Industrial Energy-Related Technologies and Systems

A Technology Collaboration Programme
established under the auspices of the International Energy Agency

“Optimisation of energy production in a bio-refining process using artificial intelligence”

Philippe Mack

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Energy Future in Industry

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About PEPITE

Vision

We believe that access to basic goods and services for all humanity requires intelligent and rational use of natural resources, which must be produced in a responsible and sustainable manner.

Mission

• We enable industrial players to make a better use of natural resources.

• We provide them with a software suite and a methodology that allows them to address many issues by leveraging the information hidden in their process data.
Aggressive scenarios to net zero are more than welcomed to minimise global warming.

Digitalisation is a fundamental asset to solve quickly this problem way too complex for human brains...

On the road to net zero, **operational efficiency** is one of the quickest way to reduce CO$_2$ emissions with the **lowest CAPEX**

Digital Transformation is a **key enabler to identify and capture** wastes in operational efficient

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### Five key markets for climate solutions would boom by 2025.

<table>
<thead>
<tr>
<th>Market</th>
<th>Annual investment by 2025, $ billion</th>
<th>Annual abatement in 2030 (estimated), million metric tons of CO$_2$ equivalents</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1 Renewable power</strong></td>
<td>300</td>
<td>990 26%</td>
</tr>
<tr>
<td><strong>2 Electrification</strong></td>
<td>290</td>
<td>920 24%</td>
</tr>
<tr>
<td><strong>3 Operational efficiency</strong></td>
<td>10</td>
<td>710 18%</td>
</tr>
<tr>
<td><strong>4 Clean fuels</strong></td>
<td>20</td>
<td>370 9%</td>
</tr>
<tr>
<td><strong>5 Carbon capture</strong></td>
<td>30</td>
<td>230 6%</td>
</tr>
</tbody>
</table>

**Source:** McKinsey Energy Insights Global Energy Perspective 2022
Consortium Presentation

2Valorise is a group that focus on maximising the recovery of end-of-life woody waste biomass streams by transforming them into electricity, heat and useful by-products for the building and construction industry.

Equans Digital is the Belgian reference in the field of design, integration, automation, digitalization and maintenance of processes and industrial installations.

PEPITe SA provides advanced analytics and AI solutions for the process and manufacturing industry. DATAmestro® software is a no-code solution to deploy at scale advanced analytics for the optimisation of operation and maintenance.

www.2valorise.be
www.equans.be
www.pepite.com
Consortium and Project Organization

1. DigitalWallonia4.ai program to accelerate the adoption of AI and its ecosystem

2. Our project is selected for the 1st Start IA call from DigitalWallonia4.ai and benefits from the support of an expert identified within the Pool of IA Experts

3. Our project was selected for the 1st Tremplin IA call for the implementation of a collective PoC (demonstrator)

Consortium goals:
- Develop and test the full-scale AI tool
- Extend the solution in the sector or other sectors
2Valorise Group

**2Valorise Amel SA**
- 2 cogeneration units
- Capacity: 40 Mw\textsubscript{th} - 11.2 Mw\textsubscript{e}
- 2017: 14M Best available technology: flue gas cleaning + process improvements
- Jobs: 25 FTE

**2Valorise Ham NV**
- 1 cogeneration unit
- Capacity: 34 Mw\textsubscript{th} - 9.6 Mw\textsubscript{e}
- Local recovery of waste heat
- Jobs: 18 FTE

**2Valorise NV**
- Biomass purchase and management
- +/- 240 à 260 kt/ year
- In-house laboratory
- Valorisation of new materials in construction sector
- Jobs: 3 FTE

**2Valorise Services SA**
- Maintenance and engineering team
- Expertise in industrial maintenance, industrial and environmental project management
- Future development of this expertise towards third parties
- Jobs: 15 FTE
2Valorise Amel

Capacity: $40 \text{ MW}_\text{th} 11.2 \text{ Mw}_e$

120 to 130 trucks per week

$+/- 140,000 \text{ t}$ of biomass recovered per year: forestry waste, composting waste, cooking waste, pruning waste

$61,000 \text{ MWh}$ of electricity produced each year: consumption of about 15,000 households
Process description

2 Boilers

Wood waste, composting residue mix

Boiler

Bag filter flue gas cleaning

Turbine generator unit (Max : 11,2MWe)

District heating

Electricity distribution network
Implementation methodology of AI based tool

- Integration into **continuous improvement programs** (six sigma on “steroids”)

- **Engage** and **Involve** Plant Operators (Co-development)

- AI tools that require **little/no IT development skills** to facilitate adoption by process engineers. (**No-Code solution**)

- **Top-down** approach: **Management support** is essential to make it a priority.

- **Bottom-up** approach: **Plant Operator support** is essential to make this a reality.
## Prioritisation of opportunities and objectives

<table>
<thead>
<tr>
<th>ID</th>
<th>KPI</th>
<th>Score (1 – 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Electrical Efficiency</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>Net Electrical Power produced</td>
<td>9.1</td>
</tr>
<tr>
<td>3</td>
<td>Turbine Electrical Efficiency</td>
<td>7.2</td>
</tr>
<tr>
<td>4</td>
<td>Self-consumption of electricity</td>
<td>8.0</td>
</tr>
<tr>
<td>5</td>
<td>Turbine Availability</td>
<td>3.0</td>
</tr>
<tr>
<td>6</td>
<td>Compressed Air Consumption</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Water Consumption</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Urea Consumption</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Baking Soda Consumption</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Cinder Production</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Fly Ash Production</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Cost of soot blowing in heat exchangers (sootblower)</td>
<td></td>
</tr>
</tbody>
</table>

### Complexity vs. Impact Chart

- Low Interest
- Middle Interest
- High Interest

**KPIs and Scores**
- Electrical Efficiency: 10
- Net Electrical Power produced: 9.1
- Turbine Electrical Efficiency: 7.2
- Self-consumption of electricity: 8.0
- Turbine Availability: 3.0
- Compressed Air Consumption
- Water Consumption
- Urea Consumption
- Baking Soda Consumption
- Cinder Production
- Fly Ash Production
- Cost of soot blowing in heat exchangers (sootblower)
Solution Architecture and Data Sources

- ERP
- MES/MIS
- SCADA/HMI
- PLC/DCS
- Sensors/Actuators

Data Sources:
- Labs Room: pcLabs (192.168.254.xxx), Excel
- Control Room: pc3 (10.48.85.3), pc4 (10.48.85.4), Scheuch (10.48.85.100), pcReporting (192.168.254.xxx)
  - pc3: WW InTouch, WW HistData
  - pc4: WW InTouch, WW HistData
  - Scheuch: WW InTouch, WW HistData
  - pcReporting: Excel

Devices:
- Amel-1: pc1 (10.48.85.1), WW InTouch, WW HistData
  - PLC Chaudière 1
  - PLC Turbine 1
- Amel-2: pc2 (10.48.85.5), WW InTouch, WW HistData
  - PLC Chaudière 2
  - PLC Turbine 2
- Schuek: pc3 (10.48.85.136), WW InTouch, WW HistData
Data management for scalable AI

Available cloud/hybrid/on premise
- Private Cloud hosted by PEPITe (Hetzner)
- Alternatives
- On premise hosting
- Microsoft Azure
- Amazon AWS

Cybersecurity
- Data are transferred encrypted on the cloud using certificate via HTTPS
- Data is always encrypted when stored on the cloud
- Access to the cloud server is protected by a firewall
- SSO

Dedicated Cloud spec
EX52-NVMe (Hetzner)
- CPU: AMD Ryzen 5 3600 Hexa-Core
- RAM: 64GB DDR4
- HDD: 2 x 1TB NVMe SSD (RAID1)
Monitoring of steam production

Based on historical data, the IA model predicts the target production and recommends setpoints for the boilers in order to maximise MW production. It avoids losses of steam bypassed directly to the condenser. This model takes into account external T°, performance of heat exchange, condenser, etc.

AI recommended range for active power
Problem detection [1/2]

Based on reference period we **compare actual** performance for active power generation with **predicted performance**. If actual production is higher than prediction, the gain is increasing (green trend segment). This chart allows to quantify and visualise impacts performances drifts and abnormal behaviour.

1. **Actual active power value minus target > 0**

   - Actual active power value minus **Target < 0**
Problem detection [2/2]

AI is used to identify and rank the parameters impacting the drift.

Visualization on most impacting parameters helps to understand more clearly what happened.
Detection of heat exchanger fouling

Key parameters are compared to a normal situation with cleaned heat exchangers. When there is a drift, the instrument panel indicates a deviation.
Impacts

• Quantitative impacts
  
<table>
<thead>
<tr>
<th>Gains 2022</th>
<th>MWhe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fouling detection</td>
<td>300 (4-8%)</td>
</tr>
<tr>
<td>Production</td>
<td>72 (1-2%)</td>
</tr>
</tbody>
</table>

• Qualitative impacts
  
  • Direct and fast access to all data
  • Accelerate faults identification and troubleshooting
  • Quickly detect small and slow production drifts
  • Anticipate the detection of deviations in order to optimise the management of maintenance
Challenges

• Human factors
  • Resistance to change
  • Not all operators are used to IT (generation gap)
  • Process control based on experience ➔ it "shakes up" habits
  • Lack of knowledge about the opportunity of AI in improving production

  Coaching, training to build capability

• Technical factors
  • Data collection
  • Various sources (Excel, PLC, Website,...)
  • Addition of extra sensors sometimes needed
Future perspectives

• Short-term perspectives
  • Develop the root cause search tool
  • Develop other tools to focus monitoring on key parts of the process
  • …

• Medium-term perspectives
  • Provide a AA template for other facilities that would allow them to monitor the status of production at a glance (for companies where this is not the core business)
  • Experience gained in implementing the tool effectively across the consortium
Questions ?