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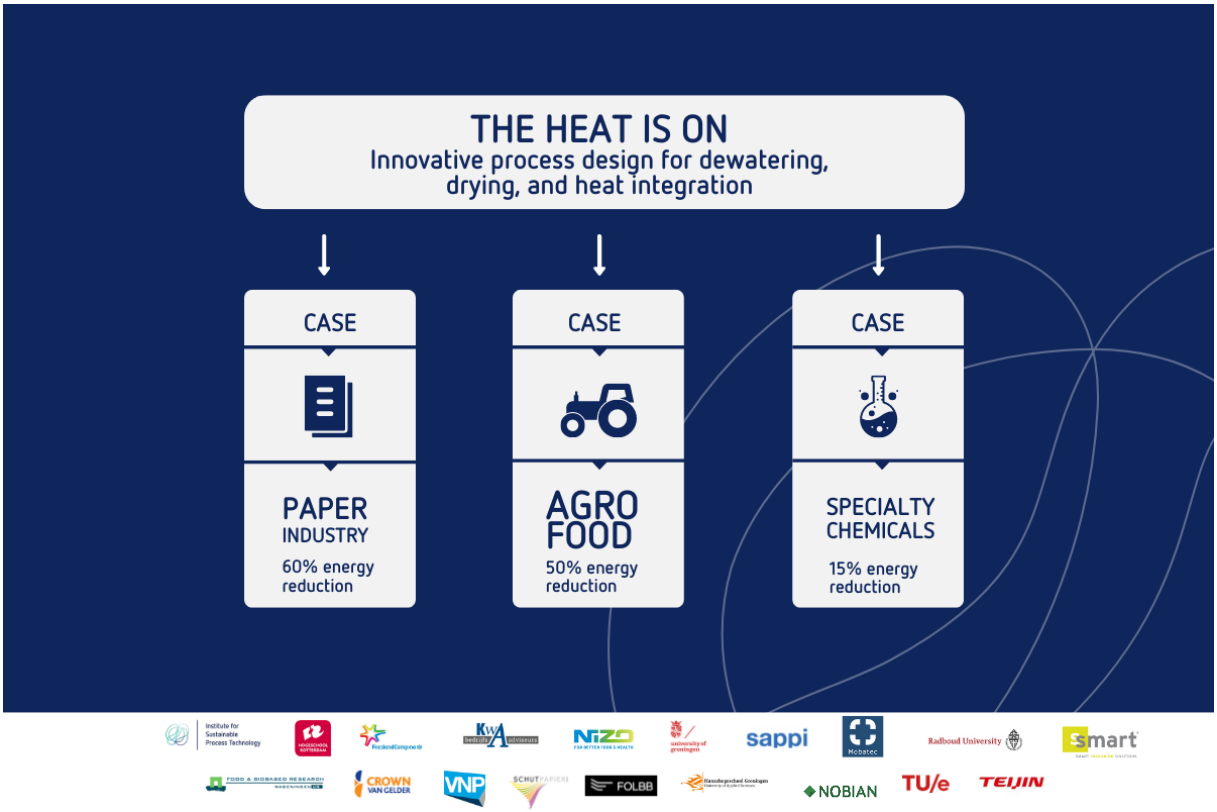

1. Public summary of basic principles, project goals and consortium partners

Basic principles

In industries like agrofood, paper and specialty chemicals industry about 40-80% of CO_2-emissions are related to energy for heat driven processes like separations and drying. Heat is mainly obtained through fossile fuels and processes proceed from high to low temperatures. Heat integration is about balance control between heat generation and use/re-use.

To achieve the CO2 reduction Climate Agreement goals, the heat system must be converted to a system with maximum application of circular heat, upgrading instead of emitting to the environment, and primary generation must come from 100% sustainable sources. For the vision year 2030, the innovations are aimed at accelerating the applicability of heat pump technologies through a case-based approach for integration into the existing industry. This requires parallel efforts to be made to increase process efficiency in unit operations, through **efficient separation and drying processes** that decrease the amount of water to be evaporated and increase the **heat upgrading potential** and **smart process optimisation** and control through digital twins.

Project goals

THIO applies a case driven system approach wherein these three innovations are integrated to obtain a substantial savings in the necessary amount of heat. The following more specific goals were determined:

- Efficient dewatering and drying by means of technologies for high solids that will result in 10% less water to be evaporated/dried and the forthcoming energy reduction.
- Innovative concepts for combined heat integration and drying that will result in 50% less use of fossil fuels for drying.
- Smart production solutions that will result in 10% less energy savings by means of improved process control.
- Case agrofood: innovative process design for dewatering, drying and heat integration with as result 50% energy savings in 2030.
- Case Paper industry: innovative process design for dewatering, drying and heat integration will result in 60% energy reduction in 2030.
- Case specialty chemicals industry: innovative process design for dewatering, drying and heat integration with 15% energy reduction in 2030 .
- Cooperation in heat innovations.
- Exploitation: proposals pilot- or demonstration projects
- Expected impact: 30% energy reduction in 2030 on average in the three industry branches (paper, agrofood and specialty chemicals); > 3,0 Mton CO_2-reduction in 2030 when implemented by all.

Consortium Partners:

CVG	Crown Van Gelder
FC	FrieslandCampina
HUAS	Hanze University of Applied Sciences / Hanze Hogeschool Groningen
ISPT	Institute for Sustainable Process Technology
RUAS	Rotterdam University of Applied Sciences / Hogeschool Rotterdam
KWA	KWA Bedrijfsadviseurs
FBE (former MM)	Folding Boxboard Eerbeek
Mobatec	Mobatec
NIZO	NIZO food research
Nobian	Nobian Industrial Chemicals
RU	Radboud Universiteit Nijmegen
RUG	University of Groningen / Rijksuniversiteit Groningen
Sappi	Sappi
Schut	Schut Papier
SmartPS	Smart Packaging Solutions
Teijin	Teijin Aramid
TU/e	Technical University of Eindhoven / Technische Universiteit Eindhoven
VNP	Royal Association of Dutch Paper and Board Factories Koninklijke Vereniging van Nederlandse Papier en Kartonfabrieken
WFBR	Wageningen Food & Biobased Research

Associated Partners

Alliander	Alliander
Cargill	Cargill
Duynie	Duynie Feed
FME	FME

2. Description of the executed activities, obtained results per milestone, bottlenecks and perspective for future applications

The THIO project consists of three workflows: reducing of water as solution for dewatering, other than evaporation, energy optimalisation in the production process and energy optimalisation by means of smart manufacturing, using the most recent data and modelling technologies. The THIO project has a duration of 4 years and started 9 months ago in October 2021. The focus now is on further scoping and definition of the opportunities.

Reducing water as solution, or water removal other than by evaporation

Drying is the most energy inefficient step in the process from liquid to solids. A challenge is to reduce the amount of water to be evaporated. One issue that must be tackled is to allow processing at high solids content of food, chemical and paper suspensions. This is only possible if the viscosity can be kept sufficiently low. With an exponential increase in viscosity due to solid content for most food products and paper slurries, technologies are required that reduce viscosity at high solid content.
Reduction of fouling also comes with reduction in energy and water usage. Another issue is to improve the effectiveness of mechanical dewatering technologies before the drying process, so that less water needs to be removed via evaporation.
Therefore means to lower viscosity, fouling reduction, and improve the effectiveness of mechanical dewatering are being investigated in this workflow:

- In this project the industry and suppliers of additives are investigating the right combination. It is also investigated if the water treatment (solution) itself could provide for a contribution.
- The newest technology now being investigated is advanced osmosis technology, like forward osmosis. Also the aspect of reduction of fouling will be investigated.
- Ways of drying other than traditional applying of energy (steam) like ultrasone, microwave, displacement pressing is investigated, if this could facilitate drying to be less energy consuming.

Energy-optimalisation in the production process

Heat integration is being combined with exploring new technologies to make processes less energy consuming. This is partially about identifying the right match between streams that need to be cooled down, and streams that must be heated, and partially about exploring the possibilities that new technologies might offer (like super heated steam drying) to be able to still reuse heat that is difficult to be reused, because of a low dew point or high degree of contamination.
In a later stage it will also be substantiated how the results of the other work packages will effect heat integration, and what this will mean for the overall energy savings that could be realised by implementing a technology like this. At this moment 5 case studies are running with different industrial partners in agrofood, paper and chemical industries.

Energy optimalisation by means of smart manufacturing – using the most recent data and modelling technologies

Combining (product-)data with existing and new decision making and optimalisation models will be worked on in this last workflow. Data collection and artificial intelligence is being used in combination with decision making models. At this moment data validation is work in progress and the research for applicability of models that were supplied by the industry are being investigated.

3. Description of the contribution of the project to the objectives of the MOOI regulation

This project contributes in several ways to energy reduction and consequently to the reduction of CO_2 emissions during production processes. In this project the paper, dairy and chemical industries cooperate in a project consortium together on these objectives.

4. Spin-off within and outside of branches

At this moment it is too early in the project to pinpoint any spin-off, however through several insights in potential solutions, conceptual and also practical applications could be adapted in other branches.

For example reuse of heat in ceramic industry, but also reuse of cold in logistics and storage, or reducing the amount of water as solution in many other applications in food and chemical industry.

Decision making and optimalisation will be necessary for each process and semi-continuous related industry.

5. Overview project's publications and sources

- THIO project page on ISPT website: https://ispt.eu/projects/the-heat-is-on/
- Press release regarding granting of project: https://ispt.eu/news/the-heat-is-on/
- NPT article: https://npt.pmg.nl/nl/dossier/EPTbe2135W01_00/innovatieprogramma-the-heat-is-on
- Process Control article: https://www.processcontrol.nl/the-heat-is-on-co2-reductie-door-integratie-van-warmtegedreven-processen/
- https://www.hanze.nl/nld/onderzoek/kenniscentra/kenniscentrum-biobased-economy/the-heat-on
- https://www.hogeschoolrotterdam.nl/onderzoek/projecten-en-publicaties/duurzame-havenstad/Industrie/the-heat-is-on/home/

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