

An aerial photograph of the TU Delft campus in the Netherlands. The image shows a mix of modern and older university buildings, green spaces, and a canal. A prominent blue rectangular bar is overlaid on the top half of the image, containing the title text. In the bottom left corner, a white, cone-shaped structure is visible on a green lawn.

CAMPUS SUSTAINABILITY *TOWARDS A LIVING LAB LEARNING NETWORK*

Leendert Verhoef, Luuk Graamans & Chris Hellinga
Hamburg, 27 September 2017

 **TU**Delft

Green Office

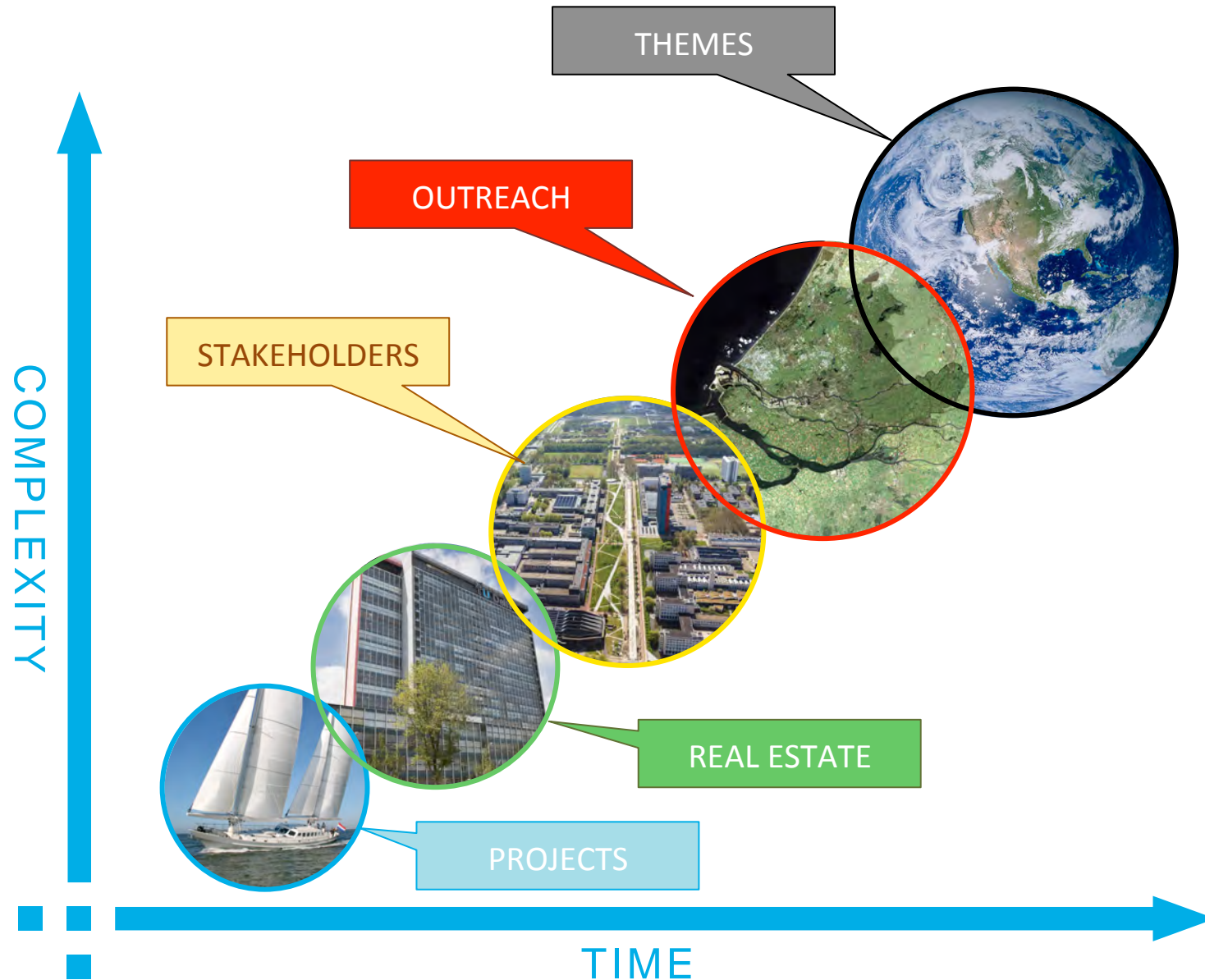
CONTENTS

- Climate: complex / urgent challenge
- TU Delft at a glance
- How to combine education-research-campus?
- Why to co-operate and with whom?
- Towards a common language...

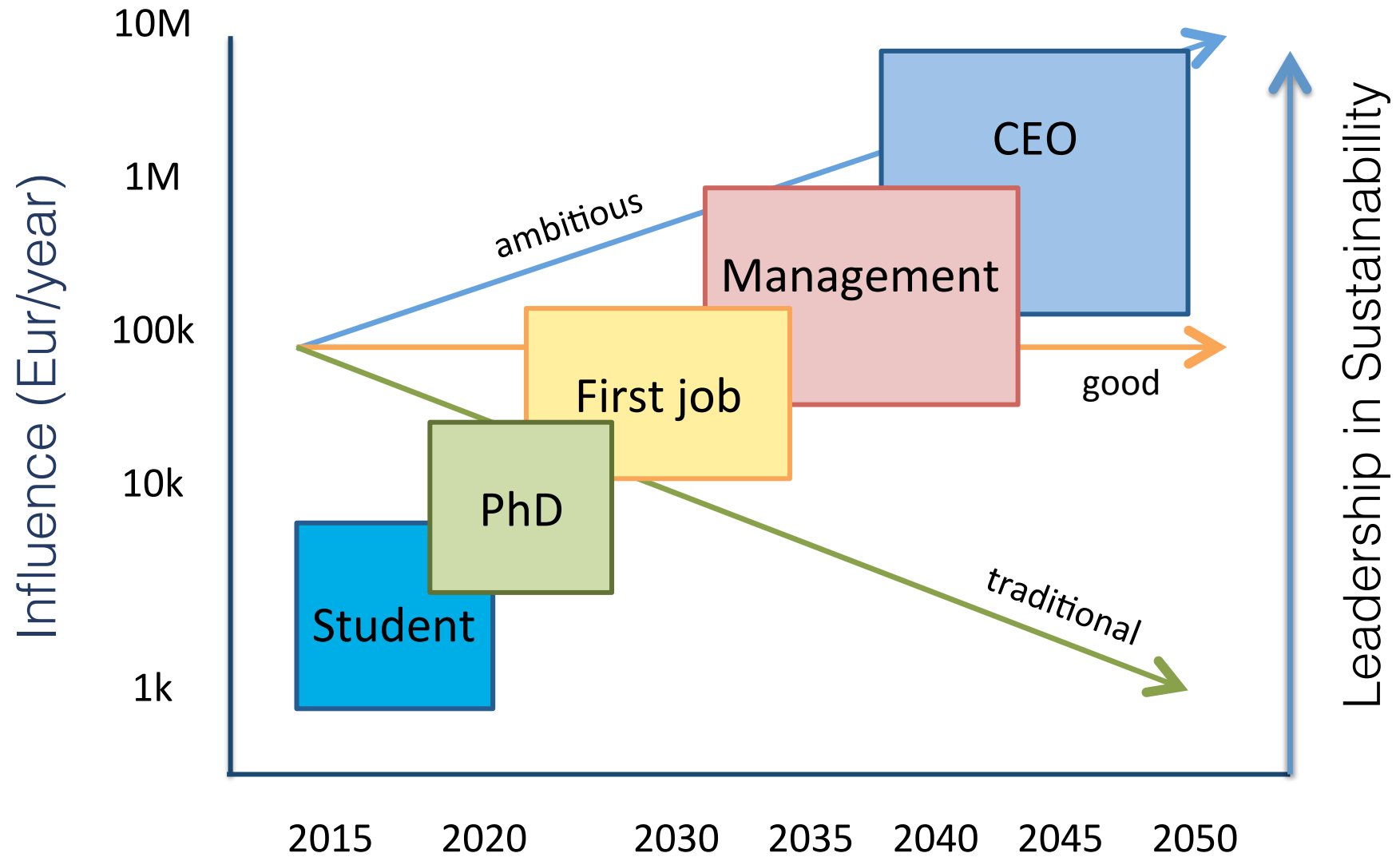
EACH CHALLENGE: A RACE AGAINST THE CLOCK



UNIVERSITIES ACTIVE ON ALL THESE LEVELS



A PROFESSIONAL CAREER: LEADERSHIP



TU DELFT AT A GLANCE



World Solar Race Team



Hyperloop Team



20,000 STUDENTS



2,500 PhD STUDENTS



5,000 STAFF



€500 MILLION



CAMPUS TRANSPORT



PROGRESS



GREEN OFFICE HQ

TU DELFT COMMITTED TO SUSTAINABILITY:

- 2020 GOALS ON CO₂, RENEWABLES AND EFFICIENCY
- CHP, SMART HEAT, GEOTHERMAL, PV, WIND OFF-SHORE, ENERGY NEUTRAL BUILDINGS, ETC.
- 1,000'S OF RESEARCHERS



ENERGY NEUTRAL BUILDINGS



BUSINESS & SCIENCE:
GREEN VILLAGE DEVELOPMENT

CAMPUS SUSTAINABILITY GOALS

1. Climate / Greenhouse Gas Emissions

- Direct and indirect: 0
- Embedded emissions ('scope 3')

2. Circularity: reduce – reuse – produce

3. Nature, Water & Ecosystems:

- Climate & Water resilience
- Biodiversity

4. Health & Well-being

CIRCULARITY AS GUIDING PRINCIPLE

REAL ESTATE



1

CIRCULARITY AS MEANS,
NOT AS A GOAL



2

DESIGN FOR
ADAPTABILITY



3

DESIGN FOR
REASSEMBLY



4

EXCLUSIVELY USE
CIRCULAR MATERIALS



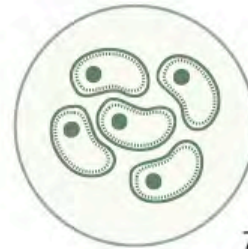
5

TECHNICAL CYCLES:
PRESERVE QUALITY



6

BIOLOGICAL CYCLES:
DESIGN USING CASCADES



7

INTEGRATE BIOCHEMICAL
CYCLES INTO APPROACH



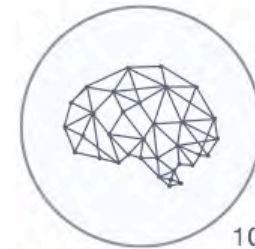
8

INTEGRATE DESIGN
INTO LOCAL ECOSYSTEM



9

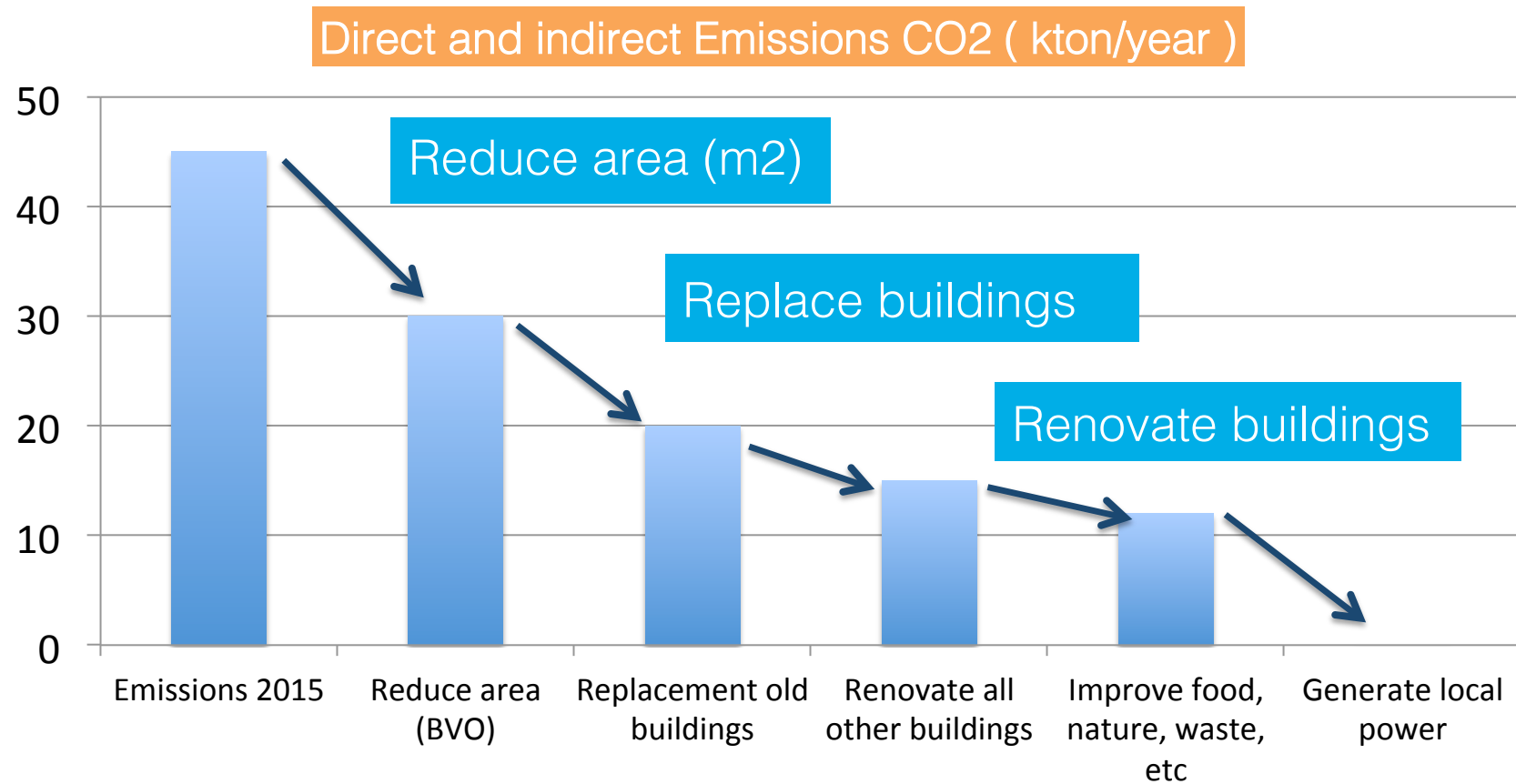
ENERGY: REDUCE,
REUSE AND PRODUCE



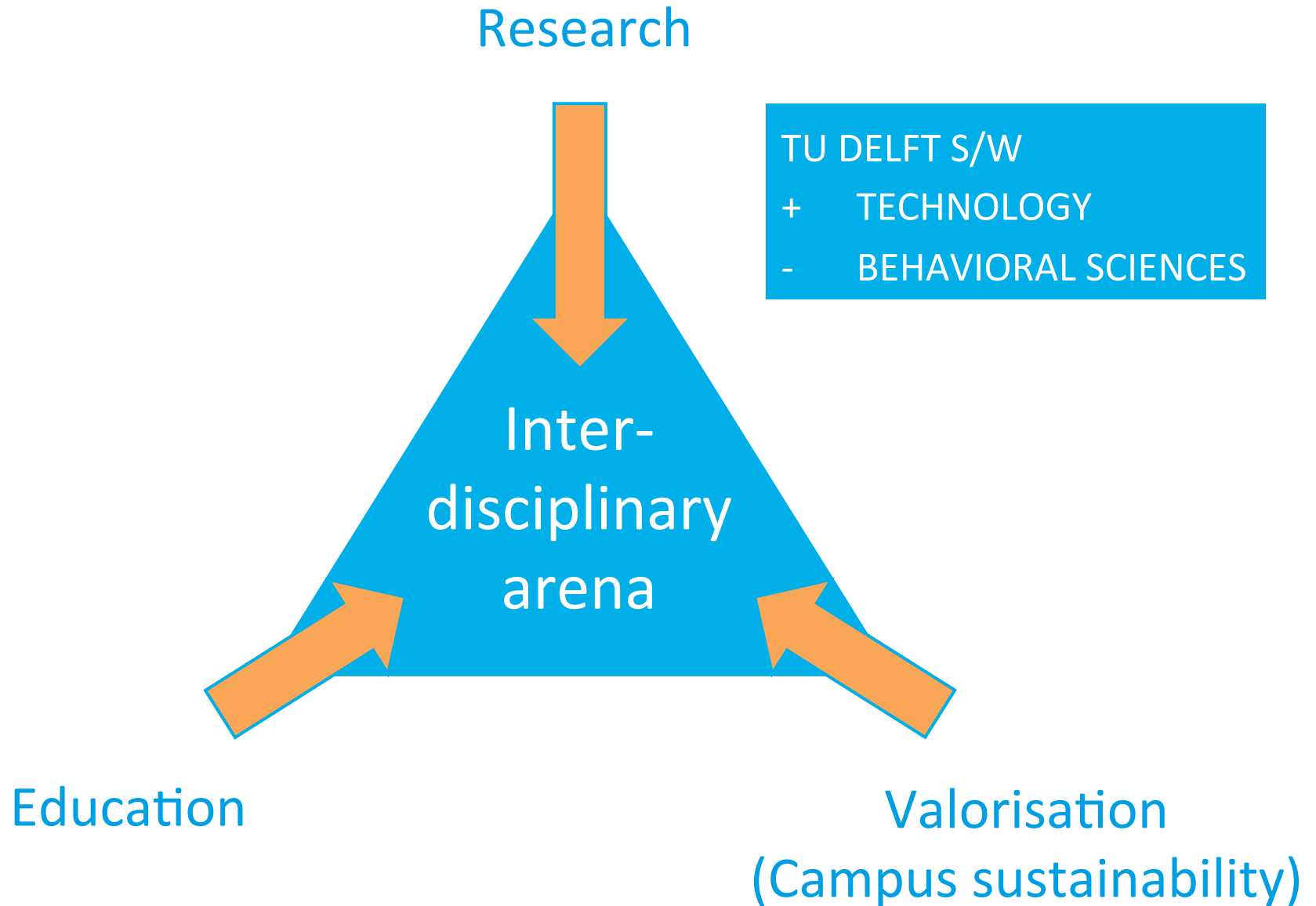
10

DEVELOP
'LEARNING' BUILDINGS

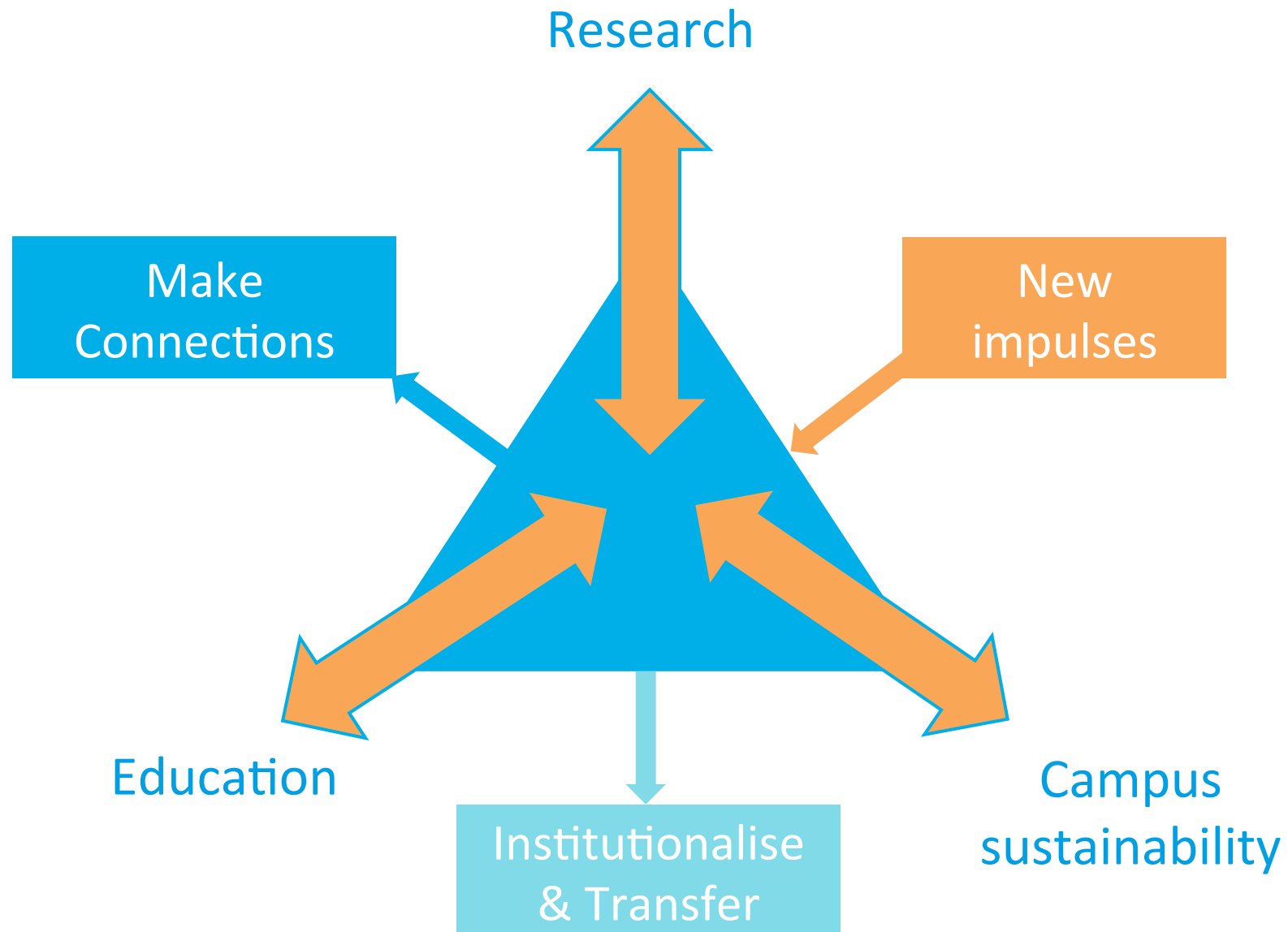
STEPS TOWARDS ZERO CO₂



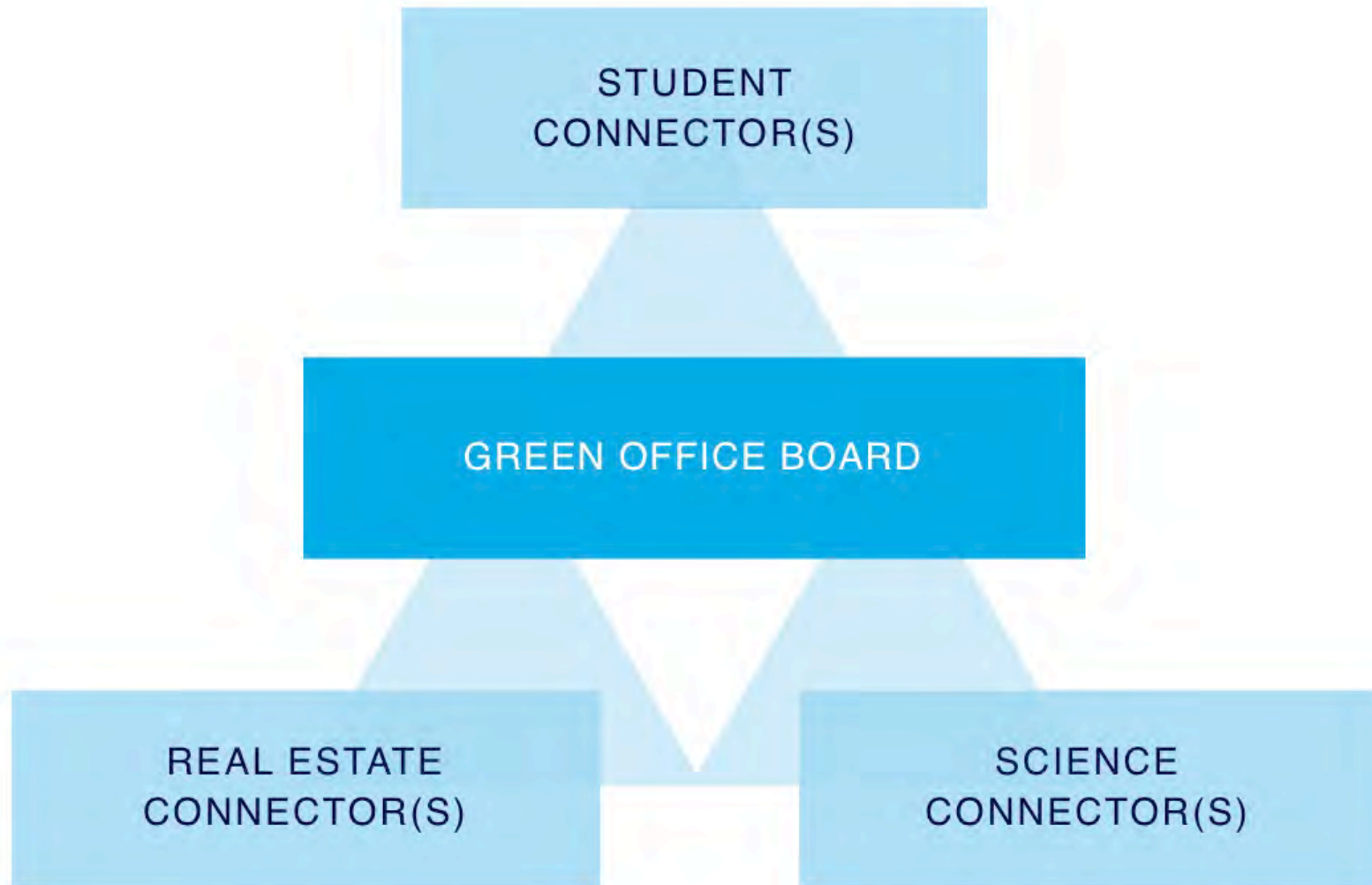
UNIVERSITIES ACTIVE ON ALL CHALLENGES...



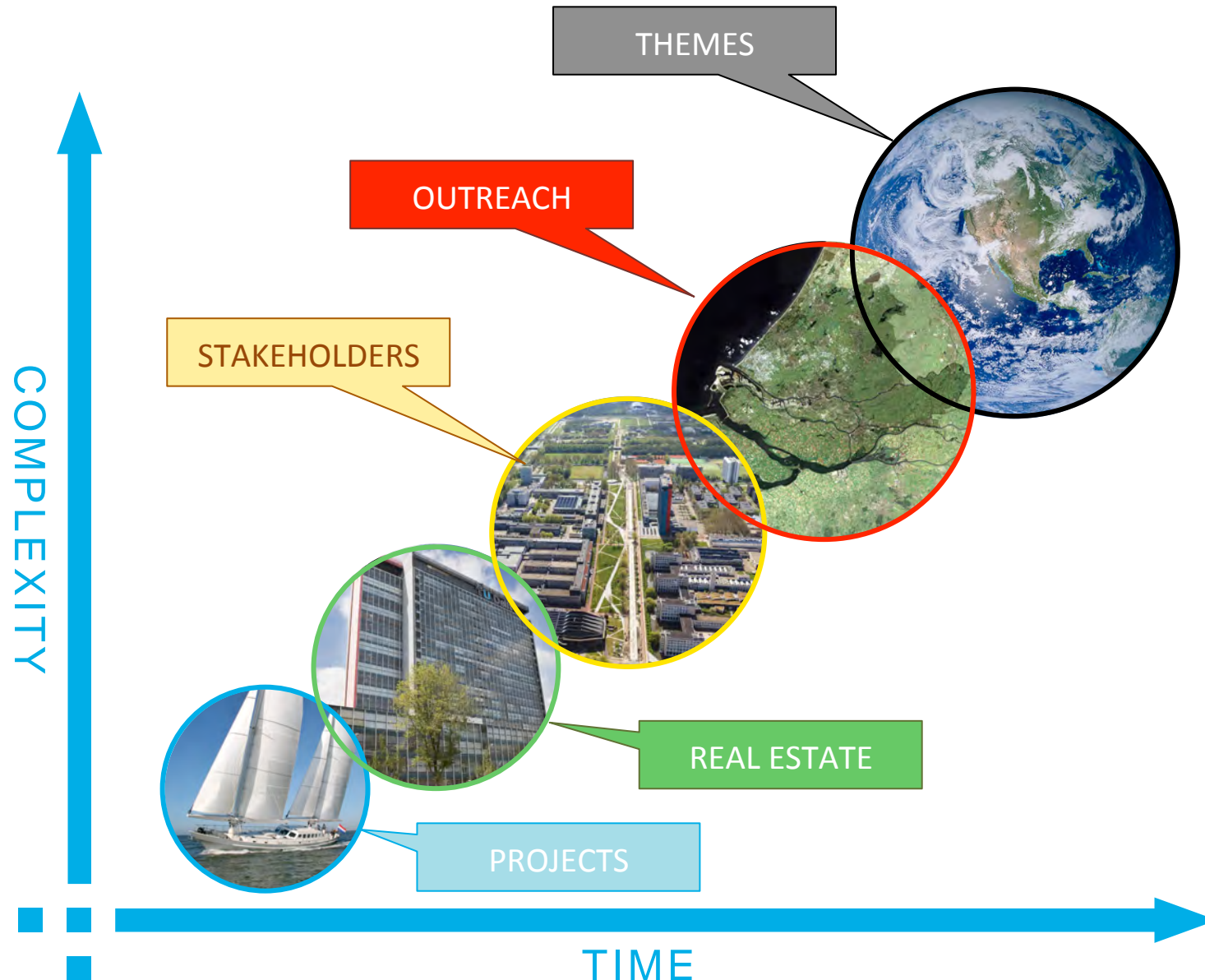
SUSTAINABILITY OFFICE – CORE BUSINESS



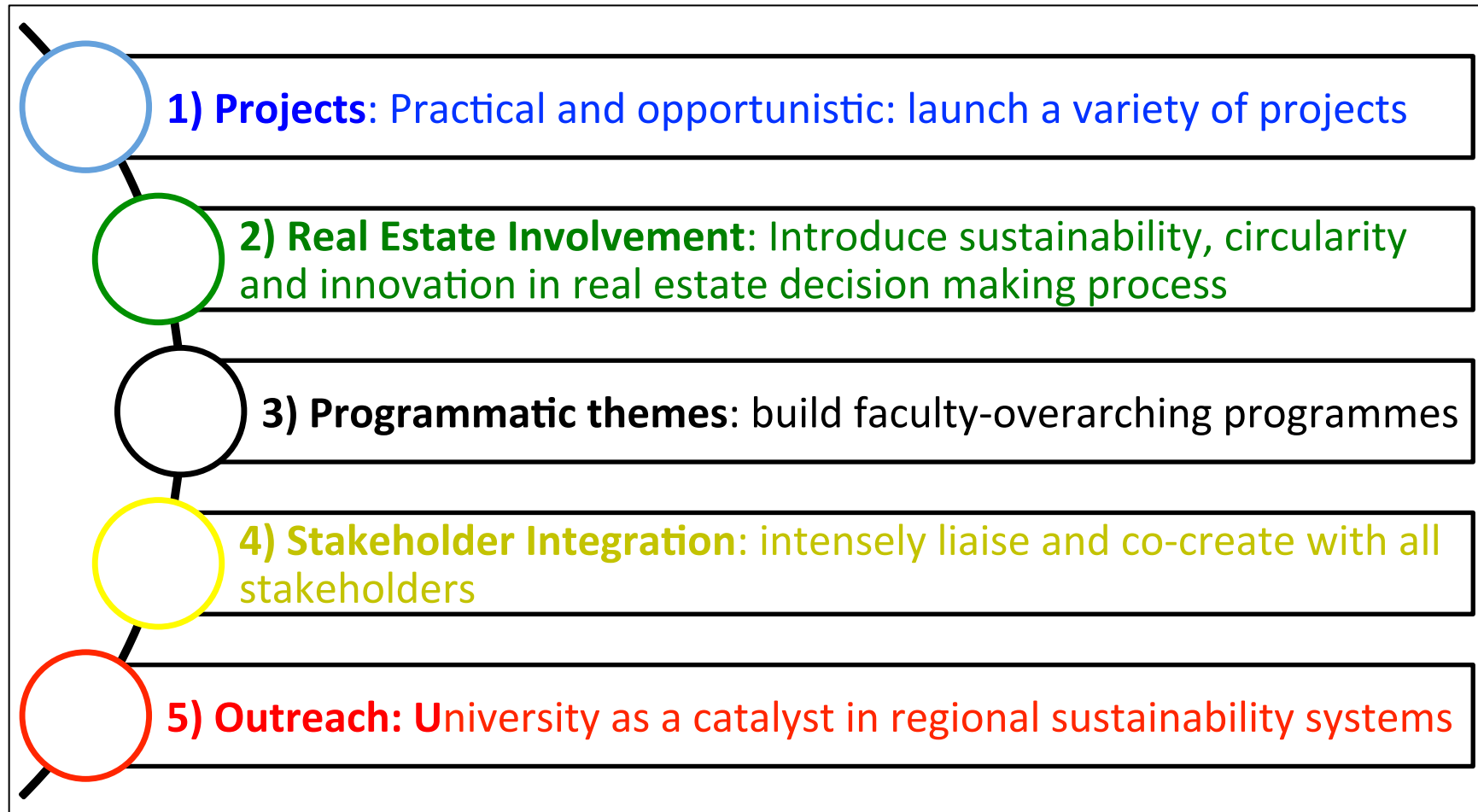
TRIPLE LIAISON STRUCTURE GREEN OFFICE



EACH CHALLENGE: A RACE AGAINST THE CLOCK

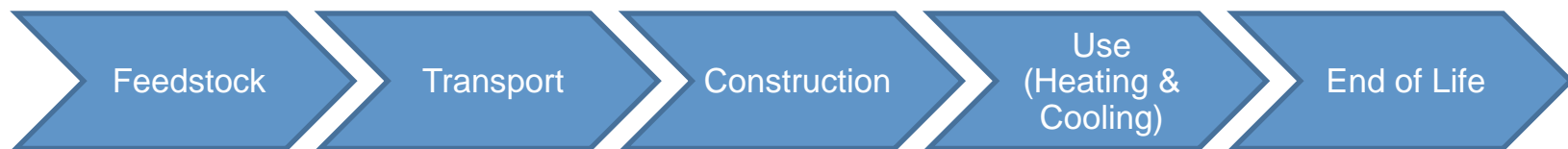


SHOW-HOW APPROACH: FIVE PILLARS



Pillar 3 - Additive Manufacturing

- Overarching idea: green additive manufacturing
- Scenario study / value chain analysis
- Additive Manufacturing (= 3D printing) can reduce global final energy by 5 – 25%
- new paradigms for IPCC
- New discourse with scientists



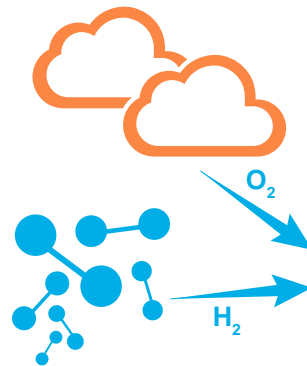
Leendert Verhoef, Bart W. Budde, Cindhuja Chockalingam, Brais García Nodar, Ad van Wijk, 2017, *The Effect of Additive Manufacturing on Global Energy Demand: An Assessment Using a Bottom-up Approach*, Energy Policy, under review

CAR AS POWER PLANT

PROJECTS



1 Fuel cell vehicles
for the production of
electricity, heat and
clean water.



2 Hydrogen
production, storage,
conversion and
distribution

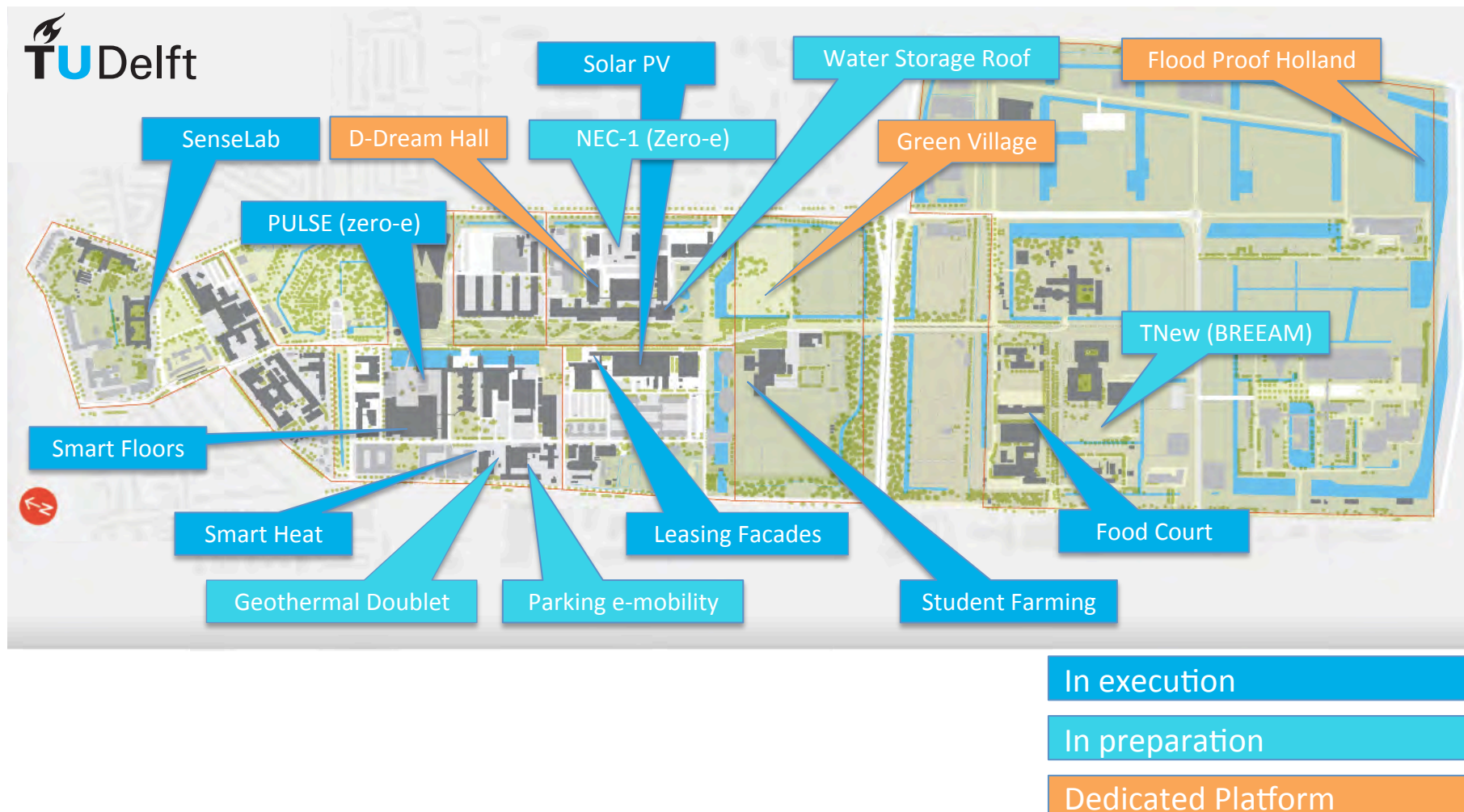


3 System integration
of fuel cell vehicles
for transport, heat,
electricity and water

- van Wijk and **Verhoef**, *Our Car as Power Plant*, 2014, IoS University Press, ISBN 978-1-61499-377-3
- Oldenbroek, V, **Verhoef L.A.**, van Wijk A.J.M., *Fuel cell electric vehicle as a power plant: fully renewable integrated transport and energy system design and analysis for smart city areas*, in print, International Journal of Hydrogen Energy 42, Jan 2017, 8166-8196

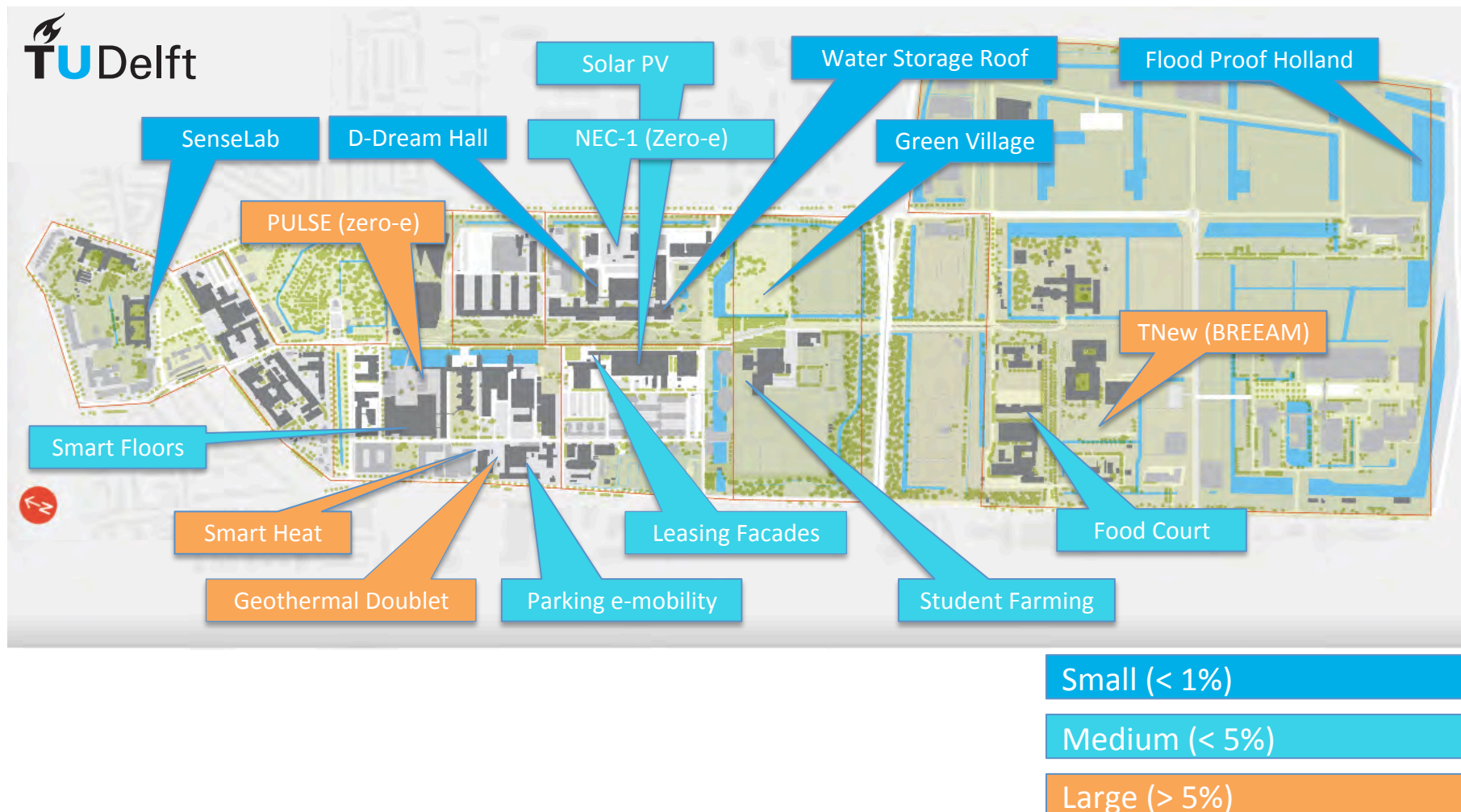
CAMPUS AS LIVING LAB – GEOGRAPHY AND STATUS

‘... is the **integrated** organisational, technological, and socio-economic **approach** in which a university uses assets and facilities to investigate and test innovative technologies or services **by, with and for** their **community**...’



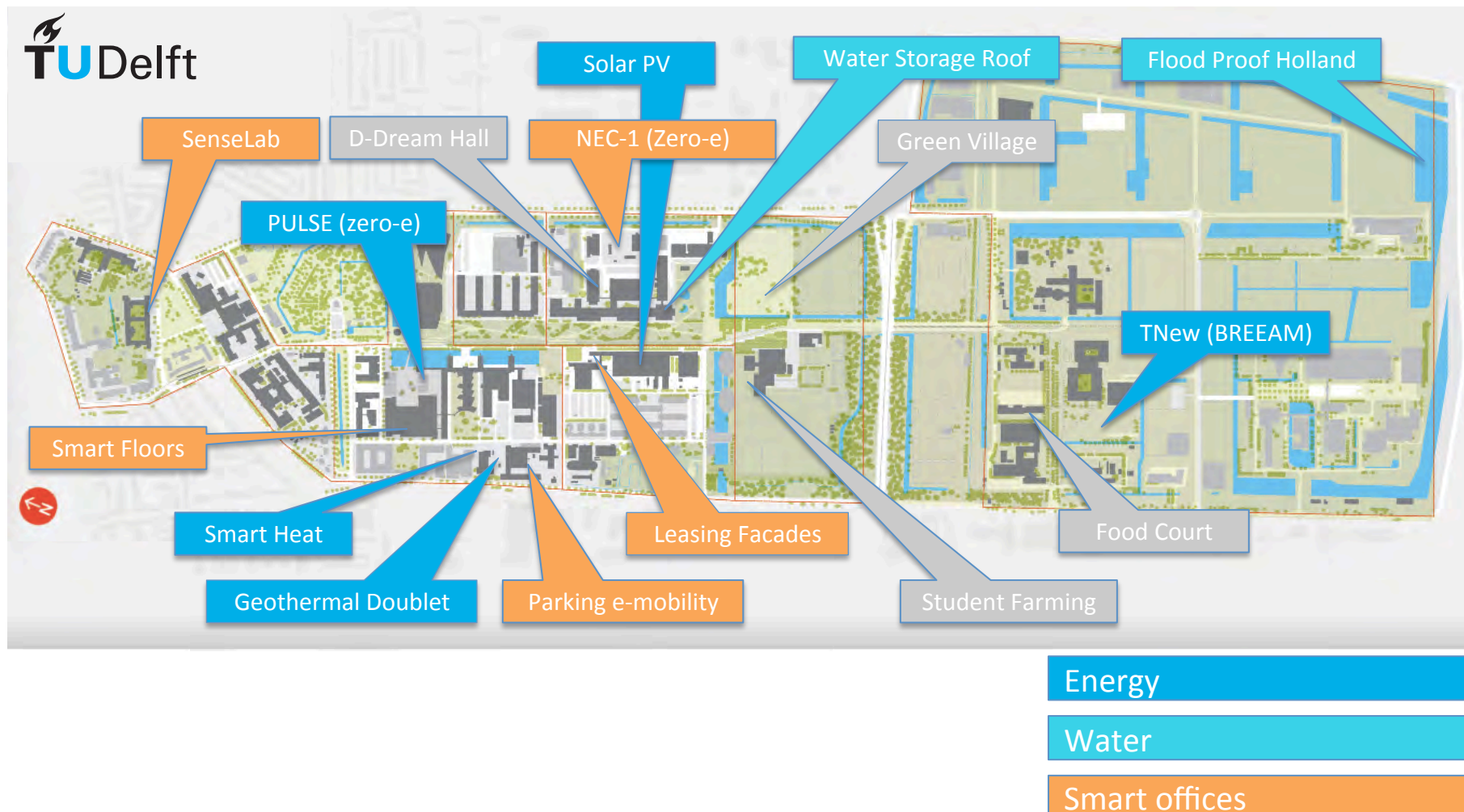
LIVING LABS – IMPACT ON CAMPUS SUSTAINABILITY

Not all living labs have large outcome for campus sustainability, but a good balance is productive: research, education and impact



CAMPUS AS LIVING LAB – RESEARCH THEMES

Nice distribution of innovation projects over themes: energy, water, smart offices, food, others...



UNIVERSITY NETWORKS OVERVIEW

Name	Members	Geography
AASHE	755	USA
GUPES	560	Africa/South America
IUSDRP	112	World
ISCN	80	World
GULF	25	World
Copernicus	22	Europe
IARU	11	World
IDAE	5	Europe
Studenten voor Morgen	13	Nederland

Feraz, F., Murphy, M., O-Broin, D., Verhoef, L., 2017, *University Campus as Living Lab, a novel integrated methodological framework for multi-helix sustainable transformations*

UNIVERSITY LIVING LABS CO-OPERATION



- How to (keep) structure...
- How to approach Stakeholder : Real estate! Faculty!
- How to achieve value outcomes?
- How to manage Living Labs ?
- How to work together as Universities?

Analysis of outcomes MIT/TUD workshop Living Labs, ISCN, 29 June 2017, Vancouver

DETERMINE PARAMETER SET(S) OF LIVING LABS

SCOPE

- Education, Research, Valorisation and Campus Sustainability
- Integration and Multidisciplinary

USER INTERACTION

- Users defined
- How many users?
- Active / Extent of participation
- Speed of feedback loops

ORGANISATION & PROCESS

- Lead
- project, programme, or platform?
- Stakeholders, trigger
- Risks taken and managed

OUTCOMES

- Education, Research, Valorisation and Campus Sustainability

IMPACT IN THE WORLD

- UN SDG's
- Campus Sustainability
- Replicability

OTHER APPROACHES



EXAMPLE: GREEN VILLAGE

GOAL

Acceleration of innovation on sustainable technologies, together with companies, in secluded area

TRIGGER

Visionary professor / closer collaboration with industry

BUDGET

approx. 5-10 million Euro

DECISION

Extensive negotiations / changes of real estate procedures / 'Green Deal'

STATUS

In exploitation

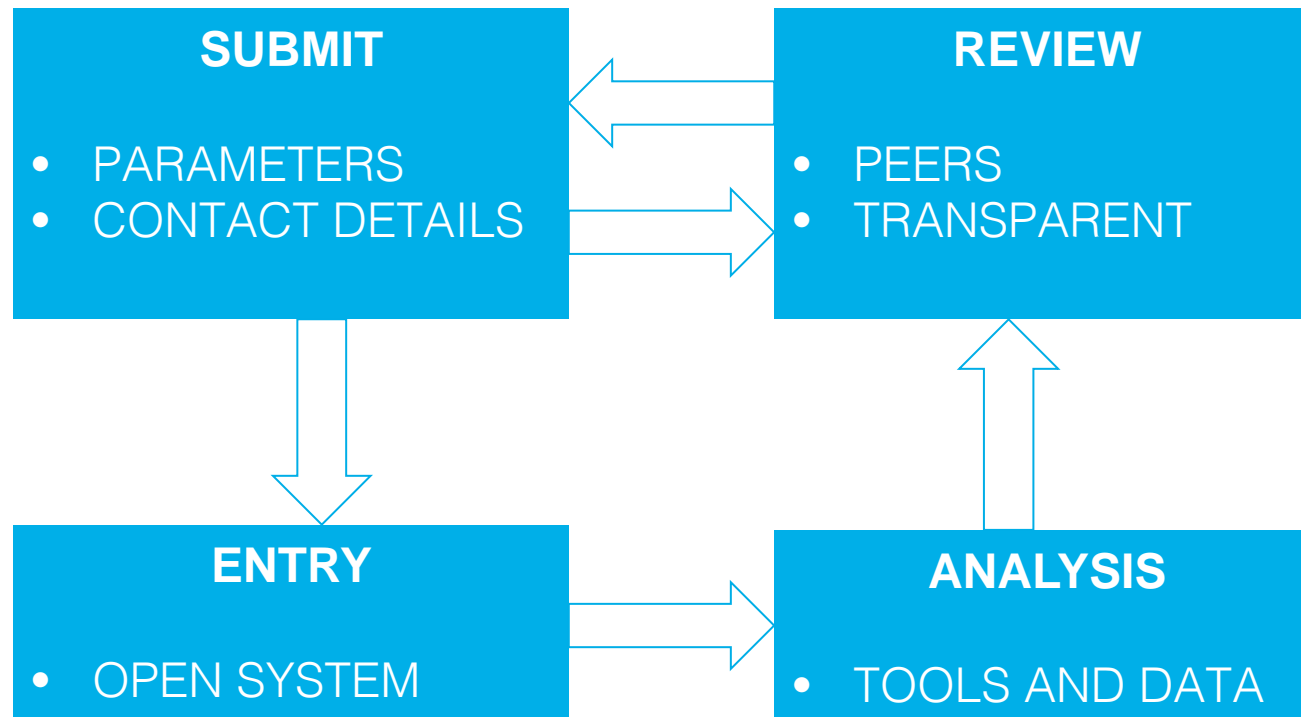
OUTCOMES

Campus: Exposure, attractiveness for industry

Research: Extensive programme development: hydrogen, smart-living, etc.

Education: Student participation and inhabitation

SET UP KNOWLEDGE SYSTEM: CAMPUS AS LIVING LABS *CHALLENGE*



PRINCIPLES:

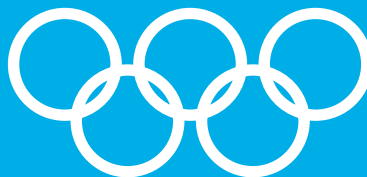
- SUBMISSION OF 'MEMBERS'
- DATABASE FOR ALL

SUMMARY / OUTLOOK

SHOW-HOW



TRIPLE LIAISON



FIVE PILLARS



CIRCULARITY

NEXT STEPS



VALIDATE
APPROACH



EXCHANGE &
COLLABORATE



STRUCTURE &
LEADERSHIP

THANK YOU

Delft University of Technology - The Green Office
Van den Broekweg 2 - 2628 CS Delft - The Netherlands
*L.A.Verhoef@tudelft.nl



Green Office