities comes through in the tenders
  - Everyone cares deeply about MV loop fault detection: large affected area, large impact on performance KPI. FPI are cheap and have a clear business case.
  - Individual LV feeders are a concern in cities: need to know load profile and fuse state (traffic, large number of people affected during an outage e.g.: an office tower)
  - Remote operation of RMUs gains importance to improve performance (traffic, distance)
  - Highly modular concept for Enedis: they have to cover everything from one lost farm house in the Alps to Paris.

# A Prototype DALI Information Page




| | Spanning L | Spanning H | Stroom H | Stroom HH | THD Stroom | THD VAr |
|---|---|---|---|---|---|---|
| L1 | | | | | 0.17 % | 0.29 kVar |
| L2 | | | | | 0.29 % | 0.17 kVar |
| L3 | | | | | 0.22 % | 0.20 kVar |

ENEXIS

| | Alarmgrenzen | | Alarmgrenzen | | Vermogen | Energie |
|---|---|---|---|---|---|---|
| | U H | 240 V | I HH | 417 A | -0.12 kW | 0 kWh |
| | U L | 105 V | I H | 83 A | -0.12 kVAr | |

- Deur open
- Lithiumcel defect
- Comm.Verbinding (RMU 301)


| Tijdstip Avond uit (MMDD \| HHMM) | | |
|---|---|---|
| Dag 1 | 0000 | 0000 |
| Dag 2 | 0000 | 0000 |
| Dag 3 | 0000 | 0000 |
| Dag 4 | 0000 | 0000 |
| Dag 5 | 0000 | 0000 |

| Tijdstip (HHMM) | |
|---|---|
| Werkdag avond uit | 2300 |
| Weekend avond uit | 2300 |
| Ochtend aan | 0600 |
| Minimum aan | 30 min |
| Random start aan | 25 sec |

| Nacht | Avond / Ochtend |
|---|---|
| Uit \| Aan | Uit \| Aan |
| Sturing | Sturing |
| Fout | Fout |

RTU status Operational | Laatst ontvangen 2015-09-18 16:40:00 | Signaalkwaliteit 52 % | Breedtegraad 51.6906 | Lengtegraad 7.0688

# Conclusion

- Tenders are a valuable source of information
  - POC show what the DSO engineers are interested in and are trying out
    → know what lives
  - Tenders are what's actually going to happen
    → know what is cost-effective (or manageable)
- Utilities move slowly, because a mistake has a large impact (up to and including death)
  - The power grid is **not** an app on a phone
  - Change is often due to external factors (don't touch it if it works)
- For an SME this translates to:
  - Get it wrong, and play time is over for a decade (or ever)
  - Get it right, and there are contracts that keep on giving
  - Keep involved with interest groups and new tenders: feel the wind
- For researchers this translates to:
  - Do your homework before contacting people
  - Listen, then talk
  - A good solution will be looked at. When it will happen, that is a different story…
    A clear bottom-line and low risk will help
  - Policy (rules & regulations) are a strong driver to the adoption of new techniques
    Know what is happening in the commissions, and help drive it, or at least anticipate it

# Speaking of Homework...

- Eandis has a nice set of booklets that are worth reading, especially if you have a non-EU power system background. It gives a nice overview of things. (Unfortunately only in Dutch.)
  - Van productie tot stopcontact https://www.eandis.be/file/4316
  - Van amber tot onmisbaar (very basic, for the family) https://www.eandis.be/sites/eandis/files/documents/van_amber_tot_onmisbaar.pdf
- Pop Quiz: what is a “seven terminal transformer” (“zevenklemmer”)? Why did a large equipment vendor once make the joke “there is the American standard, there is the European standard, and then there is Belgium.”