The electrical results from the “Weilandproef” with 48 µCHP systems connected to the low-voltage grid
What is a µCHP?
A grid companion or a grid devil
- that’s the question! -
The opportunity: “De Weilandproef”

(green meadow)

=> 50 micro-CHP’s
3 months available to play with

Practical and verified experience in local micro generation:

- More knowledge for future grid design and effects in existing grids
- Verifying models and simulation software

Goal: to share the knowledge

Result: more than 1 year voluntarily analysing of measurements
Goal of measurement

- Voltage behaviour (inc low and high)
- Power quality on external voltage events (dips)
- Transformer behaviour at zero load and mixed load
- In- and un-intended island operation
- Start and stop run characteristic of micro-CHP
- Short circuit behaviour of micro-CHP and LV grid
- Touch voltage & differential leakage
- Responses to all other possible grid failures
- Sound and vibration
- Gas flow <-> kWh <-> heat (efficiency)
- Verification of models and simulation tools

Grid strategy means thinking ahead for 20 years
This type of CHP from

A) Gas burner, heating 4 stirling cylinders
B) Heat exchanger (exhaust gas → water)
C) Stirling Engine
D) Water heating (cold side of stirling)
E) Wobble_yoke (linear → rotating)
F) Gas flow control
G) Generator (AC)
H) Water Service Plate

Power: thermal en electric

Stirling max. $7\,\text{kJ}_{\text{th}}$ and max. $1000\,\text{kJ}_{\text{e}}$
configuration 2 x 24 / 1*48

Realisation (3 months)

vinex location

75 mtr to area of 48 houses
LV cable: 4X 50 mm² Al
@ 7 meter in between
Connection 10 meter 3X 2.5
mm² → 16 A MCB
Measurements and control

Control manual & automatic μCHP Data

Dedicated transformer

8x Phase L1
8x Phase L2
8x Phase L3

PQ 1

PQ 2

170 meters

Low voltage cabinet

PQ 3

PQ 4

28 ... 45

46 47 48

75 meters

1 2 3

4 ... 21

22 23 24

569x692
start → voltage

10V in 19 min => 
= 5.2V/10min ~ 2.2% >> 
3 trafo stappen

16V..8V

3 trafo stappen

start
The results of Flow measurements
Start at 200°C

Burner on

Exhaust

Cooling in

Cooling out

cranking

Full power

Overspeed prevention

Power

Jump to 400..600W

Voltage drop

Rapid voltage rise

Voltage

Voltage drop

Voltage
16V = +7.2%

-5V = -2.3%

16V in 3min
Voltage drop on instant load $\rightarrow (2*24)$
Frequentie → on load 26kW on 48kW
Asymmetric load \rightarrow\ voltage

\[ 12\,\text{V} \quad 17\,\text{V} \]

\( \sim 3\,\text{V} = 1.2\% \Rightarrow \sim 1 \text{ tapstand} \)
Touch voltage

- >5 periods ( >100msec) under voltage
- Top voltage rises to 520V ( 370V RMS)
- NL→NEN1010_fig. 41Z → human body 80msec
- ! Easy to change in software
**Short circuit contribution single unit**

**conclusion**

by phase shift between grid contribution and µCHP is on highest grid contribution the µCHP less than 3.8* Inom

From other Icc of total < 2.7Inom
3 phase short-circuit on end of string 1
( dist. +/- 400 meters)

→ String 1: Supply fuses 3 X 80 A trips all
→ String 2: All units still operates
Complex $\Rightarrow$ U en I op PQ4 (dist. +/- 400 meters)

Reconstruction of what is happening

Voltage

Current

One period

$2.5 \, I_n$
Fused 63 A, 3 phase short-circuit at generator 25

( dist. +/- 100 meters)

→ String 1: All units still operates
→ String 2: All units still operates

Fuses
3x 80 A

Fuses
3x 125 A

3x 63 A
Complex → U en I op PQ4 (dist. +/- 100 meters)
main results and conclusions (for this type) {1}

- These µCHP can operate behind B16_MCB; **plug and play**
- This type of micro CHP is voltage tolerant to grid events
- This method of mini grid is the best test for micro CHP to transient & subtransient behaviour (48 units for ~500h)
- Grid operators would have to think about bench mark system as we did it
- This test setup will stay, and hopefully more manufacturers will follow
- This test is unique in the world and... **the only real time** in it’s kind
main results and conclusions (for this type) {2}

- Voltage rise is less as assumed and behaviour can be improved further with simple software change.
- More than 60% generation power of transformer (MVA) can be connected.
- Simulation tools as (vision, gaia, digsilent, psse) are not yet to use for decentralised production action to software makers like phase to phase.
**discussion item → need for Label**

<table>
<thead>
<tr>
<th>Electro / Heat / Redundant</th>
<th>0</th>
<th>1</th>
<th>3</th>
<th>7</th>
<th>4+6</th>
</tr>
</thead>
<tbody>
<tr>
<td>on/off Modulating</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Environmental Efficiency</th>
<th>HR</th>
<th>HR-E</th>
<th>HR-E+</th>
<th>HR-E++</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>150%</td>
<td>150%</td>
<td>200%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Electric / Heat Percentage (Max)</th>
<th>0</th>
<th>0.125</th>
<th>90</th>
<th>100</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Operational Voltage</th>
<th>30-90</th>
<th>15min</th>
<th>100%</th>
<th>110</th>
<th>115</th>
<th>120</th>
</tr>
</thead>
<tbody>
<tr>
<td>on/off Limited Power</td>
<td>90</td>
<td>95</td>
<td>90</td>
<td>110</td>
<td>115</td>
<td>120</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Voltage Limit Contribution</th>
<th>grid</th>
<th>home</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Short Circuit Contribution</th>
<th>&gt;80%</th>
<th>&gt;70%</th>
<th>&gt;60%</th>
<th>&gt;50%</th>
<th>&gt;30%</th>
<th>&gt;10%</th>
<th>0%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference Grid / Home Grid</td>
<td>0.1sec</td>
<td>0.2sec</td>
<td>0.5sec</td>
<td>1sec</td>
<td>2sec</td>
<td>5sec</td>
<td>10sec</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fault Ride True</th>
<th>standing</th>
<th>well</th>
<th>build in</th>
<th>weight</th>
<th>6 Hz</th>
<th>0.2/100</th>
<th>3 year</th>
<th>20 year</th>
<th>start</th>
<th>restart</th>
<th>stop</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Facts</th>
<th>HMI</th>
<th>RS232</th>
<th>TCP/IP</th>
<th>Mem card</th>
<th>on/off</th>
<th>Smart</th>
<th>UPS</th>
<th>black start</th>
<th>boiler</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>remotely</td>
<td></td>
<td></td>
<td></td>
<td>120L</td>
</tr>
</tbody>
</table>