Waste heat recovery systems for the Glass Industry
Why Waste Heat Recovery in the glass industry?

- Since 2008 the operating margin in many glass markets (except Asia) is almost zero
- Focus to the main production cost drivers
- Energy costs roughly are about 25% of the total glass production costs
- Only 15 - 20% of the primary energy input in a glass melter is effective for glass creation

=> More than 80% of the primary energy input is wasted!
Waste heat potential (sample: 700 tpd glass melter)

- QP_Abgas = 14.5 MW
- QP_Reg = 26.3 MW
- QP_Erdgas = 48.1 MW
- QP_Glas = 7 MW
- QP_AGR = 0 MW
- QP_Kamin = 4.9 MW
- QP_KWK = 10.2 MW
- QP_Halle = 25.1 MW
- QP_Abst = 1.5 MW

TE = 525.8 °C
TA = 180 °C

Wannenalter = 0 Jahre
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**Waste Heat Recovery solutions**

- Production facility cooling water heat recovery (for central heating system)

- Water or steam based cooling energy and heat energy generation

- Water / Steam based electrical power generation by a turbine/generator unit
  - Standard WHR solution
  - Advanced WHR solutions from qpunkt

- ORC based electrical power generation by a turbine/generator unit
Typical client WHR requirements

=> Top priority for the glass production (quality and quantity)

=> Minimized influence of the WHR system to the furnace pressure characteristics

=> High WHR utilization grade (technological & process related)

=> Maximized electrical power output

=> Independent electrical power supply

=> Short ROI

=> System implementation during operation (not only at cold repair)

=> Additional heat and/or cooling energy utilization
qpunkt WHR concept basics

Optimization potential of standard WHR systems in the Glass Industry:

- Unreliable initial WHR design data
- Over-expected power generation
- Over-expected utilization grade
- Furnace pressure characteristics
- Return of investment
- Electrical energy costs after pay back period
- Combination of electrical and heat/cooling energy production

Objective of our patent registered qpunkt WHR concept is improvement of this identified weak points, and provision of a unique high performance WHR system to our potential customers.
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qpunkt WHR concept basics
Initial WHR design data check or how operates qpunkt?

- Provision of an initial data sheet to the client
- Plausibility check of the received data
- Site survey (if required)
- WHR potential analysis
- Local supply part check
- Provision of qpunkt/Oranje Kracht quotation
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qpunkt WHR performance – Influence to the glass production process

WHR systems could cause furnace pressure peaks originated by boiler or emergency shut-down modes, and also higher ID-fan electrical power demand.

Glass production influences by qpunkt WHR system:

- Only 50 – 70 % pressure drop compared with standard WHR solutions
- Significant reduced furnace pressure peaks by implementation of patent registered EQM system, by additionally reduction ID-fan electrical power demand down until 50 %
- Continuous and uninterrupted electrical power supply of the float glass production line even in case of main power failures
- Dedicated chimney and chimney connection design by qpunkt avoids also furnace pressure peaks caused by emergency shut down procedures of the WHR / WGC system

=> qpunkt WHR system particular in combination with EQM and a dedicated chimney design improves furnace pressure progress with additional savings and further advantages!
qpunkt WHR performance - Utilization

The WHR utilization depends on:

a) System reliability
   - Granted by considering nameable and experienced WHR equipment suppliers.

b) Required cleaning and maintenance works
   - Due to dust polluted waste gas, the boilers have to be cleaned periodically during operation. Usage of automatically working boiler cleaning systems do not cause any WHR system downtime
   - The WHR system requires only one yearly check with 3-4 days downtime (no extra downtime in case of existing waste gas cleaning system!)

c) Process related waste gas conditions
   - Waste gas condition variation (temperature and volume) caused by furnace age, product change, melting capacity variation, etc., cause underperformance and also downtime at standard WHR solution
   - The qpunkt WHR system always operates with highest performance grade at all waste gas conditions.

=> Utilization grade of the qpunkt - WHR system $\geq 97\%$
### qpunkt WHR performance – Return on invest & Electrical output

<table>
<thead>
<tr>
<th></th>
<th>ORC WHR</th>
<th>Standard WHR</th>
<th>qpunkt WHR Type 1</th>
<th>qpunkt WHR Type 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available waste heat energy [MW\textsubscript{in}]</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Electrical net energy generation [MW\textsubscript{el}]</td>
<td>1,8</td>
<td>1,9</td>
<td>3,1</td>
<td>2,75</td>
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<tr>
<td>WHR utilization [%]</td>
<td>96</td>
<td>92</td>
<td>97</td>
<td>97</td>
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<tr>
<td>Total investment costs [Mio. €]</td>
<td>5</td>
<td>5,6</td>
<td>6,5</td>
<td>6,7</td>
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<tr>
<td>Market electrical energy costs [€/MW]</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
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<tr>
<td>Electrical energy production costs [€/MW]</td>
<td>6,6</td>
<td>6,5</td>
<td>23,2</td>
<td>15,6</td>
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<tr>
<td>Natural gas costs [€/MW]</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
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<tr>
<td>WHR natural gas demand [m\textsuperscript{3}/h]</td>
<td>0</td>
<td>0</td>
<td>240</td>
<td>125</td>
</tr>
<tr>
<td>Av. plant electrical energy demand [MW\textsubscript{el}]</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Pay back period except any cooling or heating application [years]</td>
<td>4,1</td>
<td>4,6</td>
<td>4,1</td>
<td>4,2</td>
</tr>
<tr>
<td>Yearly electrical energy costs after pay back period</td>
<td>991.418</td>
<td>977.402</td>
<td>604.926</td>
<td>598.554</td>
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</tbody>
</table>

Electrical energy costs without WHR: ca. 2,1 Mio.€ p.a.
(Investment costs based on Western European prices)
qpunkt WHR performance – System application and implementation

- Float and container glass plants (100 – 1.200 tpd)
- Regenerative or oxyfuel melter systems
- Natural gas or oil fueled
- Single line or multi-line implementation:

1-line concept

<table>
<thead>
<tr>
<th>Line 1</th>
</tr>
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<tbody>
<tr>
<td>Melter</td>
</tr>
<tr>
<td>Boiler</td>
</tr>
<tr>
<td>WCS</td>
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<tr>
<td>Boiler</td>
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</table>

2-line concept

<table>
<thead>
<tr>
<th>Line 1</th>
<th>Line 2</th>
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</thead>
<tbody>
<tr>
<td>Melter</td>
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<tr>
<td>Boiler</td>
<td>Boiler</td>
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<tr>
<td>WCS</td>
<td>WCS</td>
</tr>
<tr>
<td>Boiler</td>
<td>Boiler</td>
</tr>
<tr>
<td></td>
<td>Energy Building</td>
</tr>
</tbody>
</table>
qpunkt WHR performance – System implementation

- WHR systems generally could be implemented into:
  - New plants
  - Existing plants with waste gas cleaning systems
  - Existing plants without waste gas cleaning systems
  - Existing plants with later to implement waste gas cleaning systems

- WHR systems could be implemented at new plant installation, during cold repair and in many cases also during operation.

- Corresponding connections for integration of the boilers should be prepared or have to be prepared under “hot work” conditions.

=> Implementation of the qpunkt - WHR system is possible in most cases, even during operation.
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qpunkt WHR performance – System implementation

Typical WHR system space requirement:

For the boiler system: ca. 25 x 30 m

For the turbine house: ca. 15 x 20 m
qpunkt WHR performance – Heat and cooling utilization

- Additional to the electrical energy generation the waste heat also could be utilized for:
  - Heating of buildings or storage areas
  - Cooling energy
  - Process uses (i.e. cullet drying, sand storage heating, etc.)

- The qpunkt – WHR concept provides available heating temperatures up to 60 °C. A 700 tpd float glass plant provides ca. 8 MW heat power without any reduction of the electrical power generation.

- By only electrical power reduction of ca. 250 kW, more than 2 MW cooling energy (cold water at 7 °C) could be generated!

- Additional use of heat power could be made adaptable for neighbored greenhouses (extra benefit by selling idle heat energy at 60 °C)

=> The qpunkt WHR system utilizes a huge amount of heat and cooling energy, and is adaptable for each particular customer heat & cooling demand.
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Summary

<table>
<thead>
<tr>
<th>Requirements</th>
<th>qpunkt - WHR system</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top priority for glass production</td>
<td>Top priority</td>
<td>✔</td>
</tr>
<tr>
<td>Influence on the furnace pressure</td>
<td>Minimized</td>
<td>✔</td>
</tr>
<tr>
<td>Short ROI</td>
<td>&lt; 5 years</td>
<td>✔</td>
</tr>
<tr>
<td>Electrical power output</td>
<td>Maximized</td>
<td>✔</td>
</tr>
<tr>
<td>WHR utilization time</td>
<td>Maximized</td>
<td>✔</td>
</tr>
<tr>
<td>Heat &amp; Cooling utilization</td>
<td>Customized solutions</td>
<td>✔</td>
</tr>
<tr>
<td>Electrical efficiency grade</td>
<td>Maximized</td>
<td>✔</td>
</tr>
<tr>
<td>Accumulated savings</td>
<td>Maximized</td>
<td>✔</td>
</tr>
<tr>
<td>System implementation</td>
<td>during operation</td>
<td>✔</td>
</tr>
</tbody>
</table>

*1) Improved by EQM© (reduces furnace pressure peaks and reduces ID fan electrical power consumption up to 100 kW)

The advanced qpunkt – WHR system complies with all typical requirements, and provides also further saving and process optimization potential (i.e. by the patent registered EQM system).
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Thank you for your attention.