

SUSTAINABLE ENERGY TECHNOLOGY @ TNO

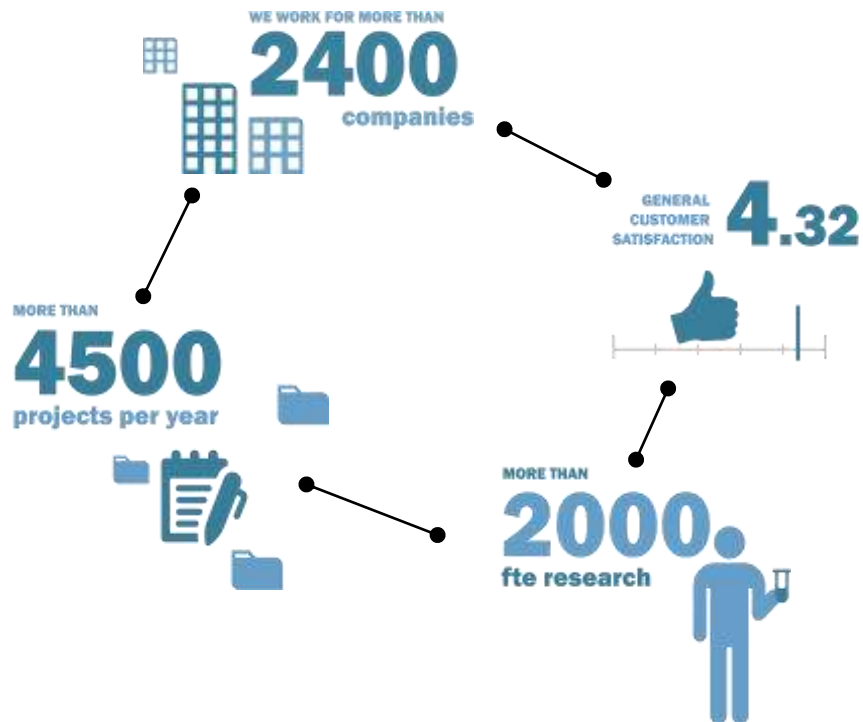
Sustainable Energy Technology TUDelft | Rogier Donkervoort

TNO innovation for life

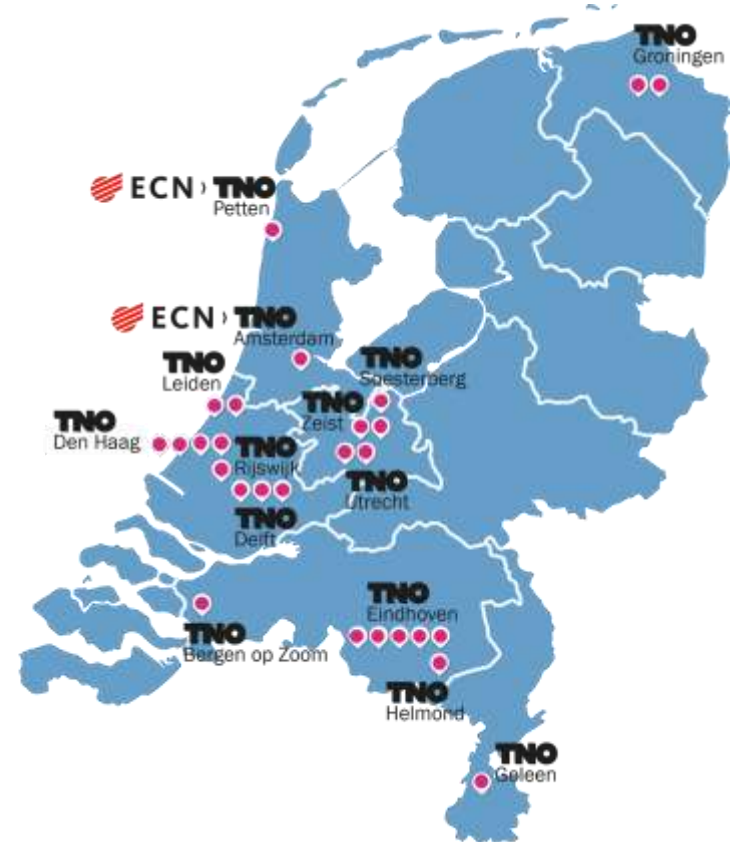
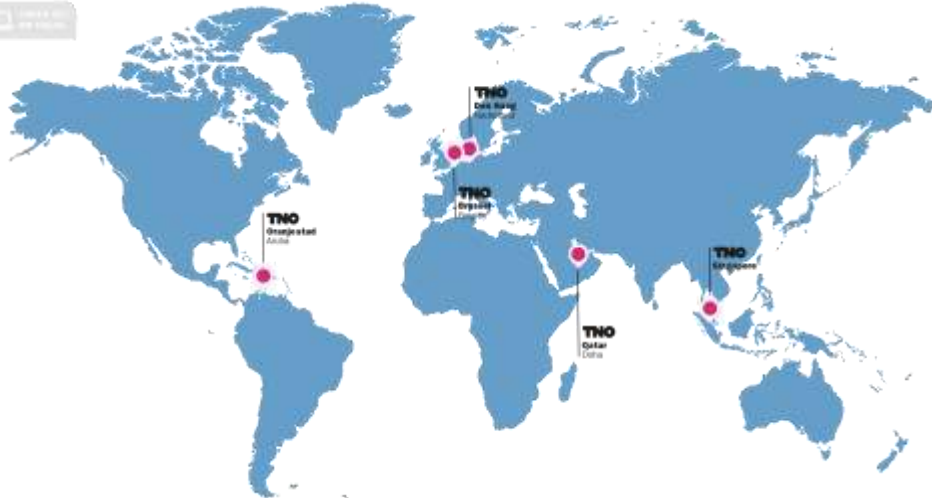


TNO

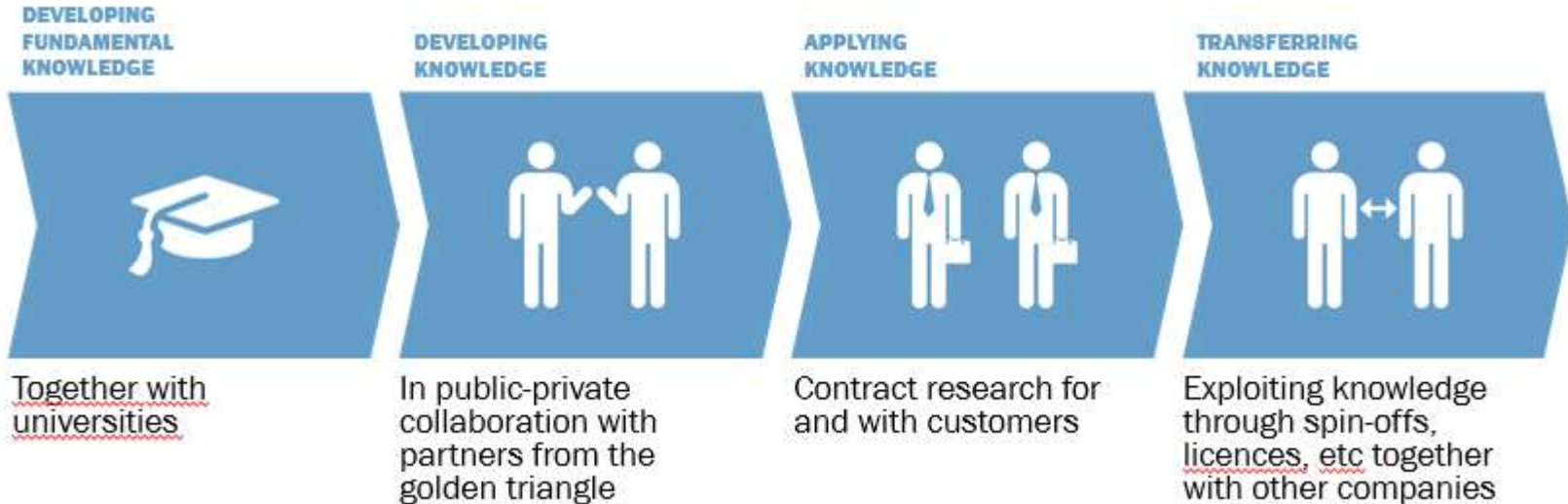
TNO IN A GLIMPSE



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SUSTAINABLE TECHNOLOGY WITHIN TNO

› Circular economy



CIRCULAR ECONOMY: HOW CAN WE MAKE RAW MATERIALS FROM ORGANIC WASTE?

13-02-2018

From organic waste to valuable raw materials. Watch our video to see how TNO and partners are shaping this transition...

[\) Read more](#)



WHAT IS THE IMPACT OF CIRCULAR CONSTRUCTION?

13-03-2018

The construction sector is one of the largest producers of waste. That's largely recycled. "But there are smarter options." ...

[\) Read more](#)

SUSTAINABLE TECHNOLOGY WITHIN TNO

› Transportation



SUSTAINABLE VEHICLES

Eighty percent reduction in greenhouse gas emissions from road transport. The Paris Climate Agreement means that the transport sector has plenty to do betw...

[› Read more](#)

KNOWLEDGE

ZERO EMISSION TRUCK POWERED BY HYDROGEN WITH A MOBILE REFUELER


In March 2017, the Belgian organisation WaterstofNet received approval for the project 'H2-Share' from Interreg North-West Europe (NWE). TNO is proud to an...

[› Read more](#)

SUSTAINABLE TECHNOLOGY WITHIN TNO

› Bio-based / alternative fuel

KNOWLEDGE



TOWARDS CO2 NEUTRAL FUELS AND FEEDSTOCK

The focus is on the transition from oil and gas to biomass-based fuels and raw materials, hydrogen production and synthetic fuels and raw materials....

[\) Read more](#)

KNOWLEDGE



NEW FACILITY ECN PART OF TNO FOR SEAWEED PROCESSING

Eerste laboratorium wereldwijd dat zich op pilot-schaal specifiek richt op de verwerking van zeewier naar biobased brand- en grondstoffen....

[\) Read more](#)

SUSTAINABLE TECHNOLOGY WITHIN TNO

› Strategy & policy making

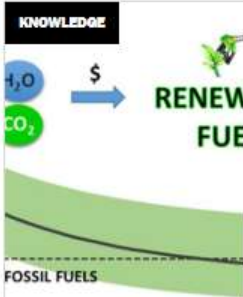


KNOWLEDGE

TOWARDS BROAD SUPPORT FOR THE ENERGY TRANSITION

The energy transition towards a fully sustainable energy system by 2050 requires innovations in both the technical and social fields. ECN part of TNO makes...

[\) Read more](#)



KNOWLEDGE

RENEW FUE THE FUTURE OF SOLAR FUELS: WHEN COULD THEY BECOME COMPETITIVE?

We analyze cost developments for technologies required to produce renewable or solar fuels by applying learning curves...

[\) Read more](#)

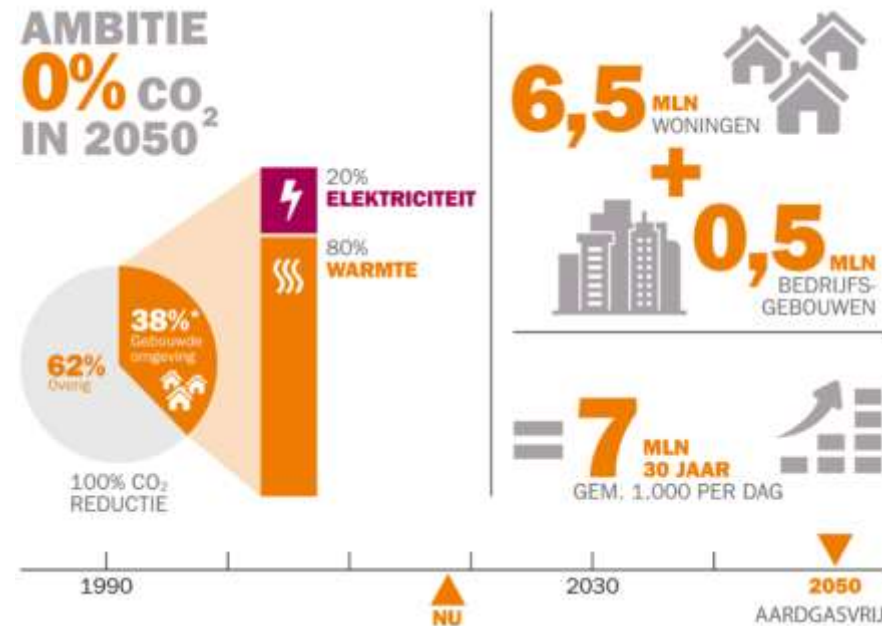


SUSTAINABLE TECHNOLOGY WITHIN THE BUILT ENVIRONMENT

› The challenge for the built environment

Om de klimaatdoelen voor 2030 te halen, moeten we gestaag het tempo van de verduurzaming opvoeren tot meer dan 50.000 bestaande woningen per jaar in 2021. En vóór 2030 moeten we al in een ritme van 200.000 per jaar zitten.

... om voor de meest kenmerkende woning- en gebouwtypen zoveel gestandaardiseerde of industrieel vervaardigbare pakketten voor energiebesparing (isolatie) en duurzame energie- en warmteoplossingen te ontwikkelen ... door opschaling, programmatische aansturing en innovatie kan een efficiencyverbetering worden bereikt, die in 2030 leidt tot een reductie van de beoogde 20% tot mogelijk 40% van de systeemkosten ...



SUSTAINABLE TECHNOLOGY WITHIN THE BUILT ENVIRONMENT

› The challenge for TNO and **you** as (future) Sustainable Energy Technologists:

development of sustainable building solutions (incl. installations)

- › with highly improved cost efficiency (~ 40 – 50%)
- › which enable large scale and acceleration (~ 1000/day)
- › for new built and especially existing building situations



Menu **nrc.nl**

Hoe het klimaat een wig drijft in het kabinet

Klimaatakkoord Zowel VVD als D66 dreigde dit weekend het kabinet te laten vallen over klimaatbeleid. De campagne is begonnen.



SUSTAINABLE TECHNOLOGY WITHIN THE BUILT ENVIRONMENT

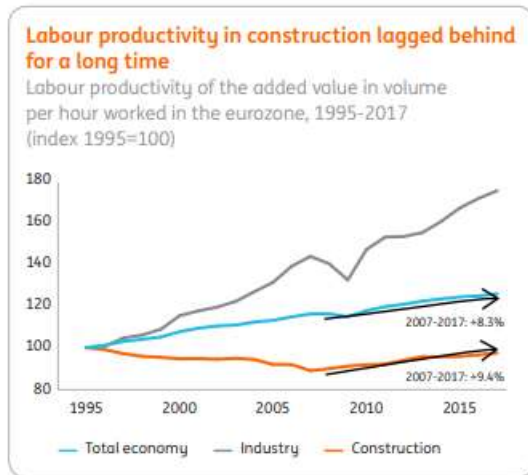
- › Why is this so challenging? → the cost-side
 - › shortage in supply of new-built houses results in cost increases (both material and labour)
 - › cost-reductions due to atomization and/or prefabrication tend to evaporate



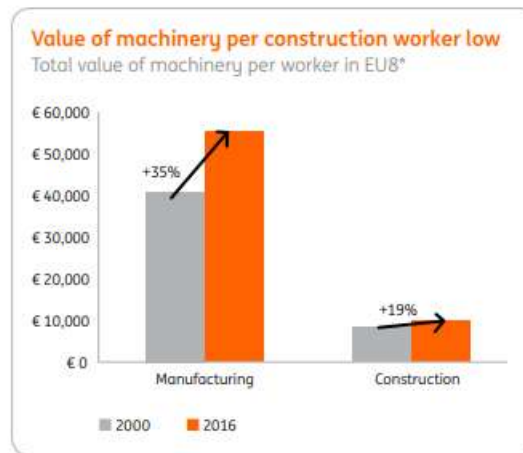
The screenshot shows the Cobouw website interface. At the top right, there are links for 'CONTACT' and 'ADVEI'. The main navigation bar includes 'HOME', 'WONINGBOUW', 'UTILITEITSBOUW', 'INFRA', 'BOUWBREED' (highlighted), and 'AANBESTEDEN'. Below this, a secondary navigation bar lists 'economie', 'cao', 'techniek', 'politiek', 'duurzaamheid', 'wet- en regelgeving', 'cijfers en trends', and 'veiligheid'. The main content area features a 'Nieuws' section with a date of '1 okt 2018'. The headline of the article is 'Bouwkosten schieten nog verder omhoog: 8,5 procent stijging'. Below the headline, there are tags for 'bouwbreed', 'Premium', and a view count of '4951'.

SUSTAINABLE TECHNOLOGY WITHIN THE BUILT ENVIRONMENT

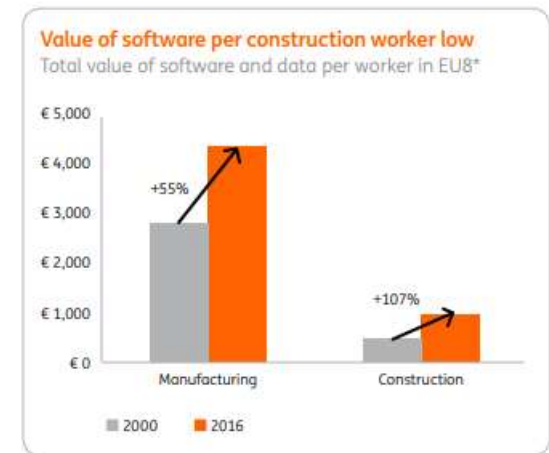
› Why is this so challenging? → the productivity side



Source: Eurostat, processed by the ING Economics Department



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* Belgium, Germany, France, Italy, Luxembourg, The Netherlands, Austria & Finland (selected on the basis of available data).



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THE
IMPACT
OF
TNO

EXAMPLE

SUSTAINABLE TECHNOLOGY WITHIN THE BUILT ENVIRONMENT

- › What is the challenge for TNO in the coming years?
 - › current and future activities at 3 levels:
 - I. development / integration of sustainable energy technologies
 - II. development of ('closed') integrated sustainable building concepts
 - III. development of ('open') industrialized sustainable building concepts



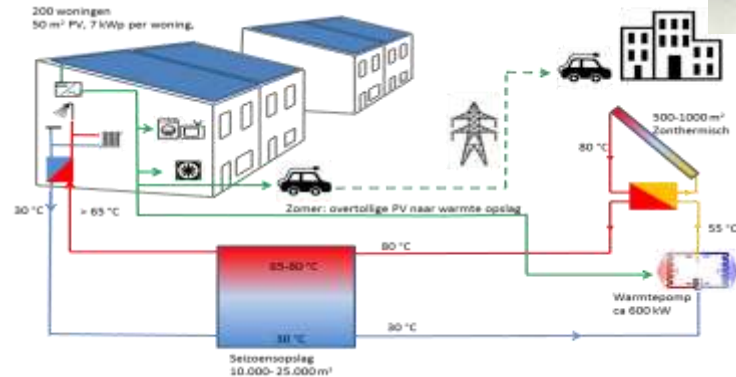
SUSTAINABLE TECHNOLOGY WITHIN THE BUILT ENVIRONMENT

- › What is the challenge for TNO in the coming years?
 - › current and future activities
 - I. development / integration of sustainable energy technologies; e.g.
 - › (thin-film) solar integration (e.g. road barriers)
 - › aesthetic heat collectors
 - › thermochemical storage / heat battery
 - › shower-cabin
 - › ...



SUSTAINABLE TECHNOLOGY WITHIN THE BUILT ENVIRONMENT

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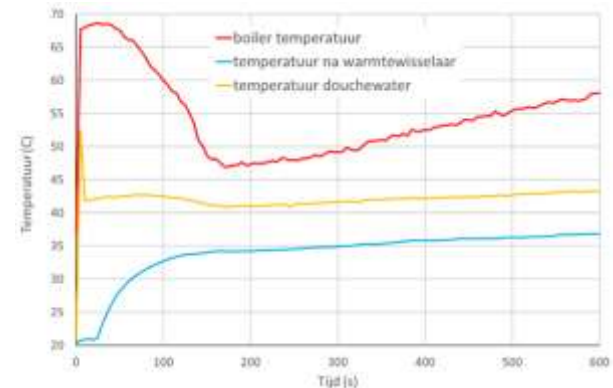
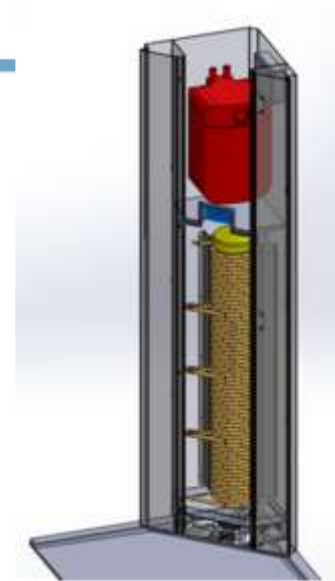


SHOWER CABIN

- › The challenge
 - › hot water and mainly showering contribute in well insulated houses to about 50% of the heating demand
 - › demand for gas-free solutions
 - › fully prefabricated to accommodate fast renovation
 - › energy efficient & comfortable

- › Conventional showering
 - › 2 kW evaporation losses
 - › 1 kW heat transmission losses to floor and walls

- › Partners: Beter Bad, Westcord Hotels, Hametech, Seinen Projectontwikkeling



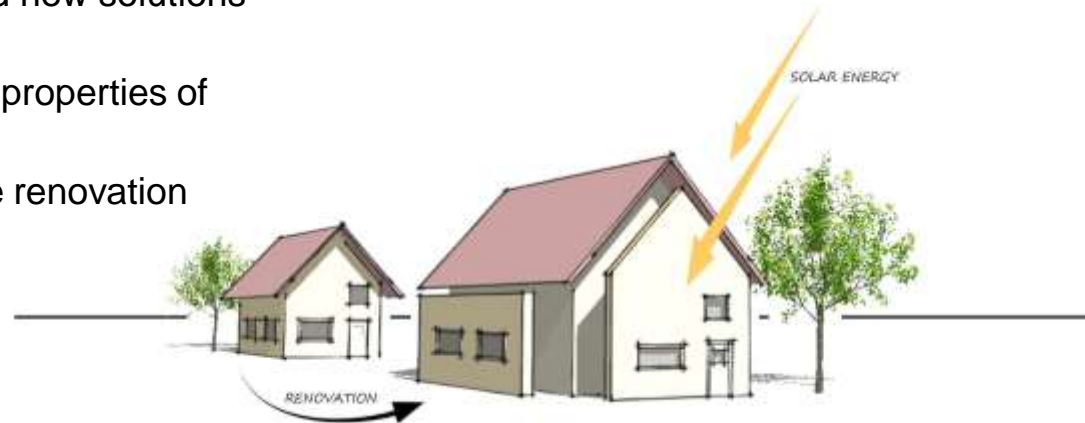
SUSTAINABLE TECHNOLOGY WITHIN THE BUILT ENVIRONMENT

- › What is the challenge for TNO in the coming years?
 - › current and future activities
 - II. development of integrated sustainable building concepts; e.g.
 - › ENVISION
 - › ADAPTIWALL
 - › SolaRoad
 - › ...



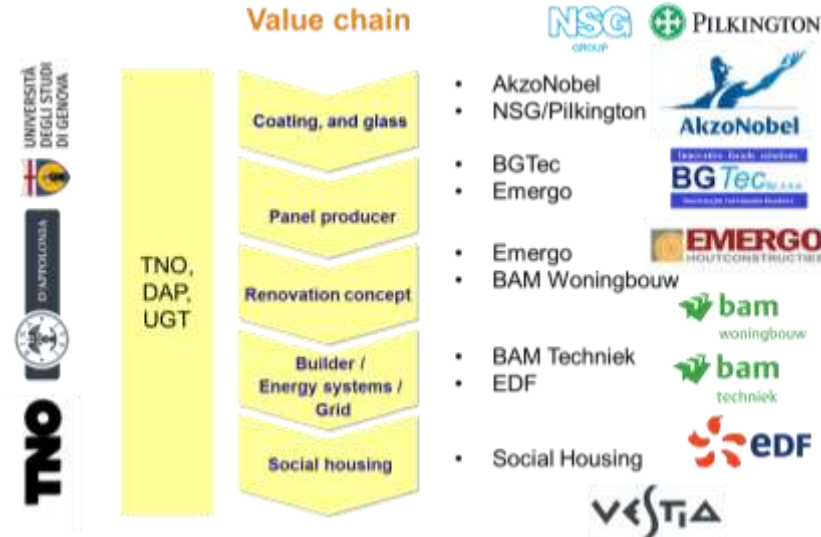
ENVISON

- › EU funded innovation project aiming to
 - i. harvest both thermal and electrical energy from all building surfaces (transparent & opaque) ~ 60 billion m² in EU
 - ii. standard PV solutions for roof and new solutions for façade
 - iii. keep the aesthetic and functional properties of the façade
 - iv. demonstrate an integrated façade renovation solution



ENVISION

- › Key development and impact
 - i. aesthetic solar harvesting building elements → 4 ENVISION technologies
 - ii. fast renovation envelope concept
 - iii. distribution and balancing via district energy grid
 - iv. demonstration of ENVISION technologies (from TRL 5 to 7/8)



ENVISON

› (1) Aesthetic solar-heat harvesting non-transparent building element

1. the FITS(4E) NIR coating technology on heat harvesting façade panels
2. harvesting non visible part of the spectrum for a wide range of popular façade colors
3. efficiency $>50\%$ i.c.t. full black (e.g. red $\sim 85\%$)
4. target $1.5 \text{ GJ/m}^2\text{y}$

LEAD: EMERGO, AKZONOBEL, TNO



ENVISON

› (2) Aesthetic solar-heat harvesting transparent building element



1. coloured transparent glass i.c.w. (standard) heat collector
2. harvesting non visible part of the spectrum for a wide range of popular façade colours
3. efficiency >50% i.c.t. full transparent
4. target 1.5 GJ/m²y

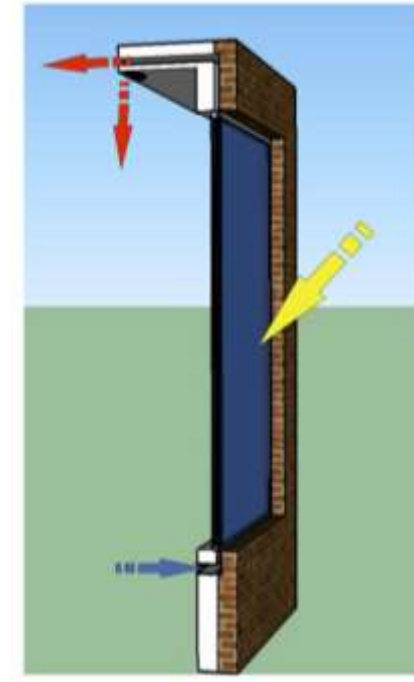
LEAD: TNO, PILKINGTON

ENVISON

› (3) Heat harvesting ventilated window

1. ventilated glass harvesting heat by NIR solar absorbing glazing
2. >30% heat absorbing efficiency
3. target 0.8 GJ/m²y

LEAD: BG TECNOLOGIE



ENVISON

› (4) Electricity harvesting windows

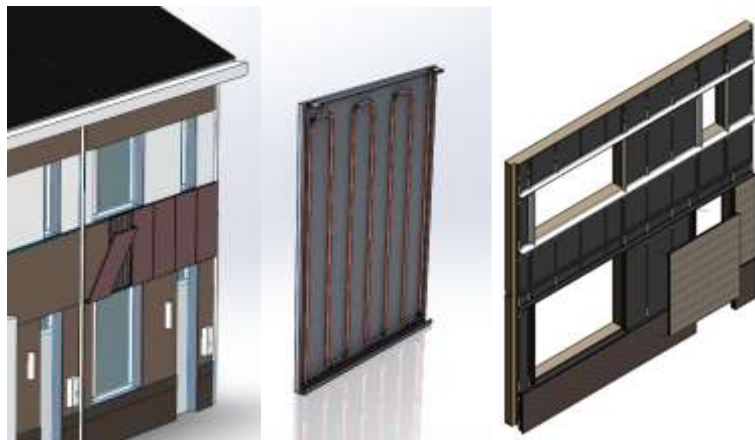


1. partial PV containing glazing
2. efficiency > 10%
3. target: 0.2 GJ/m²y or 55 kWh/m²y

LEAD: PILKINGTON

ENVISION

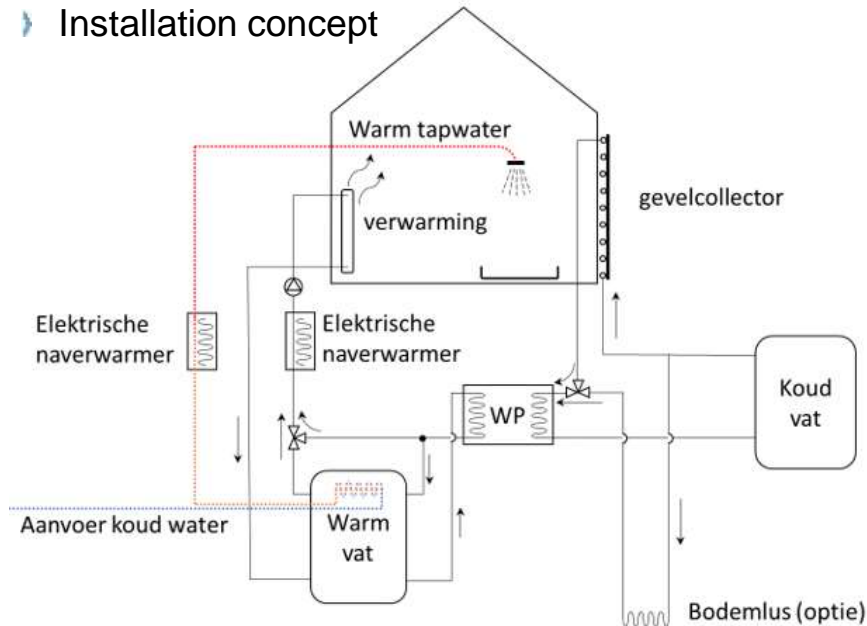
- › Fast renovation envelope concept



1. quick envelope retrofit solution (<2 days)
2. “click-on” ENVISION façade harvesting elements
3. cost-efficient (<10 years)
 - › target price for installed ENVISION technologies 150 EUR/m²
 - › total gain ~ 1.64 GJ/m²y
 - › payback ~ 3-4 years (@energy price of 25 EUR/GJ)

ENVIVSON

› Installation concept



1. Efficient use of harvested energy
 - › direct use vs. source for heat pump
 - › indoor heating and cooling
2. Replicability

SUSTAINABLE TECHNOLOGY WITHIN THE BUILT ENVIRONMENT

- › What is the challenge for TNO in the coming years?
 - › current and future activities
 - III. development of ('open') industrialized sustainable building concepts(!)

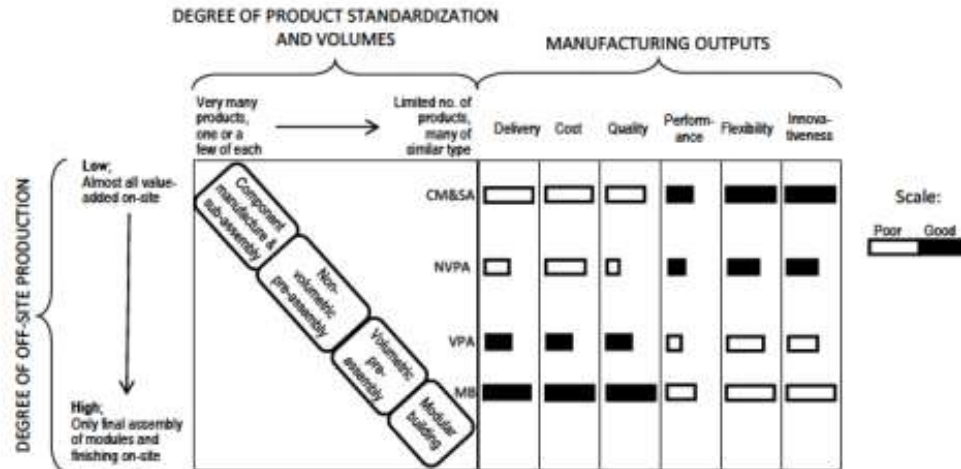


Figure 16 Classification framework presented in (Jonsson and Rudberg, 2014)

SUSTAINABLE TECHNOLOGY WITHIN THE BUILT ENVIRONMENT

- › What is the challenge for TNO in the coming years?
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 - III. development of ('open') industrialized sustainable building concepts(!); e.g.
 - › floor- and installation concept



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WE WANT YOU!

SUSTAINABLE ENERGY TECHNOLOGISTS @ TNO?

- › Opportunities for internships, graduation projects, ... etc. almost always!

SO WHAT DO YOU WANT? WHAT DRIVES YOU?

- › For more inspiration: <https://time.tno.nl/nl/>
- › Contact details
 - › TNO department of Building Physics & Systems
 - › Andries van Wijhe (internship coordinator)
 - › andries.vanwijhe@tno.nl

A nighttime photograph of a city street featuring a modern, curved pedestrian walkway with a glass railing. The scene is illuminated by city lights, creating vibrant green and white light trails that sweep across the frame. Buildings with lit windows are visible in the background.

**THANK YOU FOR YOUR
ATTENTION**

Take a look:
[TNO.NL/TNO-INSIGHTS](https://www.tno.nl/tno-insights)

TNO innovation
for life