# Final report

## General information

## 1. Project details

| | |
|---|---|
| **Project title** | Intelligent varmestyring af elementproduktion /<br>Intelligent heat control of element production (Heat insight) |
| **File no.** | 64018-0503 |
| **Name of the funding scheme** | EUDP |
| **Project managing company / institution** | Sensohive ApS |
| **CVR number**<br>(central business register) | 36424540 |
| **Project partners** | Ewii and MMTechnologies/Trifor |
| **Submission date** | 09 January 2022 |

## 2. Summary

**Referat:** Projektet Intelligent varmestyring af elementproduktion (2019-2021: Heat Insight) havde til formål at minimere energiforbruget på den bordvarme, som benyttes til speede hærdeprocessen op. Målet var at reducerer varmeforbruget med 20%. I projektet deltog Ewii, Trifor og Sensohive samt testbrugeren Contiga Tinglev som er Danmarks største elementfabrik.

I projektet lavede vi løbende målinger for kWh per leveret ton beton til kunderne og igennem projektperioden faldt kWh forbruget med ca. 40% fra 2019 – 2021 i perioden januar til oktober. Dette skyldes kombinationen af løsningen slukker for varmen nøjagtigt ved det ønskede ”target” og derved undgår man spild. Og ikke mindst så sikre system i sin helhed med Maturix at der ikke kommer spild produkter der skyldes for lidt styrke/hærdning.

Alene Heat Insight delen bidrog med 18 procentpoint af denne besparelse, men størstedelen ligger i at monitorer hærdeprocessen via Maturix løsningen – som også er en forudsætning for at benytte Heat Insight applicationen.

Undervejs i projektet er der fundet flere nye besparelser især relateret til beton-mix optimering, hvor indledende test peger på at der kan spares på cementen i beton uden risiko for slutproduktet og overholdelse af hærdetiderne. Dette kræver dog yderligere studier og dette er et arbejde som kan udføres af elementproducenterne når de har Maturix og Heat Insight løsningen implementeret.

Næste step i projektet er den kommercielle del som vil blive anført af Sensohive i det kommende år.

**Summary:** The project Intelligent heat control of element production (2019-2021: Heat Insight) aimed to minimize the energy consumption of the beds used to speed up the curing process. The goal was to reduce heat consumption by 20%. Ewii, Trifor and Sensohive and the test user Contiga Tinglev, which is Denmark's largest element factory, participated in the project.

In the project, we made ongoing measurements for kWh per delivered ton of concrete to the clients and during the project period, kWh consumption decreased by approx. 40% from 2019 - 2021 in the period January to October. This is because the combination of the solution switches off the heat exactly at the desired "target" and thereby avoids waste. And together with Maturix the system eliminates waste products are caused due to insufficient strength gain.

The Heat Insight part alone, contributed 18 percentage points of this saving, but the majority lies in monitoring the curing process via the Maturix solution - which is also a prerequisite for using the Heat Insight application.

During the project, several new savings have been found, especially related to concrete-mix optimization, where initial tests indicate that the cement in concrete can be saved without risk to the end-product and still be in compliance with the curing times. However, this requires further studies, and this is a work that only can be performed by the precasters once they have implemented the Maturix and Heat Insight solution.

The next step in the project is the commercial part which will be led by Sensohive in the coming year.

# *3.* Project objectives

The main objective of this project was to optimize the heating for casting beds in precast production with particular focus on hollow-core products. The aim was to reduce the energy consumption by 20% (compared to before installing our solution).

On the hollow-core production beds we achieved a 18%-point energy savings per ton of product delivered to the clients but combined with Maturix we achieved 40% point saving by eliminating waste-production as well. Whereas production for walls was not considered to business case as cost are low compared to hollow-core and risk and energy usage are low as well.

**Why this is important?**

The energy used for precast production is enormous as heat is used for keeping “decent” temperature (normally between 20-40c – depending on the job at hand) on the concrete including its aggregates. When the concrete is being poured into the beds then heat is applied in the beds to speed up the curing process of the concrete. Heat is applied to accelerate the hydration process. When cement, water, aggregate, and additives are mixed, a significant heat increase occurs. This is due to the exothermic process in the reaction between cement and water (called hydration).

Using Maturix (live monitoring system for measuring the temperature of the curing concrete) we can explain how much strength the concrete has achieved. But the problem is that the heating of the beds does not work together with strength gain but only works on a 12-hour cycle.

Pre-project this meant that a precaster would waste a lot of energy as the beds were going on 12-hour heating cycle independent of the actual strength gain in the cast. With Maturix applied the precaster would be able to see exactly when the cast had achieved its desired target strength. What we found is that up to a lot of energy

was used when it was not required. As result this project was designed with the aim of combining Maturix and automatic control of the heating in the beds whereby we would be able to save an additional 20% of the energy used for the beds.

The solution in the project is as mentioned above a combination of Sensohives Maturix solution for precasters, Trifors SIA units which is a unit specialized at enable online control of PLCs (particular PLC of older nature that are from the times before IOT was required) and everything controlled in the Maturix software.

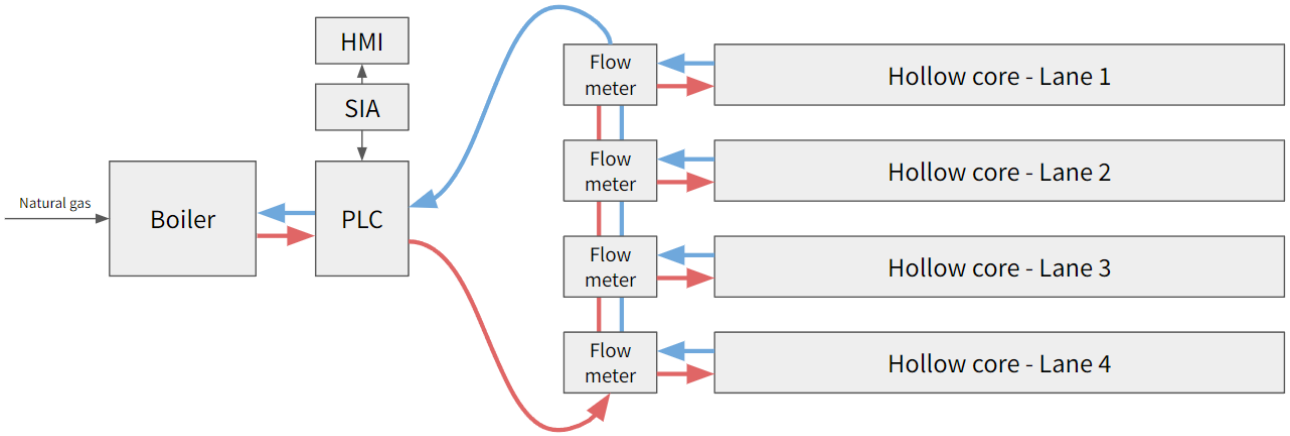
Finally, Ewii was the final partner in the project who was in charge of making the calculation in terms of savings and energy usage.

# Project implementation

The project was carried out in the mist of covid-19 which was main reason for the delay in the project – and reason for it being extended by 12 months. As we had to visit the test-client often for technical installation on the beds we were often not allowed to come by in person due to restriction (covid). As result we had to rely on local (approved) resources to install the flowmeters (Kamstrup) that would measure flow, temperature on the water used for heating the beds as well as the SIA unit installed (to control the PLCs). This unfortunately increase the risk of something going wrong which it did. But eventually this was corrected.

Beside the technical issues for getting everything installed correctly there where some significant amendments to the scope of the solution. Initially it was envisioned that the system should cater for different concrete types by using different kind of heating regimes/patterns. But during the project it was clear that this was possible, but it increased the complexity for the users on floors too much and the risk of errors (in choosing the wrong heating profile) was considered too high. As a result, this was left out in the final version on Heat insight. Another change that obvious during the project was to change to scope only to the beds related to hollow-core production as these are the costliest in terms of energy, materials, and man-hours. It was estimated to be too expensive for a simple wall bed vs output gained by having Heat Insight installed on all wall beds.

**How does it work?**



**Boiler**
The boiler is constantly keeping a volume of water heated to 70-90 degrees. In order to heat the water, it uses natural gas. The boiler regulates gas usage automatically based on the heating loss or usage in the production. It has a single outlet and inlet for water circulation - and a small pump on the inlet which is used to ensure circulation of the water.

**PLC**
The PLC system contains the logic control for operating all the valves that open and close water circulation in the system. The PLC is also connected to various sensors e.g. temperature sensors in the hollow core lanes. When the heating is not on, the water is automatically circulated back into the boiler, so a little energy is lost. When the heating is turned on, the PLC opens the corresponding valve - and keeps a timer that closes the valve after e.g., 12 hours.

**HMI**
In connection with the PLC system, there is an HMI (Human Machine Interface) which allows persons to operate the heating system (turn on / off, view status and temperature e.g.). This is how the system is turned on today, where an operator can turn on the heating on a specific lane when the production is started.

**SIA**
In between the HMI and the PLC, we have installed a SIA box, which allows cloud access to the PLC as if we were the HMI. This allows us to read status values (temperatures, on / off etc.) but also send instructions to the system. If an operator on site e.g. turns on the heating, the box will send that information to us - as well as the status of the valves it has opened. SIA units within the blue circle.

**Flow meters**
In order to measure the exact energy usage and effectiveness of each production resource, we installed flow meters on each of the lanes in the production. The meters measure both the volume of water that passes through the system - but also the temperature loss in the system, which gives us an accurate energy consumption by the system. This is not a requirement for the system to work but was installed to allow for detailed analysis as previously mentioned this proved somewhat troublesome.

**Hollow-core lanes:**
Is where the product (precast element) is being produced. They are lanes of up to 220m long that will be cast in one go, and subsequently be cut into the length required for the job.

# 4. Project results

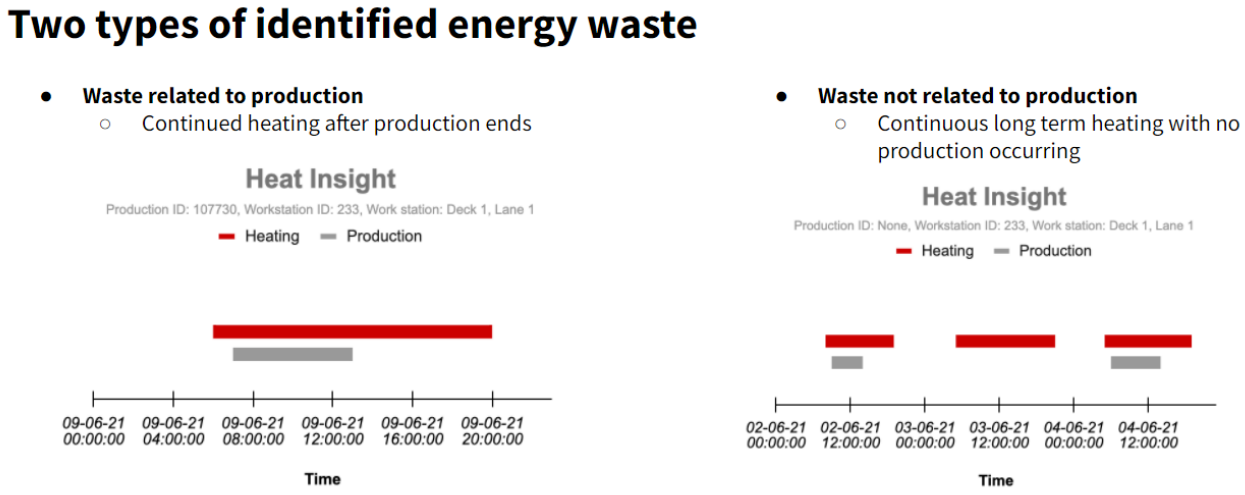
**Key milestones in the project:**

1) Benchmarking: The reason for having the Kamstrup meters installed in the beds was to provide insights and collect benchmark data (before and after). We wanted to have a figure telling us how much energy/kwh was used per ton. Unfortunately, this was delayed as the drives required was not being openly shared by the supplier and we had several problems getting them to work properly.
2) Installing SIA units and developed a communication protocol between SIA and PLCs. The PLCs installed to control the heating was different from each bed meaning that we had to program each SIA/PLC pair differently. This was very time consuming as the manufacture of the PLCs where not “super helpful”, but we manage to be able to configure all beds in the hollow-core production. Added to this problem was the fact that we were not allowed for months to go to the test site due covid-19. For future application it would be easier to just install new PLCs as this would eliminate several risks in the process.
3) Develop and make an integration between SIA unit and Maturix platform. This part was fairly simple as the API on both sides where well documented and only minor adjustments had to be made.
4) Develop new features in Maturix platform to accommodate the Heat Insight features. This part was done together with the test partner (Contiga Tinglev). The features related to Heat Insight was built within the Maturix platform as a tool on its own.
5) Develop and test different heating patterns for different concretes and seasons. As well as SOP for using Heat Insights. As stated previously this part was more or less made redundant due the fact that this would make the solution much more complex, and it was pointed out by the test client users that this would not be prudent to continue along this path as two things would happen: 1) we would use the software wrong or 2) we would not use because we do not understand it. Both scenarios resulting in a poor outcome.

In terms of the key milestones the main efforts had been put into getting 1, 2 and 4 realized due different circumstances.

**Benchmarking/results:**

The benchmarking had some serious challenge as the Kamstrup meters was installed wrongly and one of them were damaged. But we managed to get data in the end.




Energy waste is found in two categories: 1) too much energy spent and 2) energy spent without production.

During the project this has resulted in a reduction in kwh used per delivered ton of concrete to clients.

Data from January to October for the following years:

| **Kwh/ton delivered** | 2019 | 2020 | 2021 | Reduction in % |
|---|---|---|---|---|
| Hollow-core 1 | 30.54 | 25.55 | 17.71 | 43% |
| Hollow-core 2 | 36.14 | 29.47 | 20.38 | 44% |

Of this 18 pct-points can be attributed Heat insight and the rest is related to Maturix optimizing the production and minimizing waste in the production – less waste means that the kwh/ton relation is improved significantly.

Currently we have two features in the system (which account to the 18 pct. points)

- Feature 1
  - Automatic on and off switch - when target strength is reached
    - Integrating an automatic on and off switch feature to Maturix Precast that communicates with the PLC in the precast bed to turn off the heat when target strength is reached
- Feature 2
  - Alarm-system
    - Integrating an alarm system that informs relevant personnel when heating is on outside production

In the near future we see some new features that we only have been looking at from a conceptual point of view:

Prediction - turn off heat prior to reaching target strength

- Feature 3
  - Predicting target strength
    - Predicting whether the target strength can be reached within the production target time if the heat is turned off (at a given point in time before target strength is

reached) - utilizing the current energy in the concrete and future predicted temperature development. Potential: 5-10% of current energy levels.

- Feature 4
  - Minimizing/Optimizing cement content
    - Decreasing cement content with better curing time control (which also leads to improved co2 footprint per ton of concrete due to the usage of less cement – estimated at around 15-25% of current cement volumes in precast production). Potential: huge but must be done by the precasters.

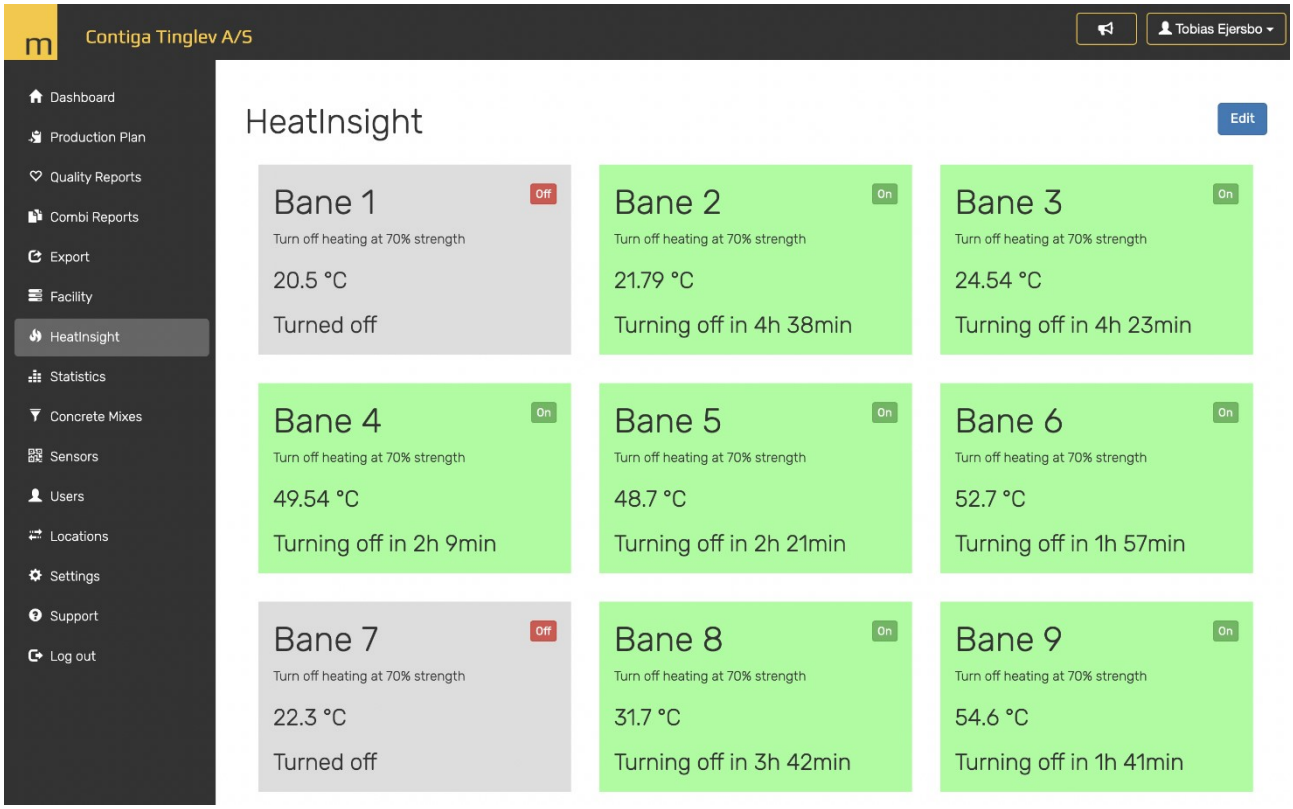
**Other decision during the project:**

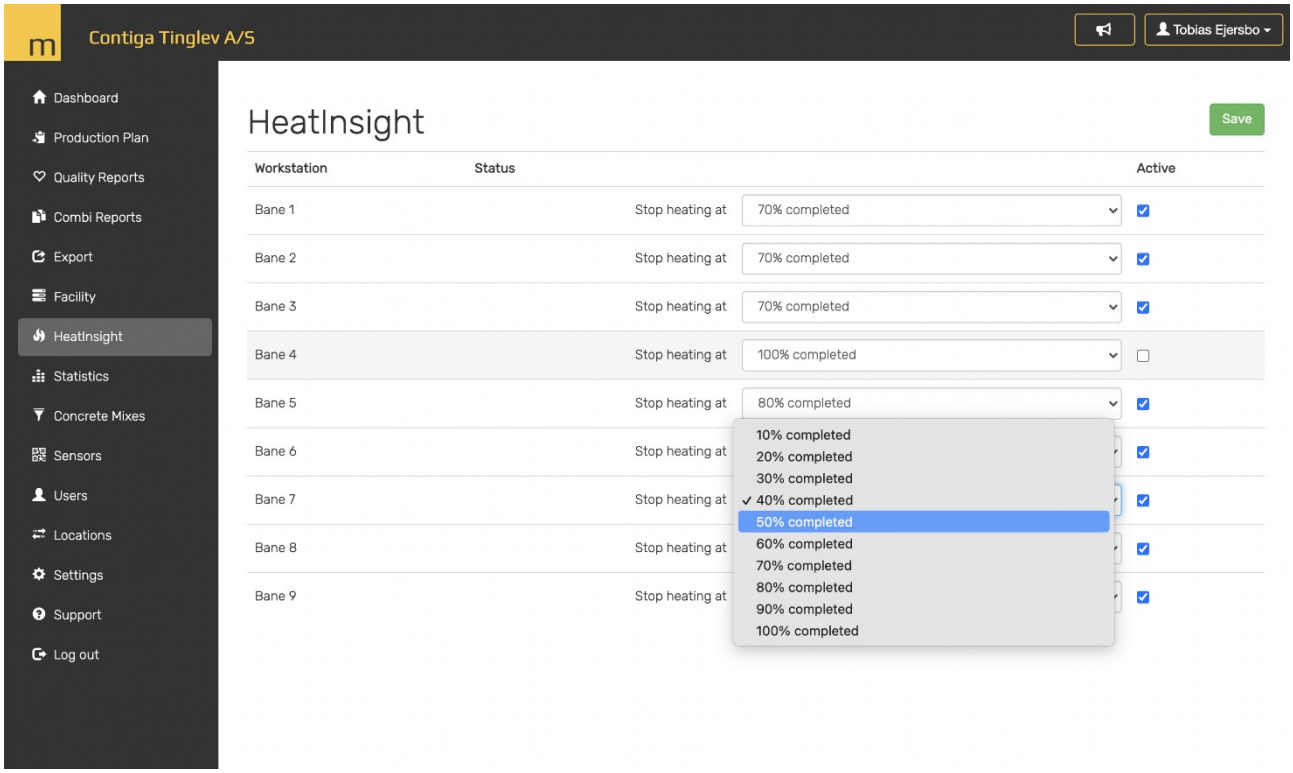
Key decision that was taken during the project relates to: only focusing on hollow-core production and the decision to keep the system very simple in terms of choices for the operator for heat-profiles. Both decisions have been validated by talking to other precaster in Europe and Canada that this is the way forward as it is vital that system is very simple in its usage on a very day basis.

**Software solution:**

The actual control of Heat Insight module is being done as an application within the Maturix solution. The system provides the users with an overview of which lanes/beds that are enabled with Heat Insight. It provides information about the actual temperature in the cast, if heating is turn on/off, and if on, when it is due to turn off.

Furthermore, there is a statistical tool that will help the users to get further insights to curing times and heating used etc. This one of several things that we will continue working on in the near future.






**Preproject vs. realised results:**

Initially we thought that we could save 20% of the heating used for the beds which would accommodate approximately 1 million kWh/year. This figure is significant but also not trustworthy. As we need to take the production volume into account as well. We decided to look at the volume delivered to the clients and the kWh used. This is a better proxy as volumes changes and the fact that the system will help increase quality assurance (hence minimize discarded product) which will improve the ton/kWh ratio.

And as stated we have seen a reduction of kWh more than 40% per ton delivered. This is better than anticipated – even though is a combination of Maturix and Heat insight.

**Dissemination of findings**:

In terms dissemination Sensohive (see maturix.com) will be focusing on our precast clients as a first adopters. We have made video materials about the project and solution that will be shared with partners and our clients.

We are also part of IPHA (international precast hollow-core association) which will be key target group for the Heat Insight solution. We want to push the message towards this audience in 2022 as their energy cost has soared as everyone else.

# 5. Utilisation of project results

In terms commercialization of the Heat Insight project is has been from the onset been Sensohive as the primary partner to bring it to the market and Trifor as secondary providing SIA units for upgrading PLCs when required.

The key value drivers provided by Maturix and Heat Insight are.

- improved product quality (optimum curing conditions)
- eliminating all waste related to insufficient curing (or too early demolding)
- improve curing cycles (either faster or longer depending on order volume status of the precaster)
- and optimize the energy used for curing by eliminating all energy waste.
- Together these provides a strong platform to address the green agenda that the industry is lacking – it is not the answer but a part of the answer.

There are still a lot of conservatism in the industry and adopting new technology is still a challenge, but the solutions ability provide cost savings and provides a strong platform to help the industry address their Co2 footprint and at the same time save costs.

In Europe it is estimated that the TAM is around 8.000 precast plants. Of these the hollow-core will be the first to be addressed – estimated to be around 200 plants. Furthermore, investigations into energy prices will have to done as this is a key indicator for how big saving can be provided by the solutions.

From a client perspective onboarding the Maturix and Heat Insight can be done very simple if the PLCs are ready (=can they be accesses online). If not, then this must be fixed either by installing SIA units or new PLCs.

When PLC issue have been solved it is almost plug'n'play implementing Maturix and Heat Insight with an ROI of less than a year.

To determine the exact benefits of using the solution, we will together with the client have to determine, current output and energy usage if possible and waste numbers. Or we will be looking at curing hours vs. heating cycles (hours) and what type of production system they use. This will provide us with an indicator of how much they can gain from using the solution.

From Maturix installation we know that on average a client can save 20-40% of curing cycles times.

These would all benefit from having the Heat Insight application as part of their production.

**Commercial – future:**

Seen from the commercial point of view we estimate that within 5 years that another 100 clients will be installing the solution. How much is hard to value currently but it will be mainly export related. In term of FTE, it is estimated between 8-15 at Sensohive.

It is also expected to have positive impact for Trifor although to a lesser degree.

In terms of competition, we have seen some systems that can control the heating in the beds, but they are connected to the actual curing process and in the Maturix. This means that we can either integrate into this solution or provide the full solutions.

# 6. Project conclusion and perspective

We started out with an idea of saving 20% of energy used for heating the beds during the curing process in precast production. But by combining Heat Insight and Maturix we where able to cut 40% of the energy used per ton of product delivered to the client.

There are several things that we need to be addressing in the near future. Optimizing the curing process so we can minimize the Co2 footprint/kWh per produced ton of concrete even more. This needs to be done by the precasters. As well as working on minimizing the usage (the dosage) of cement in the concrete combined by controlling the heating better. Our preliminary findings suggest that up to 15% of the cement content can be removed without compromising final strength quality and still be within production window. But part is also driven by the precasters but the solution enables them to do this with full control.

One of the features of the future is the possibility of the solution to help precasters to calculate a live co2 footprint together with EPDs.

# Appendices

Please visit www.maturix.com for more information.