INOVENERGY — A PROJECT FOR ENERGY EFFICIENCY IN THE AGRO-FOOD INDUSTRY SECTOR


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eficiência energética no sector agro-industrial
Participating entities

Funding bodies

inovcluster
Associação do Cluster Agro-Industrial do Centro

COMPETE
PROGRAMA OPERACIONAL FACTORES DE COMPETITVIDADE

UNIÃO EUROPEIA
Fundo Europeu de Desenvolvimento Regional
Scope of the project

As fuel and power prices continue to rise, industries struggle, making investments in energy efficient technologies and practices of paramount importance.
Targeted industries

Meat  Wines  Fish  Dairy  Fruit & Vegetables  Distribution

A total of 252 companies to be included:

✓ Six industrial ranks
✓ Seven institutions
✓ Six per rank and institution
Main objectives

Energy characterization

Emerging technology impacts evaluation

Environmental savings evaluation

Results dissemination through Workshops and good practice guides

Publication of an energy efficiency algorithm
FIRST PHASE

- Companies' general characteristics (CAE, dimension, annual turnover, etc.)
- Type, costs and amount of energy inputs
- Raw material and annual production
- Active and passive refrigeration related equipment's characterization
SECOND PHASE

In-depth energy audits to two companies per rank and institution

Assessment of collected data and study of energy efficiency measures

Results publication through Workshops and Best Practice Guides – data for benchmarks

Management software to quickly point to sector-specific energy efficiency measures

Energy Audit & Measure

Passive Energy Efficiency

Active Energy Efficiency

Fix the basics
Low consumption devices, insulation material, power factor correction

Optimise through Automation and Regulation
HVAC control, lighting control, variable speed drives...

Monitor, Maintain, Improve
Meters installation, monitoring services, EE analysis software
Main objective

To test techno-economical feasibility

Of a base-load chiller operating at -30°C, 95% of the year
BENCHMARK AND CURRENT ENERGY REQUIREMENTS

<table>
<thead>
<tr>
<th>Industry Sector</th>
<th>Electricity Used for Refrigeration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid milk processing</td>
<td>25%</td>
</tr>
<tr>
<td>Breweries</td>
<td>35%</td>
</tr>
<tr>
<td>Confectionery</td>
<td>40%</td>
</tr>
<tr>
<td>Chilled ready meals</td>
<td>50%</td>
</tr>
<tr>
<td>Frozen food</td>
<td>60%</td>
</tr>
<tr>
<td>Cold storage</td>
<td>85%</td>
</tr>
</tbody>
</table>

Graph showing energy consumption over time with different levels: On peak, Off peak, Rated demand, and On peak power.
**Description of Alternative Trigeneration Scenarios Based on the Required Refrigeration Effect**

The required prime mover(s) power was calculated (heat demand of the absorption chiller)

<table>
<thead>
<tr>
<th>Scenario I</th>
<th>3 gas microturbines + Absorption chiller (200 kWc)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Simple system</td>
</tr>
<tr>
<td></td>
<td>• Direct exhaust as energy input to Absorption Chiller</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario II</th>
<th>2 gas microturbines + Post-Combustion + Absorption chiller (200 kWc)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Reduced energy requirements from prime-movers</td>
</tr>
<tr>
<td></td>
<td>• Post-combustion with rich-in-O2 waste gas that serves as combustion air to auxiliary burner</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario III</th>
<th>1 internal comb. engine (ICE) + Absorption chiller (200 kWc)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Highest electrical efficiency</td>
</tr>
<tr>
<td></td>
<td>• Proven technology – maintenance friendly</td>
</tr>
</tbody>
</table>
THREE ALTERNATIVES STUDIED PER SCENARIO

TRIGEN OPERATING 95%/Y, ELECTRICITY SOLD AT FIXED PRICE

TRIGEN OPERATING 95%/Y, ELECTRICITY SOLD AT VARIABLE PRICE (PEAK/OFFPEAK)

TRIGEN OPERATING 71.4%/Y, ELECTRICITY SOLD AT PEAK PRICE
RESULTS & DISCUSSION

**Key Assumptions**

<table>
<thead>
<tr>
<th>Nat. gas: 46 €/MWh</th>
<th>Purchased electricity(^{(1)}): 109.56 €/MWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sold electricity at fixed rate(^{(2)}): 99.23 €/MWh</td>
<td>Sold electricity at bi-rate(^{(2)}): On-peak: 108.35 €/MWh; Off-peak: 87.37 €/MWh</td>
</tr>
</tbody>
</table>

(1) Weighted average of on-peak and off-peak electricity price

(2) Approximate value according to the Law decree 23/2010, DGEG, Nº5/2012

<table>
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<tr>
<th>Scenario I</th>
<th>Alternative 1</th>
<th>Alternative 2</th>
<th>Alternative 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating costs [€/year]</td>
<td>689.062</td>
<td>689.062</td>
<td>512.622</td>
</tr>
<tr>
<td>Annual savings [€/year]</td>
<td>597.695</td>
<td>609.969</td>
<td>462.402</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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<th>Alternative 2</th>
<th>Alternative 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating costs [€/year]</td>
<td>501.785</td>
<td>501.785</td>
<td>378.853</td>
</tr>
<tr>
<td>Annual savings [€/year]</td>
<td>432.537</td>
<td>439.605</td>
<td>333.586</td>
</tr>
</tbody>
</table>

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<th>Alternative 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual savings [€/year]</td>
<td>1.269.064</td>
<td>1.302.501</td>
<td>986.040</td>
</tr>
</tbody>
</table>
Modified "Spark Gap"

Typical COP of Electric Chiller

Typical COP of Absorption Chiller

Costs to produce 1 kWh cold at given temperature

$\text{€}_{\text{TH}} / \text{COP}_{\text{TH}}$

$\text{€}_{\text{EL}} / \text{COP}_{\text{EL}}$

Spark Gap Relationship
CONCLUSIONS AND FUTURE WORK

THREE SCENARIOS ANALYZED

NONE IS REALISTICALLY ATTRACTIVE

COMPANIES ARE PUSHED TO TRADITIONAL CHILLERS DUE TO LOW COST AND HIGH EFFICIENCY

TRIGEN SYSTEMS FACE HIGH INVESTMENT AND (EVENTUALLY) HIGH RUNNING COSTS
MORE RESEARCH NEEDED

• **Small scale prime movers have generally low efficiencies**

• **Small scale prime movers have greater investment costs than higher capacity machines (scale effect)**

• **Currently trigens for deep cold are only profitable if true waste heat is available**

IF TECHNO-ECONOMICAL PROBLEMS ARE SURPASSED...

• **For companies with heat and cold requirements, trigeneration is easily justifiable**

• **There is a vast market of companies with refrigeration-only requirements that would triple benefit if such systems would present greater efficiencies**

• **There would be a general reduction in energy and GHG emissions with the more widespread use of decentralized power systems**
THANK YOU FOR YOUR ATTENTION