Palermo, 14-03-2014
New trends and research perspectives towards a more sustainable environment

TRUST - TRANSITIONS TO THE URBAN SERVICES OF TOMORROW

Introduction and Overview

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TRANSITIONS TO THE URBAN WATER SERVICES OFTOMORROW

Background

Aim of the presentation

- Provide information and create interest about the TRUST project
- Focus on modelling solutions and applications related to the topic of today: Water&energy&emissions. (examples are provided)

Do you want to know more?

Please visit www.trust-i.net or ask me directly: rita.ugarelli@ntnu.no

About me

Senior Scientist at SINTEF Water and Environment (Norway) and professor at the Technical University in Norway (NTNU).

PhD in asset management applied to urban water infrastructure (Bologna University). Currently project manager for SINTEF of several projects related to urban water infrastructure asset management (including TRUST) and responsible for the course for PhD students on sustainable asset management of urban water systems in NTNU.

Key Data

- Large-scale integrated project, EC-funded under FP7
- 30 partners from 11 countries:
    - 13 research institutes / universities
    - 7 small/medium-sized enterprises
    - 9 utilities / end-users
    - 1 international organisation
- Duration: 48 months (May 2011 – April 2015)

Our main drivers and target group

WATER SCARCITY CLUSTER

ALGARVE

ATHENS

COMUNIDAD DE MADRID

REGGIO EMILIA

GREEN CITY CLUSTER

AMSTERDAM

HAMBURG

SCHIPHOL

URBAN - PERI URBAN CLUSTER

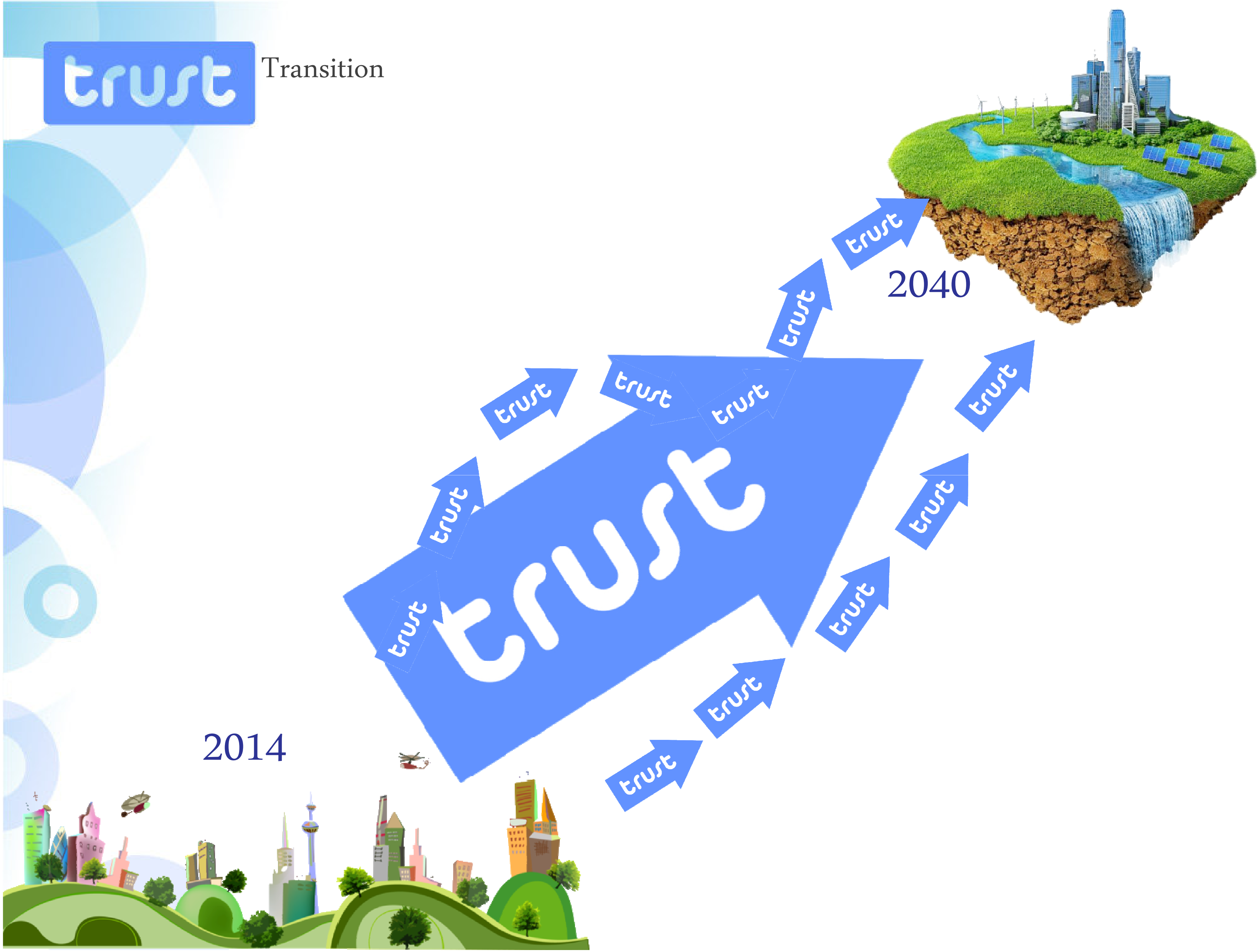
BUCHAREST

CITIES OF SCOTLAND

OSLO

Products

Innovations in governance modes, modeling concepts, technologies, decision support tools, new approaches to integrated water, energy and infrastructure asset management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Transition
2040
2014
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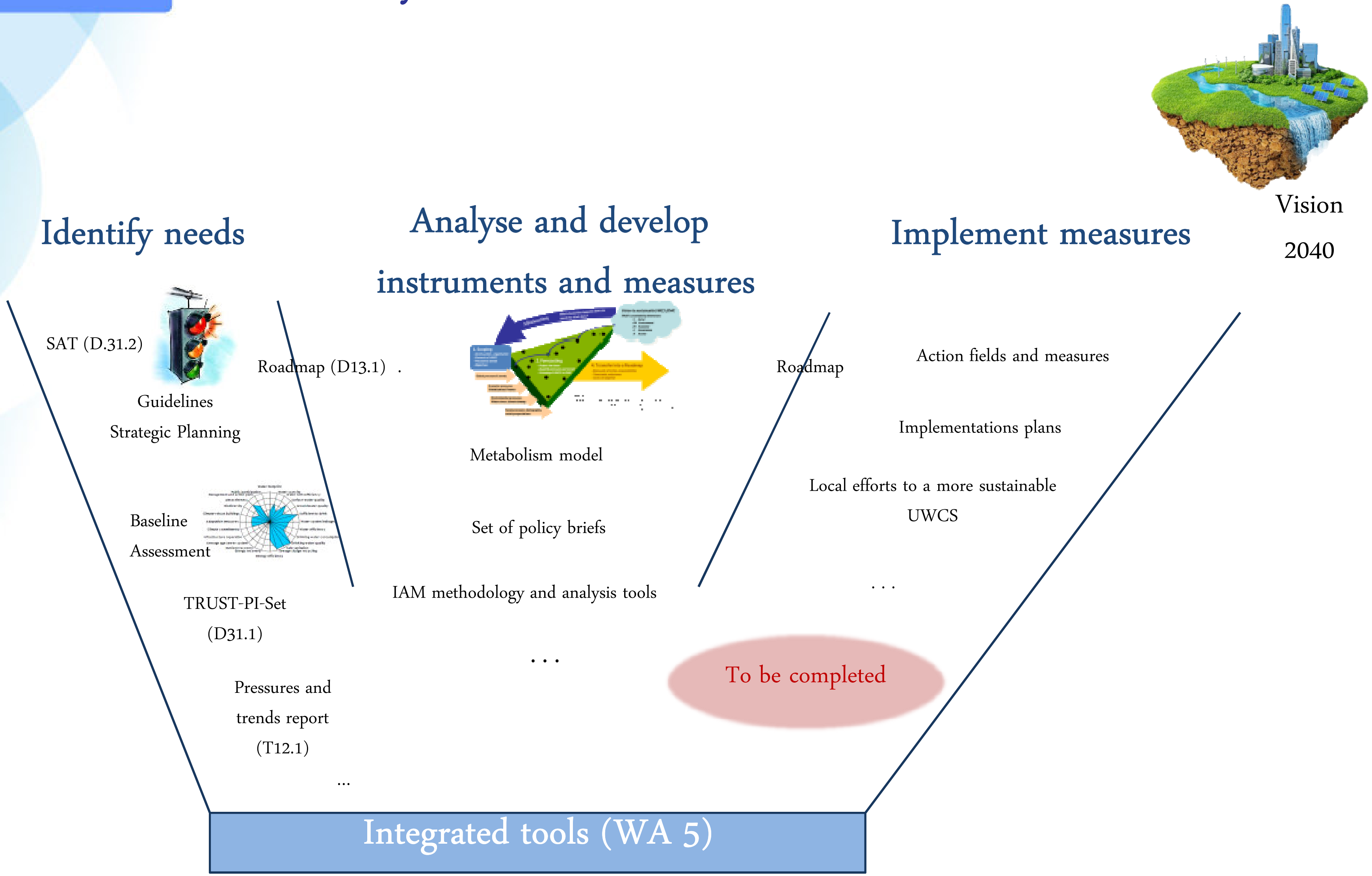
"Flow-chart" of the R&D approach in TRUST towards the sustainability vision



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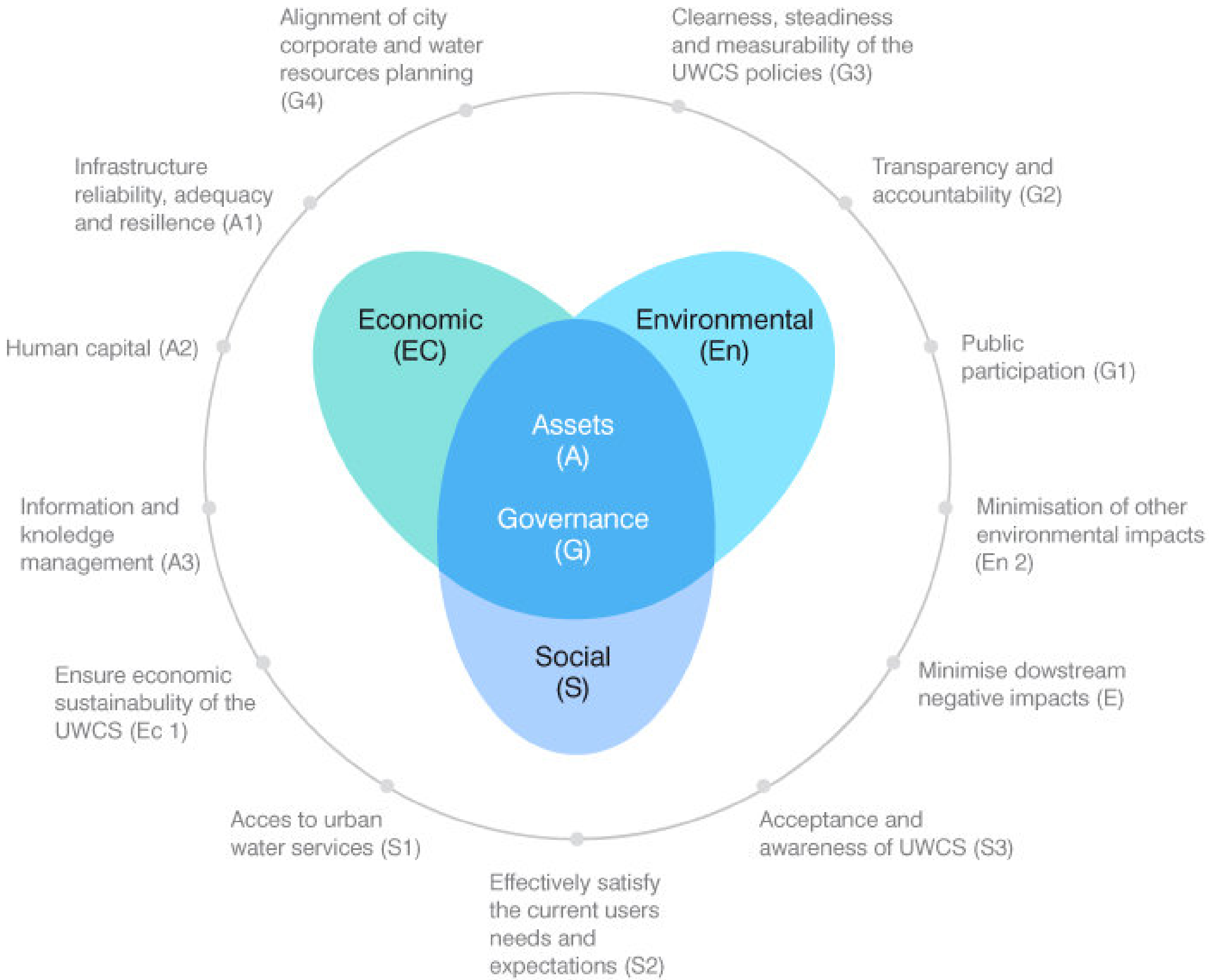
More sustainable services

- three bottom line dimensions
- plus emphasis on assets and governance involvement

(TRUST Sustainability Definition)

How do we define SUSTAINABILITY in TRUST?



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1. Diagnosis

To reach the 2040 Vision, it is necessary to know where we are. To know our strengths and weaknesses, the opportunities and the threats.

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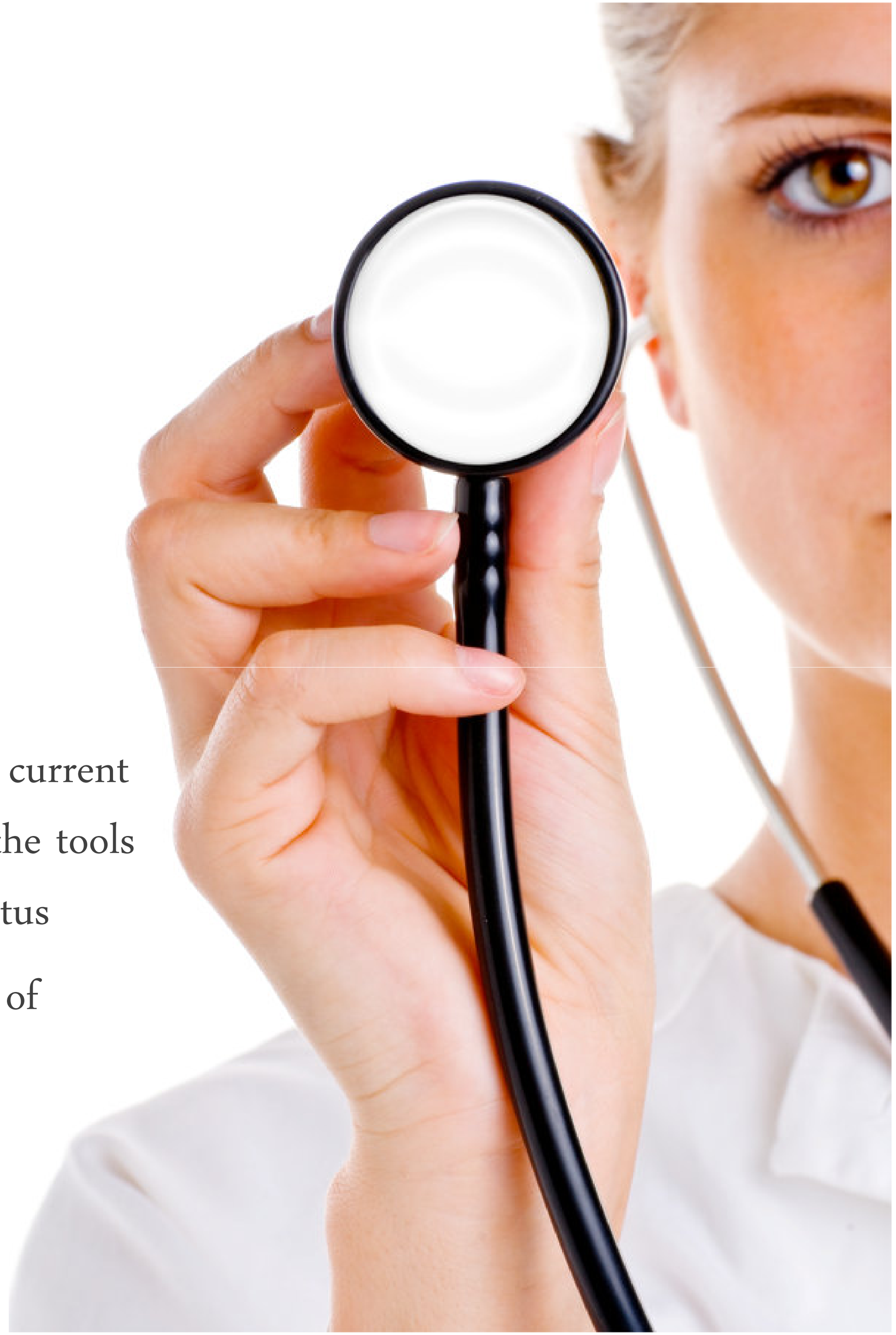
1. Diagnosis



TRUST will provide a diagnosis of the current situation of urban water services, and the tools for cities to self assess their present status

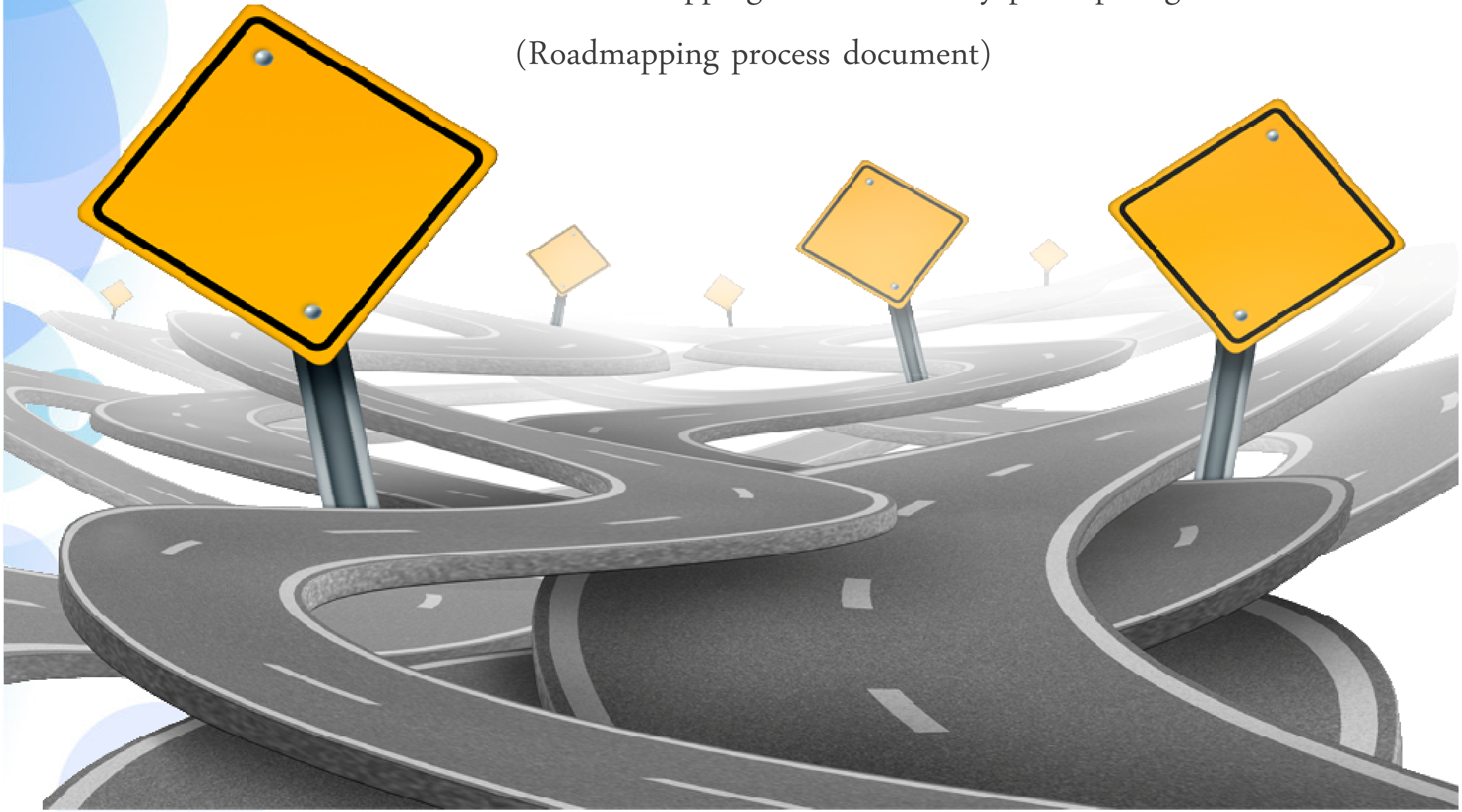
(Self Assessment Tool and Quick scan of sustainability level)

2. Getting there

Roadmaps are created to aid cities to transition to 2040.

The roadmapping tool is tested by participating cities

(Roadmapping process document)



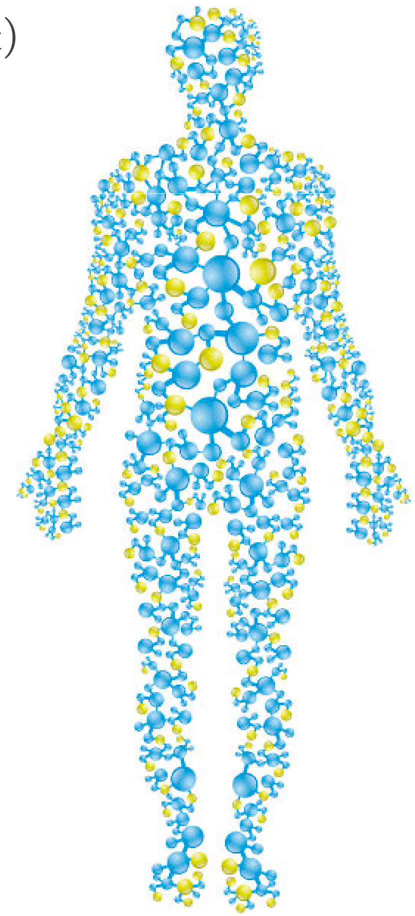
3. Will it work?

Which alternatives are the optimum ones?

(Decision Support system and Multicriteria analysis)

Predict the behaviour of the system and related risks

(the metabolism model and risk assessment)



Metabolism of a generic urban water and wastewater system (1/2): what is it? and what does it do?

Each system or subsystem involves a set of functions

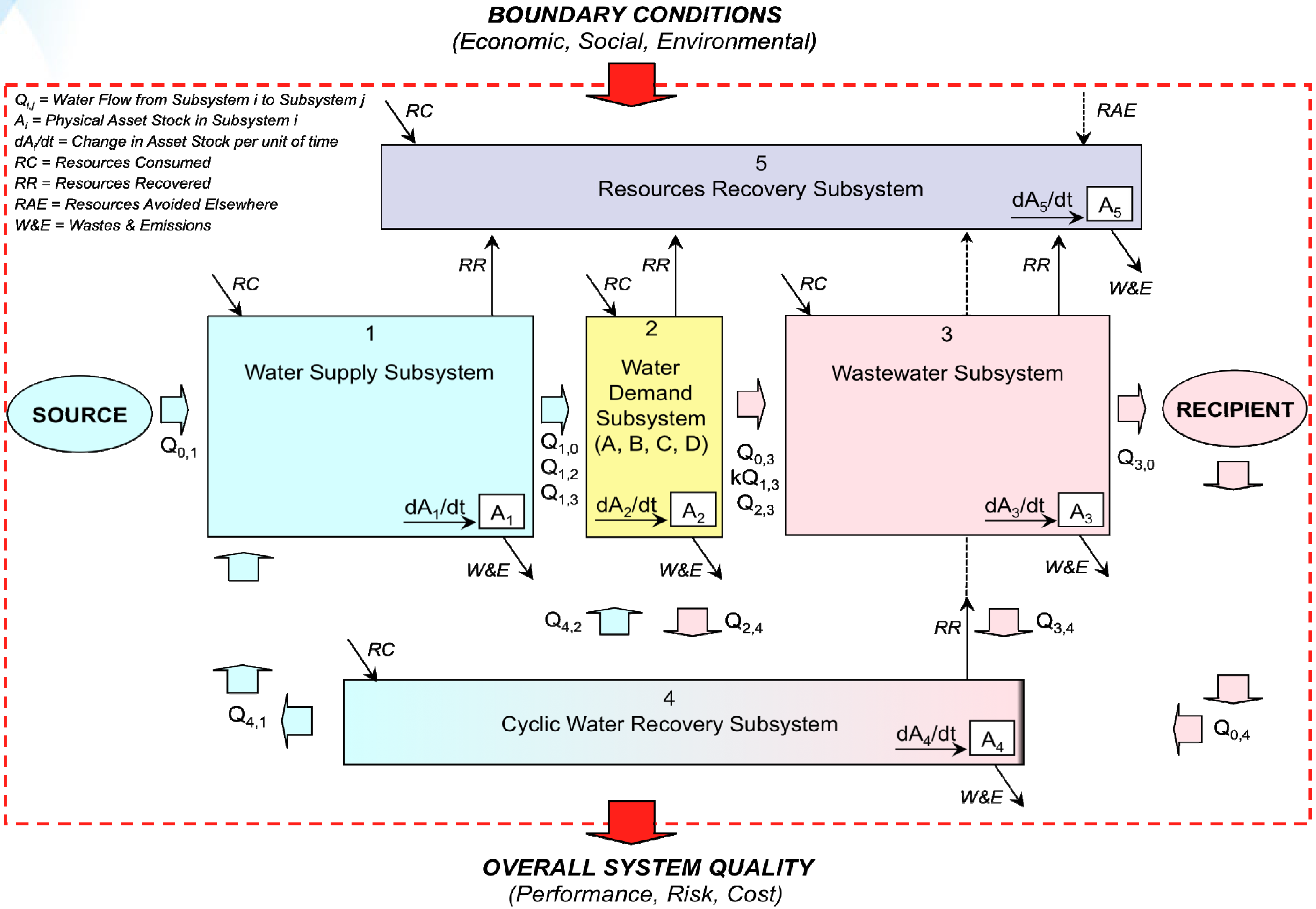
The key functions will:

- Provide a service
- Represent given activities, technologies and physical assets
- Mobilize a metabolism of resources, wastes and emissions
- Lead to costs
- Represent risks

Metabolism modeling:

- It describes and model the relationships between these factors, in order to assess the overall system quality
  - Performance (effectiveness and efficiency)
  - Risk
  - Cost

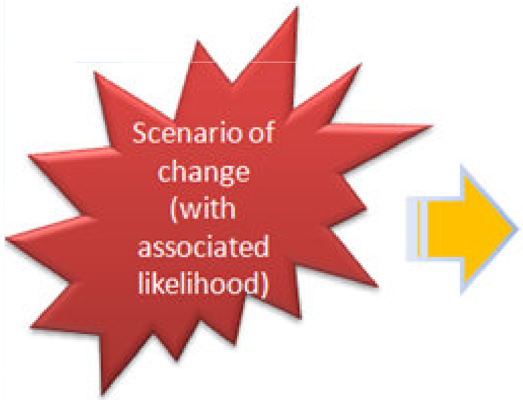
Metabolism of a generic urban water and wastewater system (2/2): what is it? and what does it do?



Ref.: Brattebø, H., Sægrov, S., and G Venkatesh (2011). “Metabolism modelling of urban water cycle systems system definition and scoping report”, TRUST, Internal deliverable, WA 3.3.

New concept of Risk

Considering the definition of sustainability in TRUST and that the analysis is to be carried out mainly at a strategic (macro) level, using an integrated approach, risk is here identified in the context of the occurrence of certain events causing undesired and uncertain deviations from the sustainability objectives (risk defined as effect of uncertainty on objectives in ISO Guide 73:2009).



Set of risk factors producing scenarios of change	
A	Population growth
B	Rise in industrial water demand
C	Asset deterioration with time
D	Climate change

A new risk methodology has been developed in parallel to the metabolism model and tested on the case study of the city of Oslo in Norway

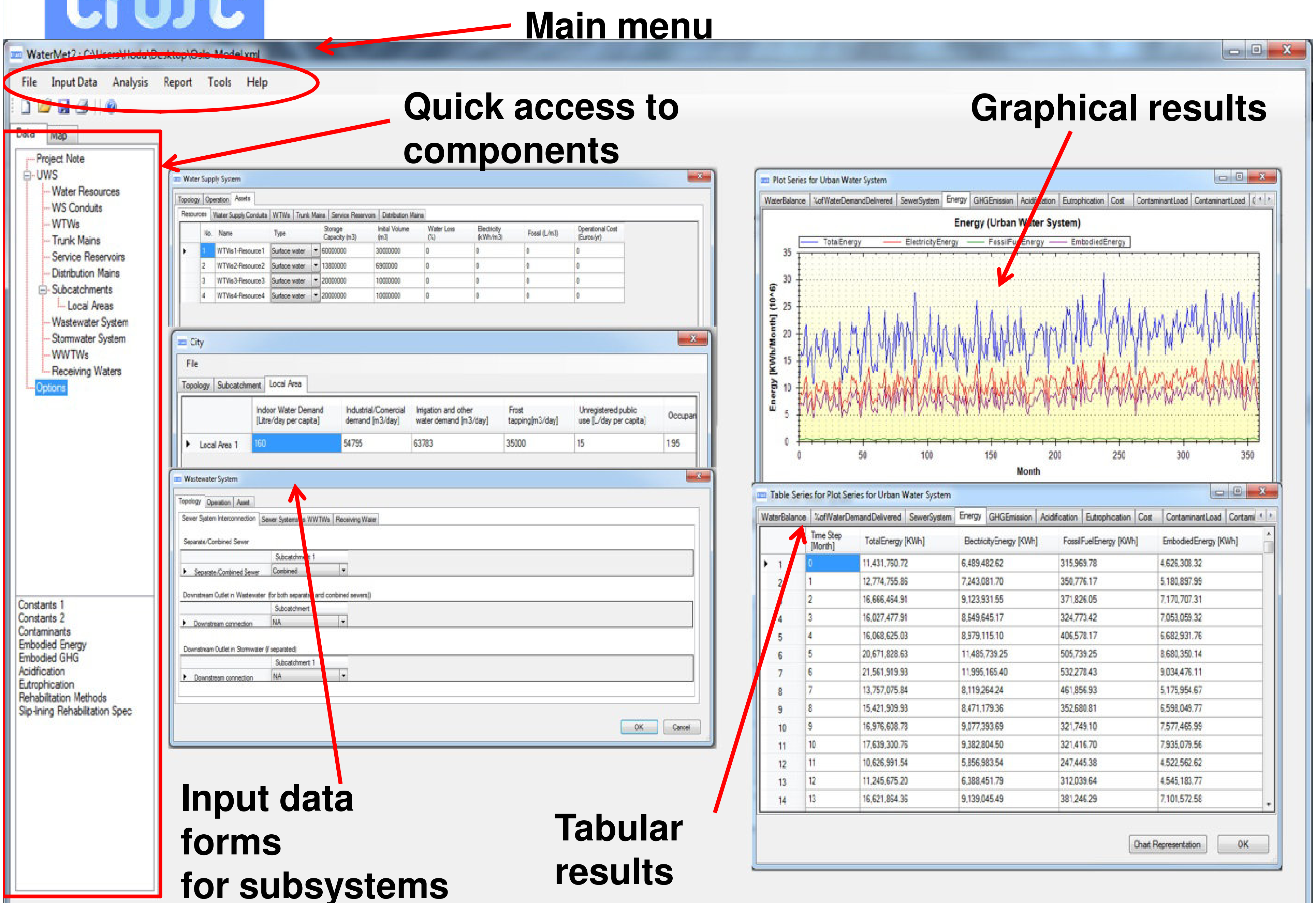
Ref.: R Ugarelli, M C Almeida, T. Liserra , P Smeets (2014). D.3.2.1 Metabolism risk-controlled model (Demonstrated for the city of Oslo), TRUST deliverable (under QA).

WaterMet^2 model characteristics

Main features	• Quantitative, simulation type model • Deterministic model • Simplified model based on mass conservation only • Developed for a generic urban water system (UWS) • Tested and verified on the city of Oslo, Norway
spatial scales	Four spatial scales: 1. Indoor area 2. Local area 3. Subcatchment area 4. City area
Temporal scales	Daily time step for a duration of *N* years
Key output flows/fluxes	• Water flows/balance (e.g. clean water, storm water) • Water quality related flows (e.g. contaminant loads) • Energy flux • Chemical consumption flux • Greenhouse gas emission (GHG) flux • Operational costs • Material flux

Ref. K. BEHZADIAN MOGHADAM, Z Kapelan, G Venkatesh, H Brattebo, S Sagrov, E,. Rozos, C Makropoulos, R Ugarelli, J Milina, L Hem , "Urban water system metabolism assessment using WaterMet2 model" , 12th International Conference on Computing and Control for the Water Industry, CCWI2013, Italy , 02 September2013 _ 04 September2013

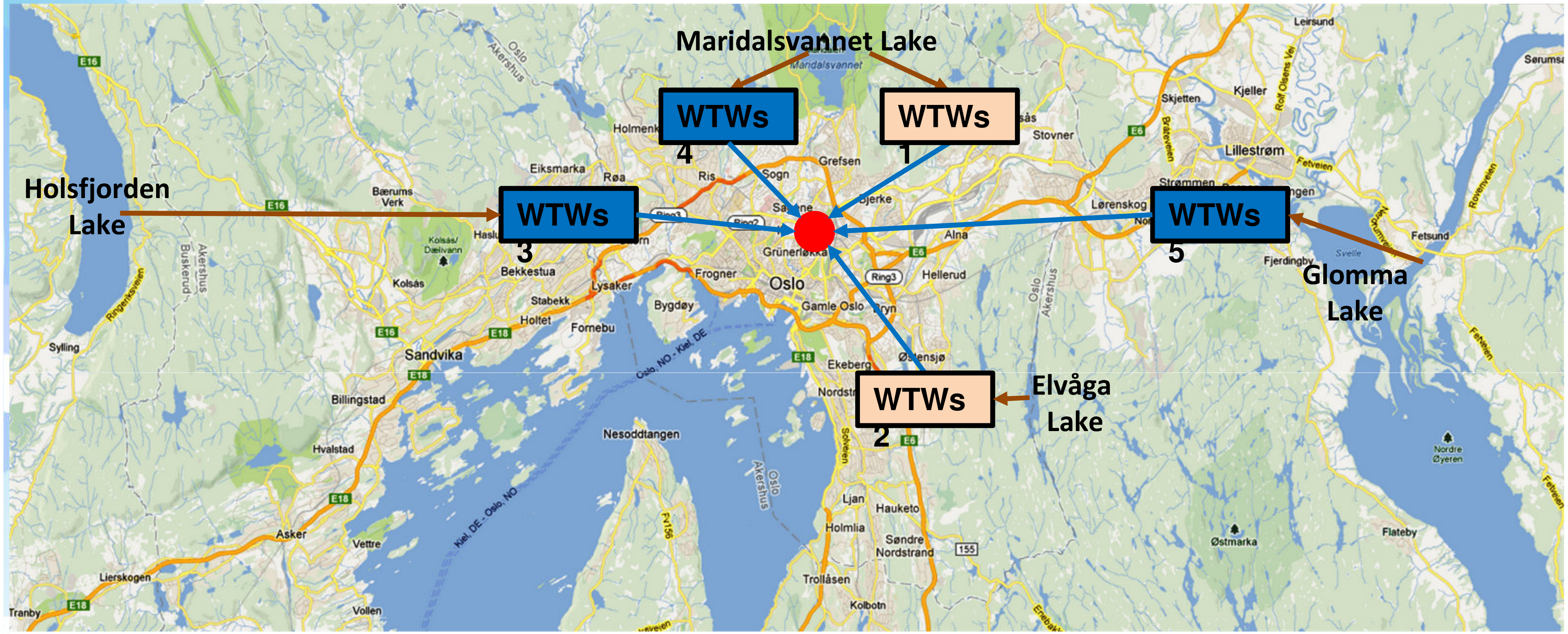
WaterMet2 Interface



Application: Oslo Urban Water System (UWS) assumptions

- The case study is the urban water system of Oslo, Norway
- Two main existing resources and WTWs (%90 and %10)
- Population of Oslo city: 607,257 inhabitants in 2011
- Number of properties: 202,419
- Two existing WWTWs (%63 and %27)
- A single WaterMet^2 subcatchment with a single local area
- WaterMet^2 aims to simulate intervention strategies in the UWS over 30 year planning horizon (2011-2040)
- The only scenario is the highest rate of water demand as a consequence of the highest population growth projection over the planning horizon

Layout of Oslo water supply system

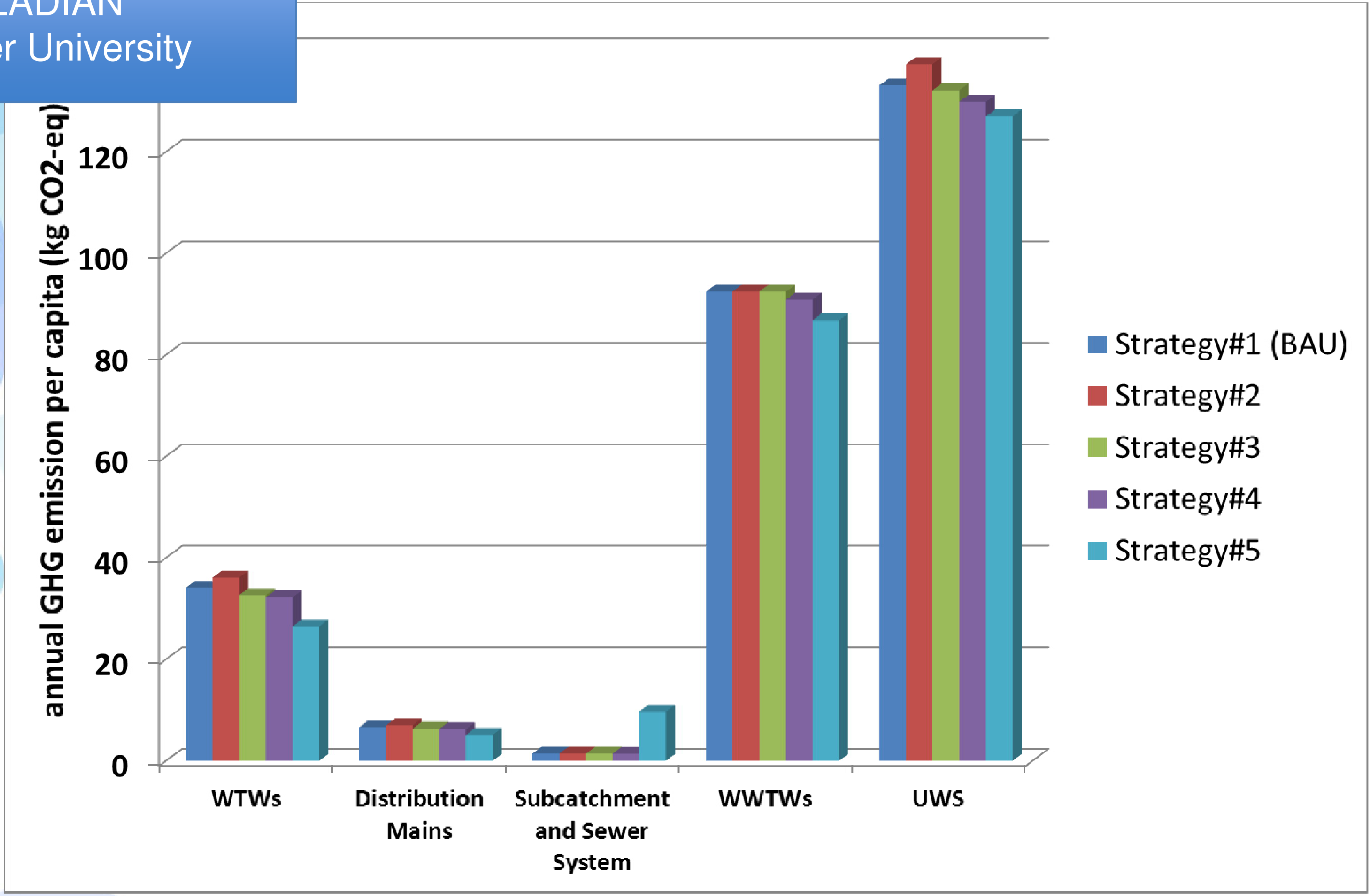


Existing WTWs | New WTWs | Treated water main | Raw water main

existing Oslo WTWs and water sources

Example 1
Courtesy of K . BEHZADIAN
Exeter University

Annual GHG emissions per capita



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4. How to do it?

Transition to a more sustainable future of UWCS will require new stools and technologies

(For Alternative water resources

For Water Supply

For Water demand management

For Wastewater and stormwater management

For Water-energy nexus

For Infrastructure Asset Management)

4. How to do it?

- Assess the potential of new technologies
- Produce free training materials and software tools

(Theatre Proof of concept, training and e-learning)

Overview of the type of applications performed related to Energy

	Algarve	Reggio E.	Oslo	Athens	A'dam / Schipol	Madrid
Energy saving						
• w.supply	X	X				X
• wwtp			X			
Energy generation						
• wwtp				X	X	
• heat + utes			X		X	
• microgeneration	X	X		X		

Example 2: Courtesy of Prof. Z. KAPELAN, University of Exeter

PUMP & VALVE SCHEDULING FOR IMPROVED LEAKAGE & ENERGY MANAGEMENT

Prof. ZORAN KAPELAN

University of Exeter

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Ref: M. Morley, A. Bello-Dambatta, Z. Kapelan, A. Bolognesi, C.Bragalli (2013). Task 42.3 –New Technique for Leakage Reduction via Integrated Energy and Pressure Management – TRUST Deliverable.

Scheduling Problem

Given a water distribution system network configuration and 24 hour water demands, determine optimal schedules of pumps and fixed/time modulated PRVs that minimise total water lost through leakage and the total cost of energy used for pumping.

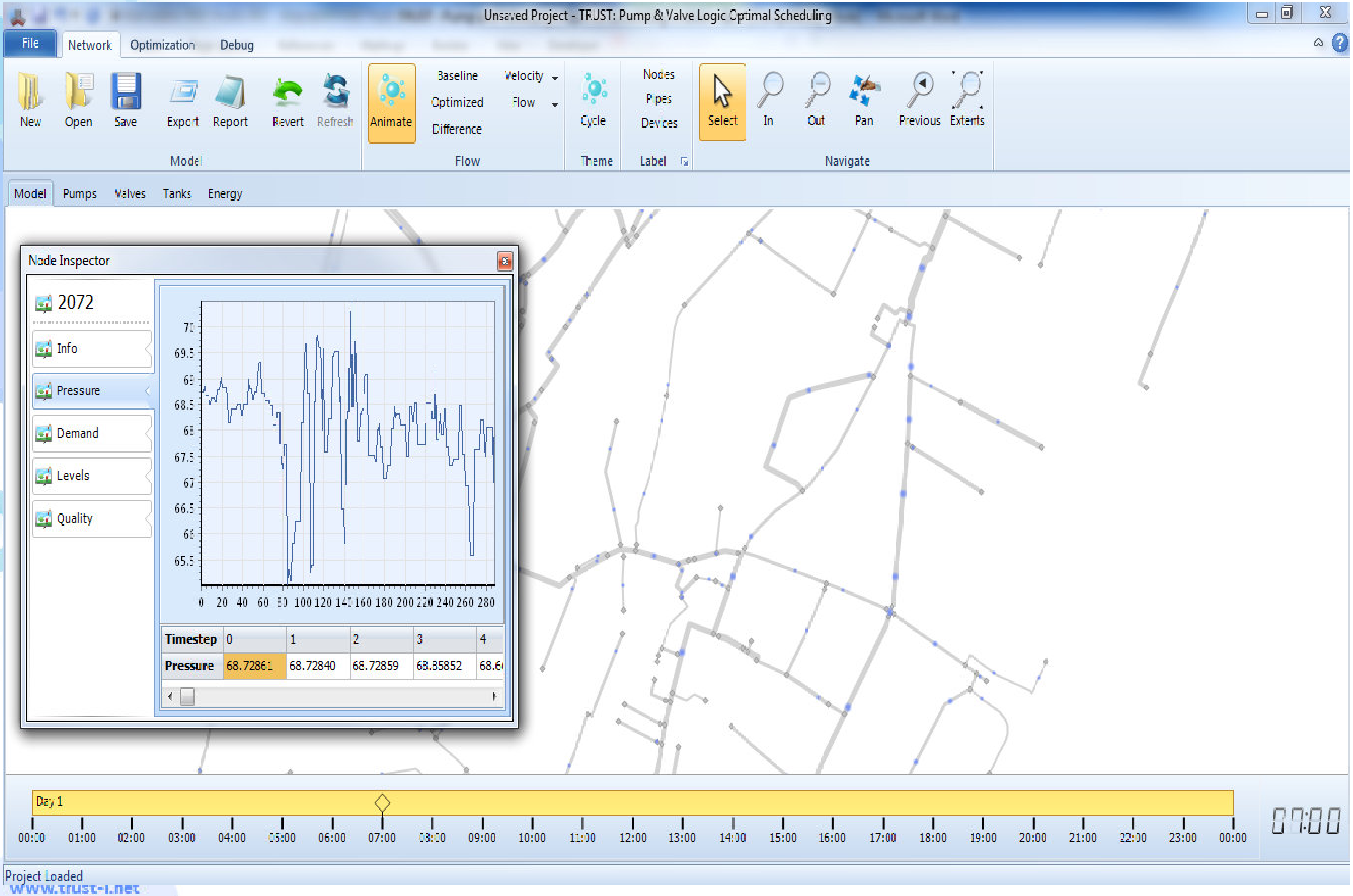
Methodology

Scheduling formulated as a multi-objective optimisation problem:

- Objectives:
  - Minimize total pumping cost
  - Minimize water lost through leakage
- Decision variables:
  - Pump status (on/off) for each time step; *and/or*
  - Valve status (setting) – for PRVs; *and/or*
  - Initial levels for each tank in the system
- Constraints: hydraulic feasibility, tank levels, minimum pressure at demand nodes

Leakage modelled as a pressure-driven

Software Tool



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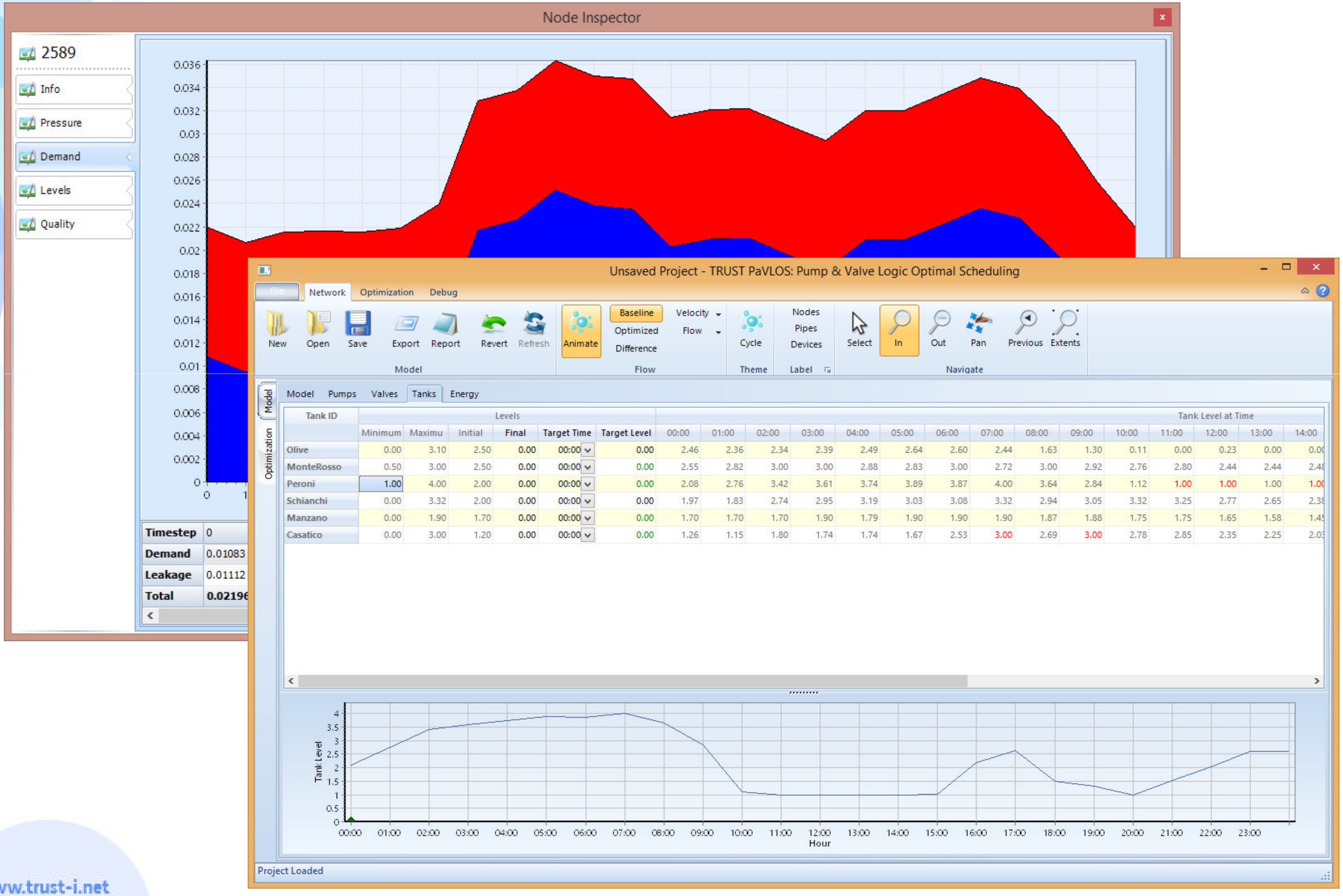
Software Tool



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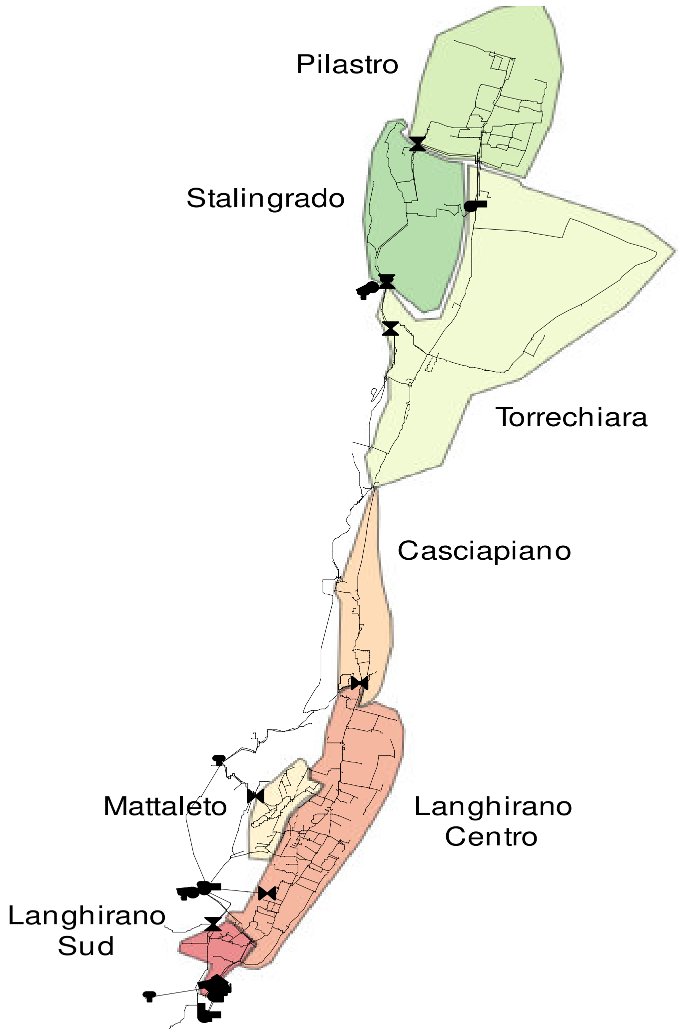
Langhirano Case Study: Overview

Existing Langhirano system:

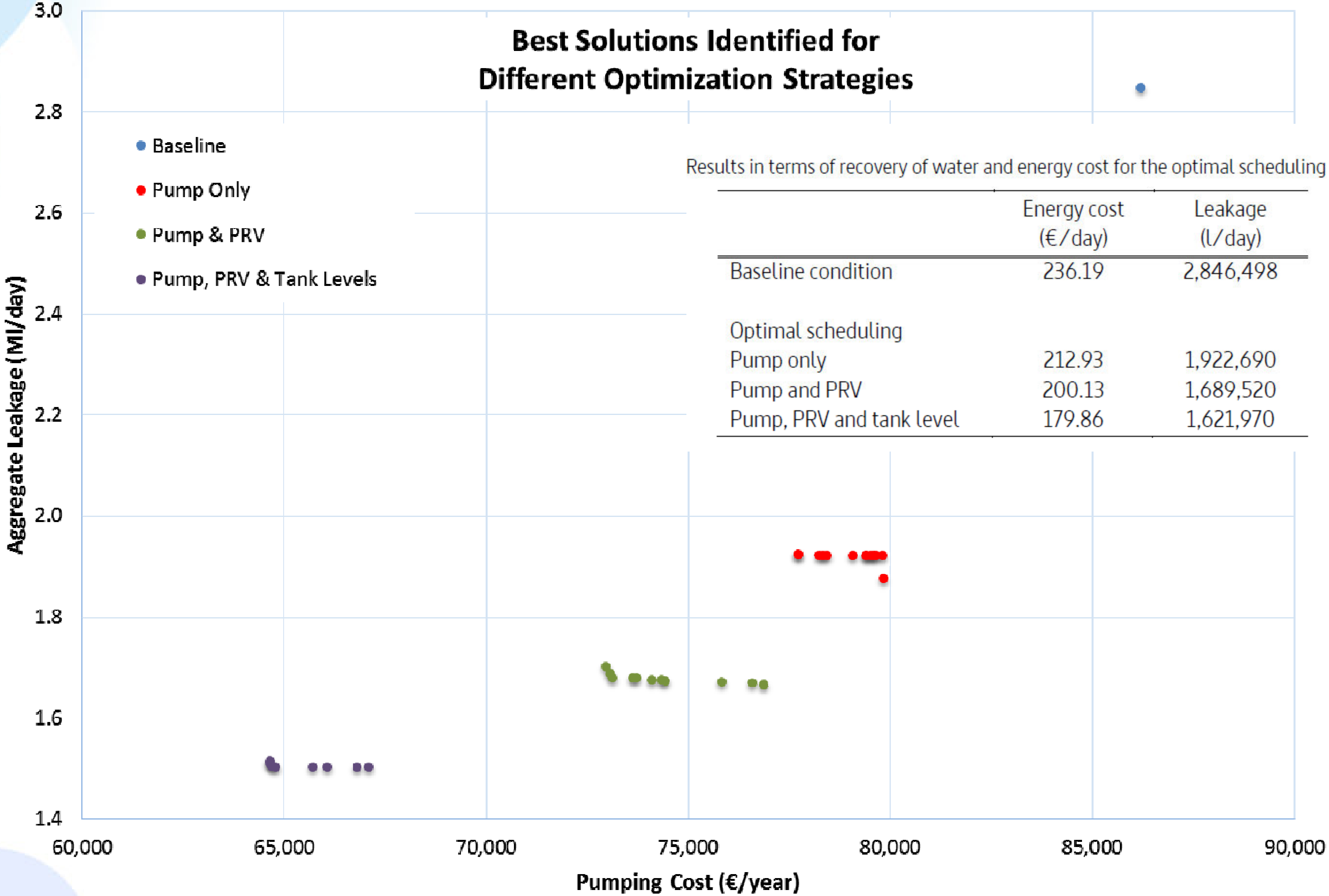
- 7 pressure management zones
- Non-revenue water approximately 35%
- Epanet model calibrated by Uni. of Bologna

Three optimization scenarios considered:

- Hourly scheduling of pumps only
- Hourly scheduling of pumps and PRV settings
- Hourly scheduling of pumps, PRV settings and setting of initial levels for the three principal tanks



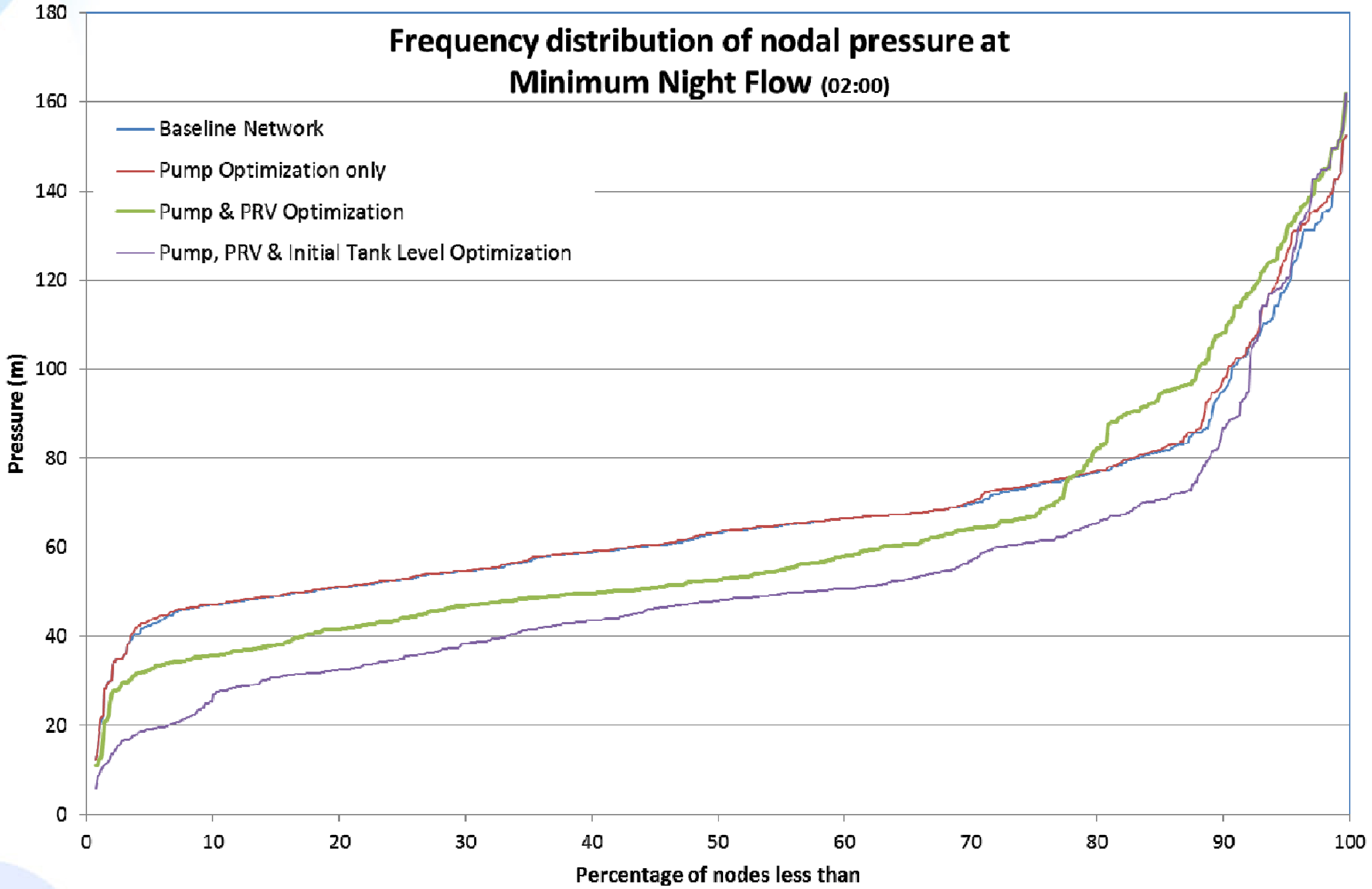
Results: Leakage – Cost Tradeoffs



Results in terms of recovery of water and energy cost for the optimal scheduling

	Energy cost (€/day)	Leakage (l/day)
Baseline condition	236.19	2,846,498
Optimal scheduling		
Pump only	212.93	1,922,690
Pump and PRV	200.13	1,689,520
Pump, PRV and tank level	179.86	1,621,970

Results: Pressure Distribution



Summary

- Software tool implementing a new methodology for optimizing leakage through integrated energy and pressure management demonstrated
- Joint optimization of pump schedules and PRV settings can lead to a substantial reduction in both system leakage and energy costs
- Integrated pressure and energy management, i.e. simultaneous scheduling of pumps and valves has a synergistic effect, is more beneficial than each of these on their own.
- The tool is generic hence it can be applied to other water systems

Example 3
Courtesy of B. Eikebrokk, SINTEF

WP4.1 – ACTIVITIES IN PILOT CITIES STANGAASEN WTP, OPPEGAARD – THE NORWEGIAN TEST SITE

Ida E. Johnsen and K. Tafjord, Oppegaard
B. Eikebrokk, SINTEF

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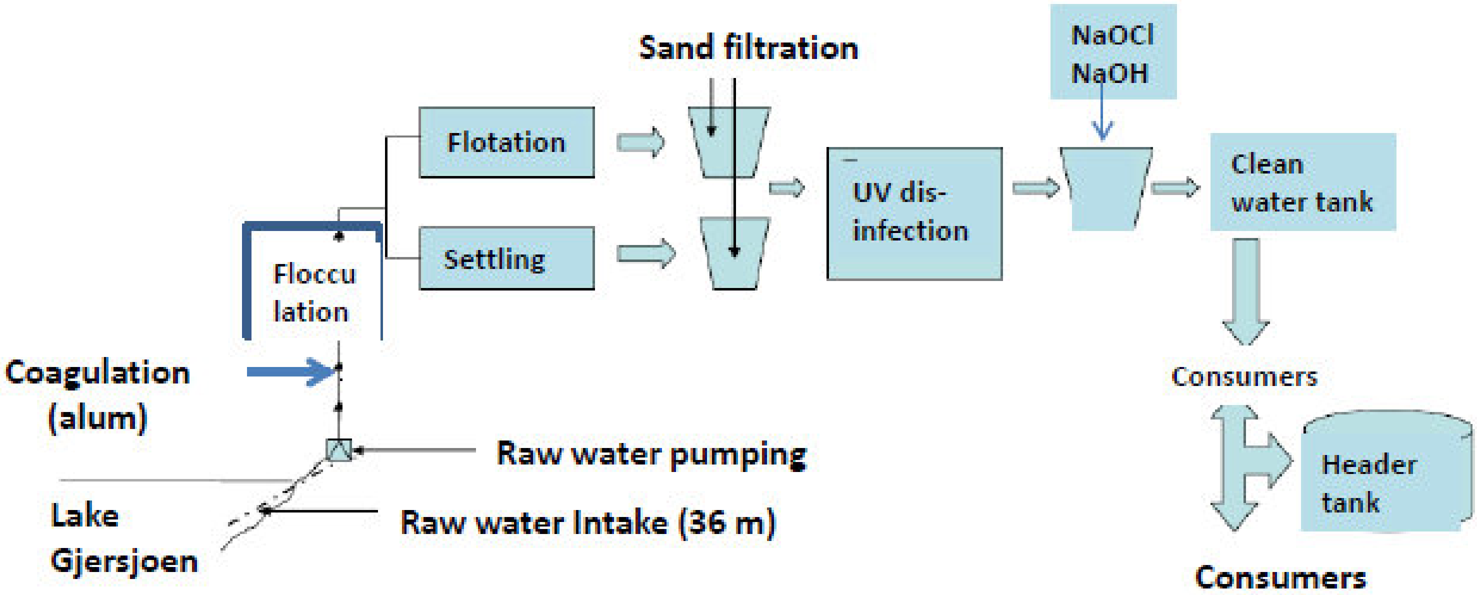
Oppegaard municipality (Oslo area)

Main activities at Stangaasen WTP

1. Mapping of current operation performance, incl. water quality, resources use (energy, chemicals, etc)
2. Advanced raw water/NOM analyses: Rapid NOM-fractionation, BDOC, ATP, etc – on raw, treated (different steps) and distributed water samples
3. Full-scale optimization trials
4. Treatability and treatment performance assessments
5. LCA, incl. sensitivity to different types of chemicals, different doses, etc



Conclusions on LCA

- ✓ Actual operation of Oppegård's WTP has been analyzed
- ✓ Alum followed by sludge treatment and electricity have the largest overall impact
- ✓ In terms of CO_2 emission electricity has the largest contribution followed by alum, transport and sodium hydroxide.
- ✓ The electricity mix has a large impact on the overall impacts and therefore the parameter to be optimized would be different depending on the location of the plant
- ✓ There is a potential for the reduction of the environmental impacts, according to the estimated reduction of coagulants and corresponding chemicals, transport and sludge treatment, as well as the change of the coagulant type
- ✓ LCA to be performed after the optimization (will start soon)
- ✓ Triple bottom line assessment guided by a trio of considerations – costs, environmental impacts and social health/welfare - Before and after optimization (Study to be completed)

5. Is it enough?

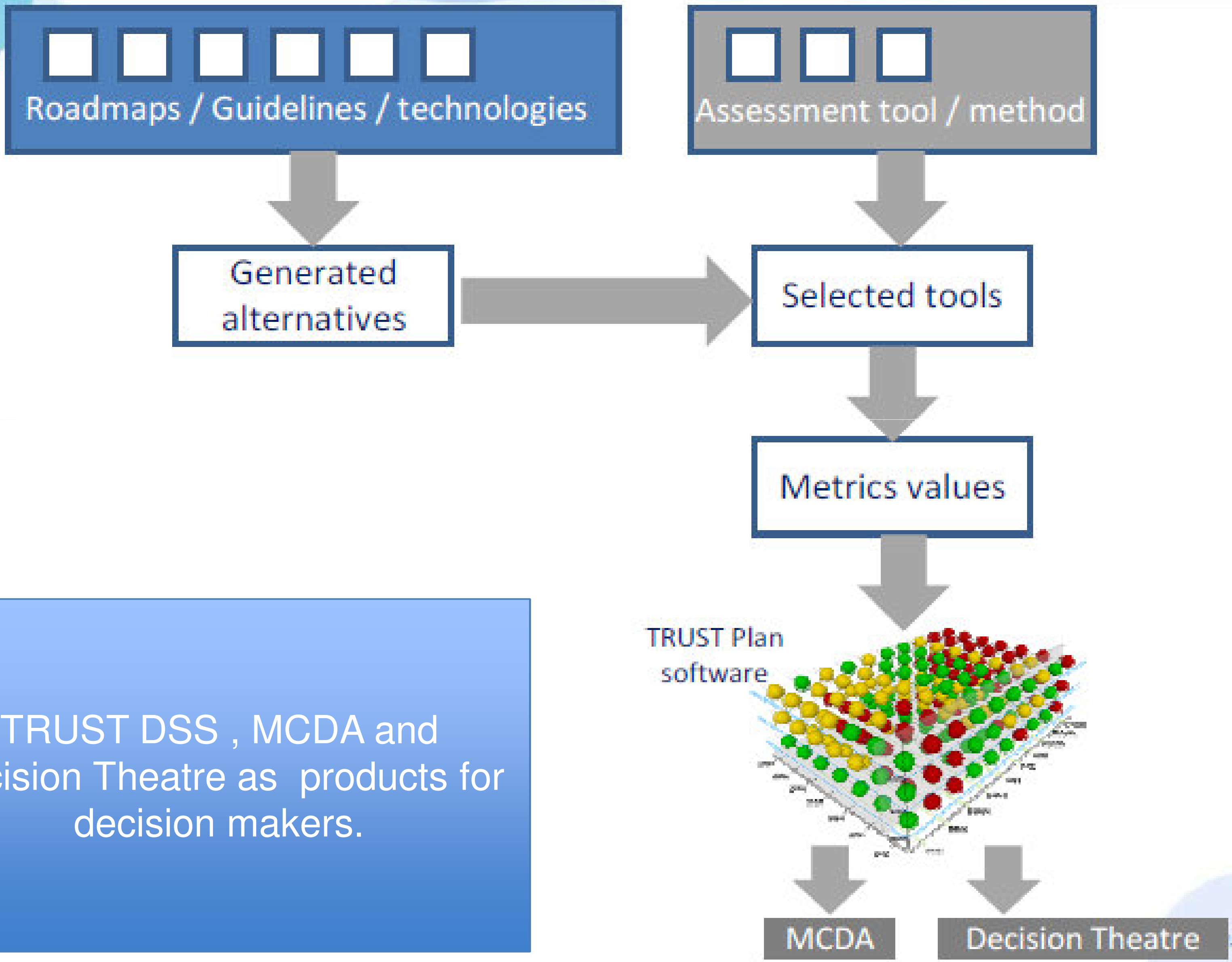
Change is created by society and decision-makers.

Without their involvement, the transition will not take place.

5. Is it enough?

Consider the regulatory, economic and financial triggers of change.

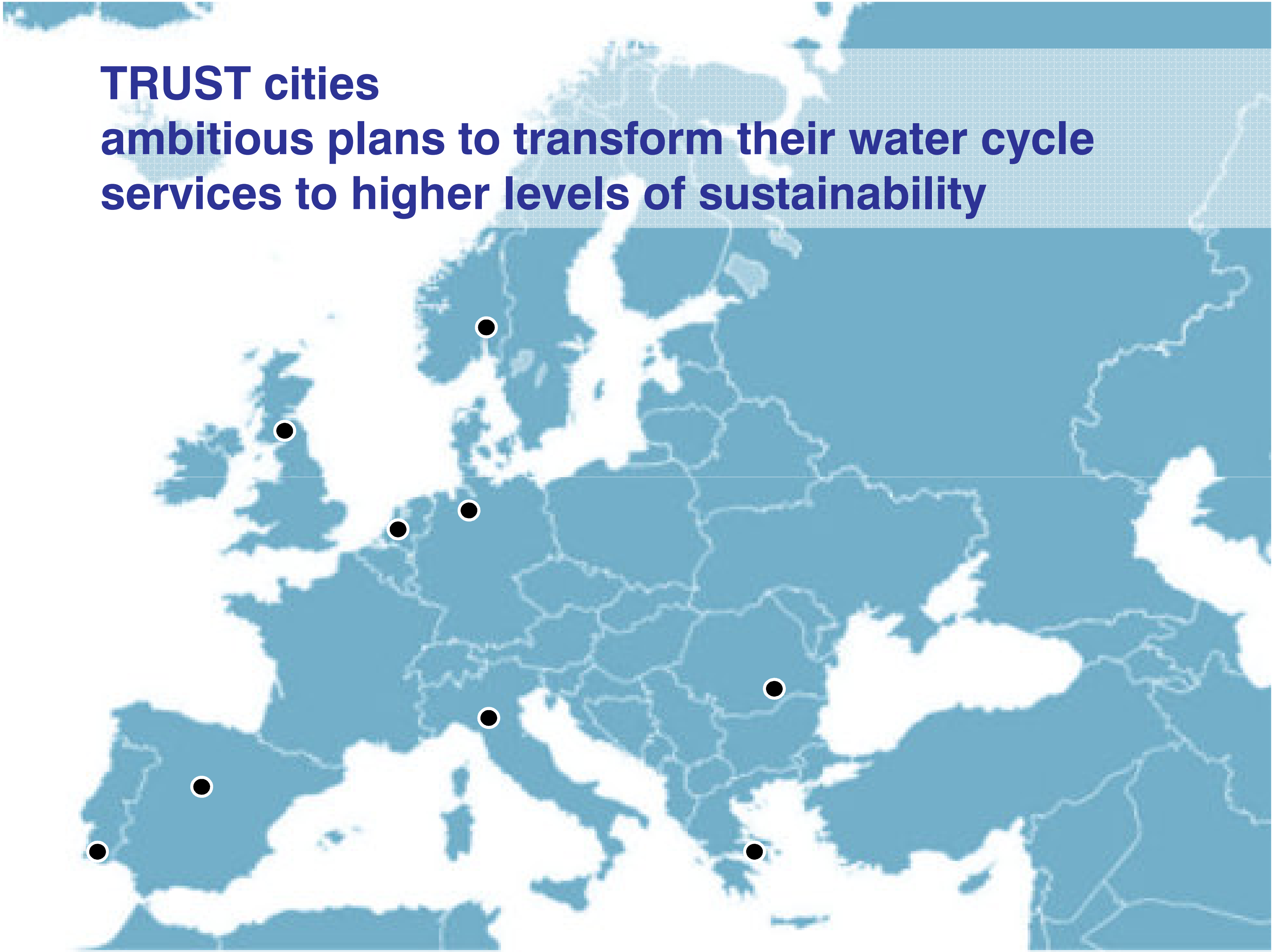
Produce specific products for decision-makers.



TRUST DSS , MCDA and Decision Theatre as products for decision makers.

CITIES AND REGIONS

TRUST cities
ambitious plans to transform their water cycle services to higher levels of sustainability



Overview of the partners

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Stakeholder

IWA International Water Association

Universities & research institutes

IWW

KWR

n|w Fachhochschule Nordwestschweiz

SINTEF

Cranfield UNIVERSITY

UNIVERSITY OF EXETER

NTNU Det skapende universitet

ΔNEK

VEOLIA ENVIRONNEMENT

INSTITUTO SUPERIOR TÉCNICO Universidade Técnica de Lisboa

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA

Small/medium enterprises

HR Wallingford Working with water

KOMPETENZ IN SACHEN REGENWASSER. INGENIEURGESELLSCHAFT PROF. DR. SIEKER MBH

BREIVOLL INSPECTION TECHNOLOGIES

S.T.E.P.

ADD+ON

YDREAMS

Utilities/end-users

Scottish Water

APA NOVA BUCUREŞTI

Canal de Isabel II

HAMBURG WASSER

iren

Schiphol Amsterdam Airport

ÁGUAS DE PORTUGAL

waternet

H2O OSLO

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