Smart Thermal Grid Management

Andrew Marshall

Spirax-Sarco Ltd.

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Agenda

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3. SYMBIOPTIMA concepts & objectives
4. Business model to address barriers to collaboration
5. Smart thermal grid overview
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Introduction

SYMBIOPTIMA?

Our project title refers to the concept of achieving optimal energy consumption within industrial symbiosis scenarios.

SYMBIOPTIMA consortium companies are developing a variety of new techniques that will facilitate efficient application, recovery and re-use of thermal energy in industrial scenarios.

The concept of a ‘Smart Thermal Grid’ (STG) lies at the heart of our approach.

15 organisations from 7 E.U. countries.

Spirax Sarco acting as Project Co-ordinator.

Funded under Horizon 2020 – SPIRE 6
Spirax Sarco

Spirax Sarco is a worldwide thermal energy business operating in 50+ countries around the world.

- Exploring new opportunities for our customers
- Invention
- Building and testing prototypes
- Links to Academia
- Partnership progress & external funding
- Harnessing new technologies
Spirax Sarco

At our Cheltenham Technology Centre we develop new techniques & technologies for thermal engineering applications.
Thermal Energy Inefficiency Today

Energy not completely used in the target process is often lost because ‘there is no where for it to go’ afterwards.
Today, when production is planned, energy is ‘assumed to be available’. Safe for production but energy inefficient.
Lack of co-ordinated, energy aware, production planning leads to:

- Unpredictable energy demand peaks
- Higher cost power contracts
- Higher cost energy infrastructure to meet peaks
- Possible power peaks over the limit with production down-time

In Germany today companies can be charged for their energy ‘ramp rate’.
SYMBIOPTIMA Concepts

Production Unit (PU)

Consumes energy and material resources. Outputs products. Outputs waste energy and materials.

Cluster of PUs
Kalundborg Denmark Cluster

Industrial clusters today operate with inflexible and ‘static’ long term contracts.

Waste avoided: 200,000 tons fly ash and clinker; 80,000 tons scrubber sludge; 2,800 tons sulphur as H2S in flue gas; 1 million cubic meters of water treatment sludge; 1,500-2,500 tons sulphur dioxide; 130,000 tons carbon dioxide avoided.

Fuel savings: 30,000 tons of coal. 19,000 tons of oil

Chemical savings: 800 tons nitrogen; 400 tons phosphorous; 2,800 tons sulphur; 80,000 tons gypsum
SYMBIOPTIMA Objective

To enable **dynamic (near real-time) co-ordination** of thermal energy supply and demand at cluster level.
SYMBIOPTIMA partner, **SUPSI (University of Applied Sciences and Arts of Southern Switzerland)**, has been investigating barriers to Industrial Symbiosis.

Examples:

<table>
<thead>
<tr>
<th>Technical</th>
<th>Organisational</th>
<th>Financial</th>
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Barriers to Collaboration

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We have experienced such reluctance on SYMBIOPTIMA.
Business Model

A third party service provider performs the following tasks:

Green Bank to collect contributions & distribute dividends.

Safeguards to oversee partners’ behaviour.

Confidentiality to protect sensitive partner company data.

Identification of industrial symbiosis opportunities.

Managed transition of by-products between inter-linked production units.

Turnkey solutions to engineer links between production units.
A ‘Thermal Grid’ can be considered as comprising of physical infrastructure for the generation, conversion, distribution, storage and recovery of thermal energy.

The grid becomes **Smart** when networked instrumentation and application software enable an over-arching management of thermal energy flows.
Smart Thermal Energy Grid - SIMS

The Spirax Sarco ‘SIMS’ application forms the interface between grid hardware and higher level systems.

SIMS provides information relating to capacity and condition of grid hardware.

SIMS receives desired energy delivery schedule information from the higher level systems.
Smart Thermal Grid – Cluster Level

Data from multiple Production Units are elevated to network level for use by the centrally located **Energy Resource Management System (ERMS)**.
Energy Aware Resource Management (ERMS) from ITIA-CNR.

Desired production schedule
Energy Aware Resource Management

Energy Aware Resource Management (ERMS) from ITIA-CNR.

24 hour look ahead energy tariffs

Desired production schedule
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Grid status
Energy Aware Resource Management

**Energy Aware Resource Management (ERMS)** from ITIA-CNR.

24 hour look ahead energy tariffs

Grid status

Desired production schedule

\[
\begin{align*}
\text{min} \quad & \sum_{i=1}^{n} x_i + \sum_{i=1}^{n} y_i \\
\text{s.t.} \quad & \sum_{i=1}^{n} \left( p_i - \sum_{j=1}^{m_i} \frac{f_j}{m_i} \right) x_i + \sum_{i=1}^{n} \left( p_i - \sum_{j=1}^{m_i} \frac{f_j}{m_i} \right) x_i \\
& \sum_{i=1}^{n} \left( p_i - \sum_{j=1}^{m_i} \frac{f_j}{m_i} \right) x_i + y_i > \sum_{i=1}^{n} \left( p_i - \sum_{j=1}^{m_i} \frac{f_j}{m_i} \right) x_i \\
& p_i = \{ p_1, p_2, \ldots, p_m \} \in U_1, i = \{ 1, 2, \ldots, n \}, \\
& \sum_{i=1}^{n} \left( p_i - \sum_{j=1}^{m_i} \frac{f_j}{m_i} \right) x_i + y_i > \sum_{i=1}^{n} \left( p_i - \sum_{j=1}^{m_i} \frac{f_j}{m_i} \right) x_i \\
& x_i = 0, 1, i = \{ 1, 2, \ldots, n \}, y_i \geq 0, y_i = \{ 1, 2, \ldots, n + 1 \}
\end{align*}
\]
Energy Aware Resource Management

Energy Aware Resource Management (ERMS) from ITIA-CNR.

24 hour look ahead energy tariffs

Desired production schedule

Grid status

Rolling horizon energy delivery schedule

Algorithms

Energy Tariffs

\[
\begin{align*}
\text{min}_{x^*, y^*} & \quad \sum_{i=1}^{n} x_i + \sum_{i=1}^{m} y_i + \sum_{i=1}^{m} z_i + \sum_{i=1}^{m} \sum_{j=1}^{n} \beta_{ij} x_i \\
\text{s.t.} & \quad \sum_{i=1}^{n} b_i - \sum_{j=1}^{m} c_{ij} + \sum_{i=1}^{m} d_{ij} x_i - m_i y_i \leq \sum_{i=1}^{m} e_{ij} \\
& \quad \sum_{i=1}^{n} b_i - \sum_{j=1}^{m} c_{ij} + \sum_{i=1}^{m} d_{ij} x_i + m_i y_i \geq \sum_{i=1}^{m} f_{ij} \\
& \quad x_i, y_i \in \{0, 1\}, \quad i \in \{1, 2, \ldots, n\}, \quad z_i \in \mathbb{R}_{\geq 0}, \quad j \in \{1, 2, \ldots, m\}, \\
& \quad \beta_{ij} \geq 0, \quad j \in \{1, 2, \ldots, m\}, \quad \beta_{ij} \in \mathbb{R}_{\geq 0}, \quad i \in \{1, 2, \ldots, n\}. 
\end{align*}
\]
Energy Aware Resource Management

Energy Aware Resource Management (ERMS) optimises the production schedule for energy efficiency.
Application Scenario

**Spirax Sarco** will demonstrate SYMBIOPTIMA at its own facilities in Cheltenham as part of a company initiative to reduce our own carbon footprint.
Summary

• **SYMBIOPTIMA** is providing technologies and techniques enabling **dynamic industrial symbiosis**.

• The supply of thermal energy is managed **centrally and independently** of its consumers.

• **Production schedules** are optimised to minimise peaks in energy demand.

• Fully effective industrial symbiosis has **significant challenges**.

• Technology alone is not enough. A **business model** that incentivises organisations to **behave differently** is essential.
Today’s Takeaway

Achieving a step-change in industrial thermal energy efficiency requires changes in organisational behavior toward much greater collaboration.

Energy costs and government legislation are likely to be the drivers for such behavioural change.
Thank you.

5 minutes for Q & A.
Back Up
Demonstration Scenarios

PET – production process based on Zimmer Technology (nowadays Lurgi) with continues Melt Polycondensation followed by Solid State Polymerization (SSP).

Production utilities:
- waste water treatment;
- HTM heat supply;
- production of cooling water (+30°C), cooled water (+7°C), soft water, demineralized water;
- compressed air (6.5 bars), instrumental air;
- nitrogen generation unit;
- steam production;
- 2X10 MW bio-ovens (on biomass and lignin).