Meso-level eco-efficiency indicators to assess technologies and their uptake in water use sectors

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EcoWater Product Fliers

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Abstract

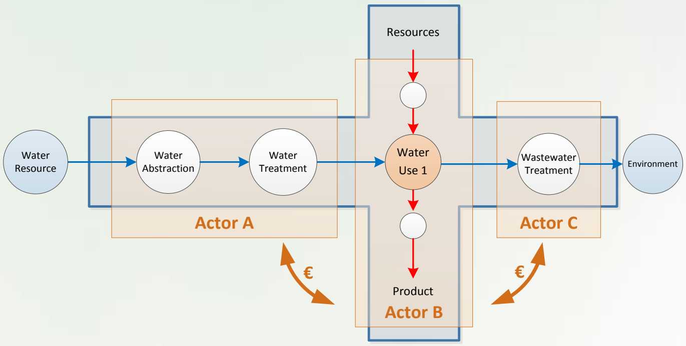
The EcoWater Product Fliers are a series of documents developed with the aim to disseminate the EcoWater approach, methodology and outcomes to a wide audience. The fliers are primarily addressed to stakeholders, policy and decision-makers and the private sector, summarizing the main Project outputs and the results from the Case Studies. They have been widely disseminated, both in electronic format to European networks in which Project Partners participate and in printed format at project events that took place in the final Project year and at relevant Conferences/Meetings attended by Partners.

Contents

Meso-level eco-efficiency indicators to assess technologies and their uptake in water use sectors

Research Objectives

The EcoWater project aims to develop a metric for assessing the contribution of different technological innovations on the environmental and economic performance of water use systems. Through a systemic approach, the entire value chain is examined, together with the water-use processes involved in the production of agricultural and industrial goods or the provision of potable water services.



The specific research objectives that delineate the EcoWater approach include the:

- Selection of eco-efficiency indicators, suitable for assessing the system-wide eco-efficiency improvements from innovative technologies;
- Integration of existing tools and assessment methods in a coherent modeling environment, allowing for the system-wide environmental and economic benchmarking of innovations;
- Elaboration of exemplary Case Studies in different systems and sectors to assess innovative technologies and practices;
- Understanding of the impact of innovative technology implementation to heterogeneous actors; and
- Analysis and characterization of existing structures and policy instruments for technology uptake, through the conceptualization and simulation of different scenarios on relevant policy and management factors.

Analytical Framework

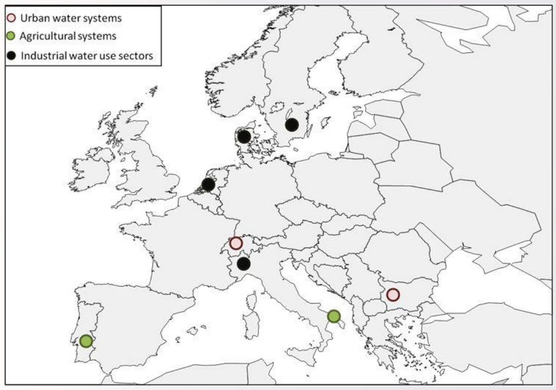
The analytical framework of EcoWater consists of four stages, to aid informed decision making, beginning with mapping the whole water use value chain and identifying the governance issues and actors involved. In the second stage, the system eco-efficiency is estimated, through a lifecycle analysis of the mid-term environmental influences and the added value resulting from the water use. The third stage identifies eco-innovative technology opportunities for upgrading the value chain, finally followed by the determination of distributional issues (who wins and who loses in the value chain) and of policies that could mitigate these.

Case Study Analysis

The EcoWater framework has been successfully tested in eight Case Studies, formulated around a unifying theme (water use in agriculture, urban and industrial systems); each Case Study focuses on the significant socio-economic and environmental impacts of non-efficient use of resources.

The eight EcoWater Case Studies include:

- Two Case Studies for the agricultural water service systems of Sinistra Ofanto, Italy and Monte Novo, Portugal, focus on shifts from rainfed to irrigated agriculture and innovations that can reduce the relevant water and energy footprints and production inputs.
- Two Case Studies for the cities of Zurich, Switzerland, and Sofia, Bulgaria, which have addressed issues and technologies associated with more sustainable and economically efficient urban water management, water conservation practices and cleaner production technologies in households.
- Four Case Studies have addressed water use in the textile, dairy and automotive industries, and for the cogeneration of thermal energy and electricity. Emphasis is placed on the assessment of technologies towards closed-loop systems, recovery of resources and advanced treatment, and on the economic impacts among the actors involved.



Results

The main EcoWater results include:

1. A validated and tested methodological framework for assessing technology impacts on water use systems;
2. An online platform (EcoWater Toolbox) which can be used by actors for the eco-efficiency assessment of their system;
3. An improved understanding of the socio-technical dynamics that influence technology uptake and implementation, and insight on policies to foster eco-efficiency improvements, focusing on different sectors of water use.
4. A range of values for each eco-efficiency indicator, which helps:
   a. Identifying opportunities for upgrading value chain;
   b. Highlighting the weak stages along the water supply chain;
5. Inter-comparison of stages/processes across sectors
6. Selection of the most eco-efficient technology options and scenarios for each water use system (*More than 25 technologies have been identified as eco-efficient among the technologies included in the online inventory*).

Through a number of policy events and regional workshops involving local stakeholders, the prioritization of policy actions (e.g. subsidies for eco-innovation uptake) has been discussed; the preliminary Project results, and particularly the feasibility of implementing proposed eco-innovations, have attracted the attention of local actors.

EcoWater

Meso-level Eco-efficiency Indicators to Assess Technologies & their Uptake in Water Use Sectors

Methodological Framework

Motivation

- **Water** is a critical **resource** to most production processes
- There is need for improving water use systems by identifying solutions which improve both their economic and their environmental performance ("**eco-innovations**")
- The **technology** focus is on water efficiency gains with little attention to other environmental aspects (e.g. carbon footprints) or potential benefits from by-products
- **Uptake** of water-related innovations remains regulatory-driven and existing standards offer limited incentives for further improvement
- There is a lack for a validated **technology assessment framework** in complex systems, such as the water-use production chains

Objectives

Development of a methodological framework:

- Assessing eco-efficiency of a water use system at the **meso–level**
- Estimating the anticipated eco-efficiency improvement from the introduction of **innovative technologies**
- Applicable to different systems and **sectors** of water use
- Able to describe and predict **system-wide** impacts from multiple interventions
- Targeted to heterogeneous **actors** with conflicting interests

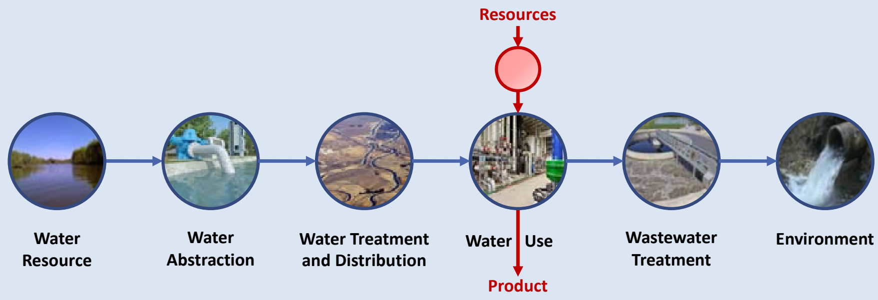
The Three Facets of Water

As a **resource**, which allows assessing the resource efficiency of the system

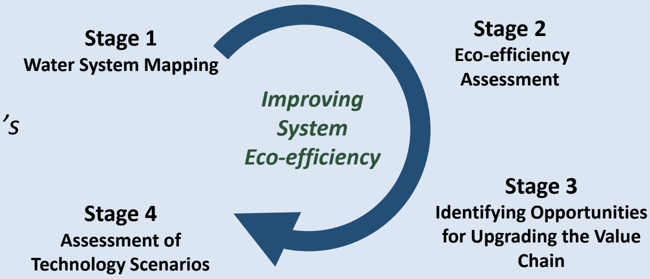
As a **productive input**, in the estimation of the total value added from the water use to the final product

As a **waste stream**, in the assessment of the environmental impacts from its use and the potential synergies & uses

A Systemic View of a Meso-Level Water-Use System



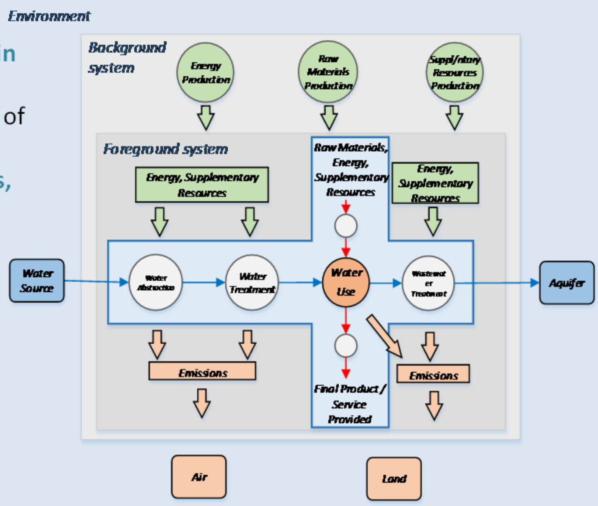
A four-stage methodology for improving a system's eco-efficiency



Stage 1 – Mapping the Water-Use System

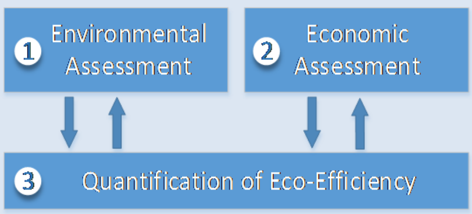
A structuring step, leading to a clear, transparent view of the water system at hand:

- A nexus of two physical chains (water **supply chain** and **production chain**)
- Mapping and description of the water supply and production chains (**stages, processes** and existing **technologies**)
- **Value chain** mapping, including all the actors directly or indirectly involved
- Socio-economic dynamic and decision making structures



Stage 2 – Assessing Eco-Efficiency

A three-phase approach, according to the **ISO 14045 standards**.



Environmental impacts are evaluated following a **Life Cycle Analysis** and, therefore, eco-efficiency assessment shares principles with LCA such as:

- Life cycle perspective
- Comprehensiveness
- Functional unit approach
- Iterative nature
- Transparency
- Priority of a scientific approach

Environmental Performance Assessment

- **Life-cycle inventory analysis** including both the foreground and the background system
- **Functional units**:
  - i. One unit of product or service delivered (when comparing alternative technologies, applied in the same system)
  - ii. One unit of water used (when comparing alternative water use systems)
- **Life cycle impact assessment** estimating environmental indicators for **midpoint impact categories**

Economic Performance Assessment

Total Value Added (TVA) to the product from water use takes into account the performance of both the water supply and production chains.

Eco-Efficiency Quantification

Eco-efficiency metrics: Indicators to measure the most cost-effective way of reducing environmental pressures/impacts.

$$\textit{Eco-efficiency indicator} = \frac{\textit{Economic output}}{\textit{Environmental influence}} = \frac{TVA}{ES_c}$$

"more" welfare

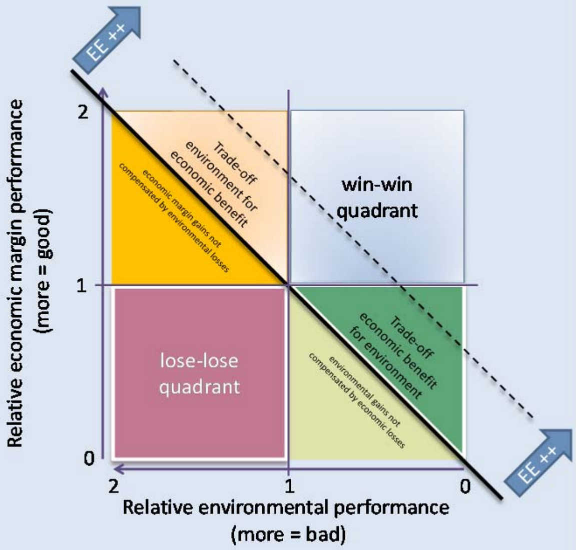
...from "less" nature

Stage 3 – Upgrading the Value Chain

- Focus on **process/product upgrading**
- **Innovative technologies** may reduce the overall environmental impact or improve the quality/quantity of the final product
- Selection is guided by the eco-efficiency of the baseline scenario, which indicates the vulnerabilities of the system (environmentally weak stages/economically weak actors)

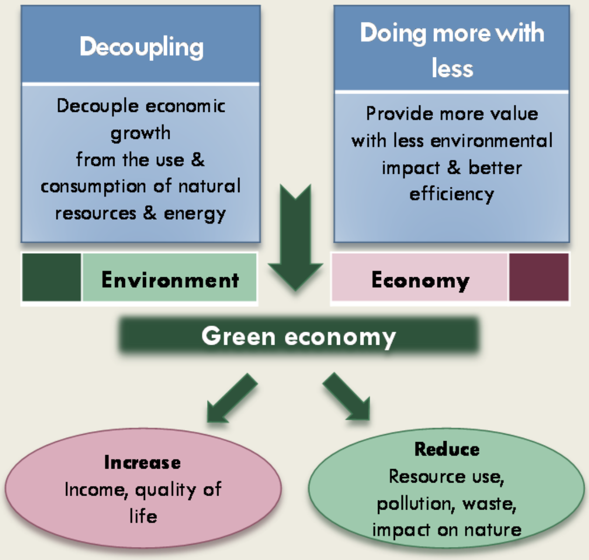
Stage 4 – Assessing Technology Scenarios

- Screening of eco-efficient technologies through individual assessment of all technologies selected in Stage 3
- **Scenario** development which support the three major policy objectives:
  - i. **Resource Efficiency** by reducing the use of natural resources
  - ii. **Recycling, Reusing** and other **Symbiotic Activities** for developing closed resource loops & synergies
  - iii. **Pollution Prevention** by decreasing the release of harmful substances



Challenges

- Delivering same or greater value with less input/pollution
- Sustainable use of resources
- Minimising environmental impacts



Adapted from UNIDO/UNEP RECP Programme Strategy

The EcoWater Consortium

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EcoWater Details

A Collaborative Research Project of the 7th Framework Programme

Theme: ENV.2011.3.1.9-2

Development of eco-efficiency meso-level indicators for technology assessment

Project Duration: 01/11/2011 - 31/12/2014

EcoWater

Developing Eco-efficiency Indicators

Meso-level Eco-efficiency Indicators to Assess Technologies & their Uptake in Water Use Sectors

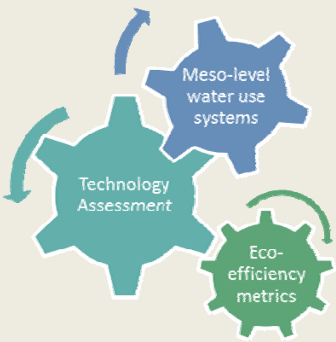
Motivation

- **Eco-efficiency** is an effective measure of progress towards a greener and more sustainable economy
- Water use conveys an **added value** in products and services
- There is a significant **environmental impact** and cost in making water suitable for use
- It is critical to develop **eco-efficiency metrics** for measuring both the environmental and economic performance of a water use system
- Although eco-efficiency metrics are commonly used at the micro- and macro-levels, the corresponding indicators for the **meso-level** are not well structured or missing

Objectives

Develop eco-efficiency indicators

- Appropriate for meso-level/systemic analysis
- Suitable for assessing innovative technologies
- Applicable to different sectors and water-use systems
- Relevant for supporting policy development

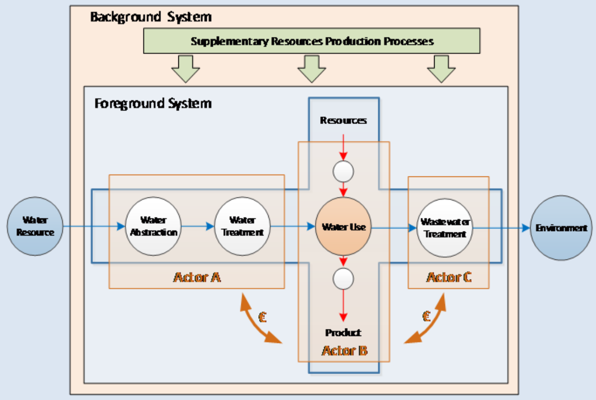


Indicator Content and System Scale

Macro-level	Meso-level	Micro-level
National or regional	Water supply and water use chain	Company or consumer
National Statistics	Data on every stage of the processes	Company level data
Neglects lower level variability of data	Based on modeling of system interactions	Detailed analysis of technologies
General framework for scenario formulation	Economic and environmental aspects of scenario formulation	Technological and economic factors for technology uptake
Policy relevance		
Initial signals of potential environmental problems	Technological or management option with a crucial impact	Incubator for the identification of innovative ideas
General policy direction	Selection of appropriate options to be promoted through policies	Verification mechanism for meso or macro level policies

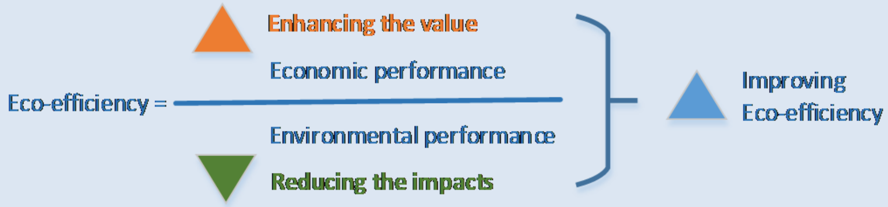
A Systemic Approach

- A nexus of two chains (**water supply chain** and **production chain**)
- Distribution of economic costs/benefits and environmental pressures over different **stages** and **actors** in the value chain
- Based on a **life cycle perspective**
- Including impacts from the **foreground** and **background** system



Eco-Efficiency Metrics

Eco-efficiency addresses both resource efficiency (minimizing the resources used in producing a unit of output) and resource productivity (the efficiency of economic activities in generating added value from the use of resources)

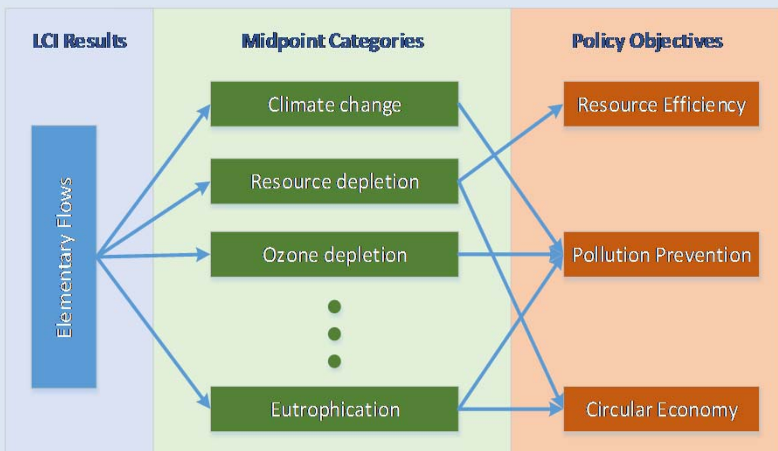


An eco-efficiency **metric** is defined as the ratio of the **economic performance** (value of the product or service) to the **environmental performance** of the system (environmental impacts)

Environmental Performance Indicators

Life cycle inventory results are transformed into a limited number of environmental indicators for **midpoint impact categories** that:

- Cover all aspects of different impacts on human health, natural environment, and availability of resources
- Provide a common basis for consistent and robust environmental performance analysis
- Are comparable to the indicators used in the micro and in the macro level



Economic Performance Indicator

Total Value Added (TVA) to the product from water use, taking into account the performance of both the water supply and production chains.

It combines the:

- **Economic value of water use**, estimated using the:
  - i. **residual value** approach when the water is used as a resource in a production process
  - ii. **willingness-to-pay** concept when the system delivers a service to the customers
- **Income** generated from by-products, of the water system
- **Total financial cost** incurred for rendering the water suitable for the specific use purpose and for meeting applicable standards for effluent discharge

Results from EcoWater Case Studies

Indicators	Agricultural		Urban		Industrial			
	Case Study #1	Case Study #2	Case Study #3	Case Study #4	Case Study #5	Case Study #6	Case Study #7	Case Study #8
Climate Change	1081	186	94	373	1351	57.5	30.1	44000
Stratospheric Ozone Depletion	NR*	NR	>10^6	>10^6	NR	NR	NR	>10^6
Eutrophication	109	15.4	41.7	4.9	1025	NR	0.99	42000
Acidification	82.6	21.8	4.4	215	366	78.4	3.1	15000
Human Toxicity	19.9	1.7	1.1	4.5	6.8	28.9	28.5	2000
Aquatic Ecotoxicity	74.5	10.9	13.3	15.6	0.8	8391	737	1800
Terrestrial Ecotoxicity	3866	106	513	6000	9.5	2169	630	>10^6
Photochemical Ozone Formation	8417	518	111	8822	6959	602	3271	>10^6
Respiratory Inorganics	3007	143	22.5	1257	NR	15498	NR	NR
Minerals Depletion	7948	923	42.4	NR	NR	NR	NR	NR
Fossil Fuels Depletion	4.9	0.007	0.01	0.03	NR	0.002	NR	NR
Freshwater Depletion	7.0	0.6	1.1	31.6	122	6.1	203	17000

*NR: Non relevant indicator to the Case Study

Significance

- **Range** of values for each eco-efficiency indicator
- **Reference** values for normalizing eco-efficiency indicators
- **Identification** of stages for upgrading value chains
- Highlighting the **weak stages** along the water supply chain
- **Inter-comparison** of stages/processes across sectors
- Identification of the most **eco-efficient technology options** and scenarios for each water use system
- Prioritizing and targeting **policy actions** (e.g. subsidising the eco-efficient sectors for eco-innovative uptake)

Proposed Eco-Efficiency Indicators

No	Impact Category	Unit
1	Climate change	€/kg$CO_{2,eq}$
2	Stratospheric ozone depletion	€/kgCFC-11_{eq}
3	Eutrophication	€/kg$PO^{-3}_{4,eq}$
4	Acidification	€/kg$SO_{2,eq}$
5	Human toxicity	€/kg1,4DCB_{eq}
6	Ecotoxicity a. Aquatic b. Terrestrial	€/kg1,4DCB_{eq}
7	Respiratory inorganics	€/kg$PM_{10,eq}$
8	Ionizing radiation	€/kBq U-$235_{air,eq}$
9	Photochemical ozone formation	€/kg$C_2H_{4,eq}$
10	Resource depletion a. Minerals b. Fossil fuels c. Freshwater	€/kgFe_{eq} €/MJ or €/TOE €/m^3

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EcoWater

Meso-level Eco-efficiency Indicators to Assess Technologies & their Uptake in Water Use Sectors

EcoWater Toolbox

Aims

The **EcoWater Toolbox** is an online suite of **tools** and **resources** aiming at:

- Assessing **the eco-efficiency** of a **water use system** at the **meso-level**
- Assessing the system-wide eco-efficiency improvements from **innovative practices/technologies**
- Analysing factors influencing **decisions** to adopt such practices
- Facilitating **multi-stakeholder discussions** on eco-innovation for process upgrading

Features

The EcoWater Toolbox is equipped with:

- A continuously updated **Inventory** of currently available **Technological Innovations**

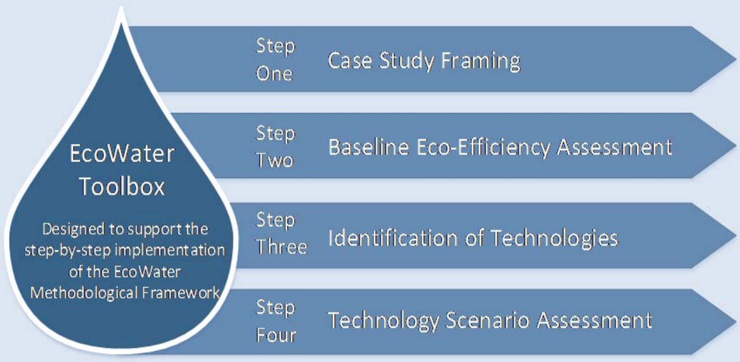
  *Currently, **more than 50** technologies and practices (both sector specific and system-wide) are ready to be applied to the examined system*

- An extendable list of **Eco-Efficiency Indicators** and their evaluation rules

  *Currently, **13 system-wide and 5 sector specific** indicators are included*

- **SEAT** modelling tool, supporting the environmental assessment of a meso-level system
- **EVAT** modelling tool, supporting the economic assessment of a meso-level system

Approach

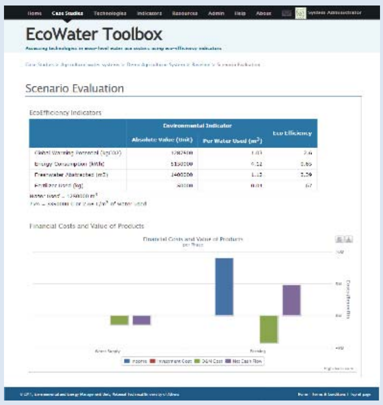


Framing the System

The Toolbox allows the user to frame the water-use system by:

- Defining the **system boundaries**
- Mapping and describing the **water supply chain** (stages, processes and existing technologies)
- Mapping the **water value chain**, including all the direct and indirect actors and their interrelations

Establishing a Baseline Eco-Efficiency Assessment



The Toolbox helps users establish a baseline eco-efficiency assessment, using the SEAT and EVAT tools to model the water supply and water value chains respectively, and facilitates the interpretation of the results.

It provides estimates for:

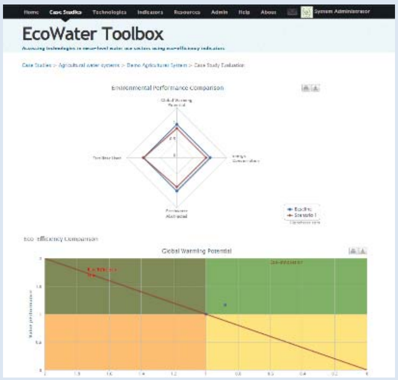
- **Environmental** impact indicators
- **Total value added** to the system from water use
- **Net economic output** of all the involved actors
- **Eco-efficiency** indicators

Identifying Technologies

The Toolbox integrates a **technology inventory**, with detailed information on the possible technologies/ practices for the eco-efficiency improvement of the water system.

Technologies can be **selected** from the inventory and automatically **implemented** either throughout the water supply and wastewater treatment stages (common for all water use sectors) or within the water use processes (sector specific technologies).

Assessing Technology Scenarios



The Toolbox enables the user to assess innovative technology solutions by:

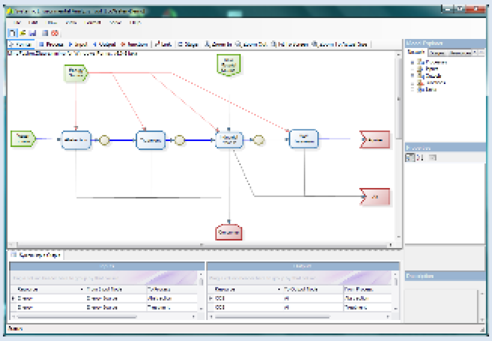
- Supporting the development of predictive **technology scenarios**
- Providing tools for modeling the impacts from technology implementation on the water use system
- Facilitating the **comparison** of technology scenarios to the baseline results

The EcoWater Modeling Tools

Systemic Analysis Tool (SEAT)

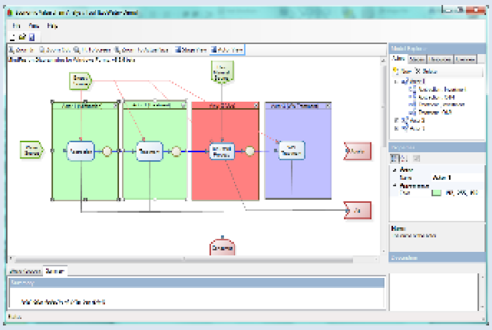
SEAT addresses the **water supply chain**, which is the physical representation of the various processes that are involved in producing goods (and services).

- Allows the development of a **model representation** of the corresponding physical system, its processes and interactions
- Provides the **flows** of the materials that can be used for estimating the environmental impacts of the system



Economic Value Chain Analysis Tool (EVAT)

EVAT addresses the **water value chain**, consisting of the various actors, directly and indirectly involved in the water supply chain, and their economic interactions.



- Allows the development of a representation of the value chain and the various **actors** involved in the water supply chain and their interactions
- Provides the **monetary flows** that can be used for estimating the economic performance of the system

The EcoWater Toolbox can be found online at: http://environ.chemeng.ntua.gr/ewtoolbox

Themes Addressed

Water users

- Footprint of water use
- Economical interventions that reduce this footprint

Technology providers

- Performance of developed innovations
- Impact of technologies on water use systems
- Marketing opportunities

Decision-makers

- Holistic assessments of environmental & economic performance
- Incentives towards users for adopting promising technologies

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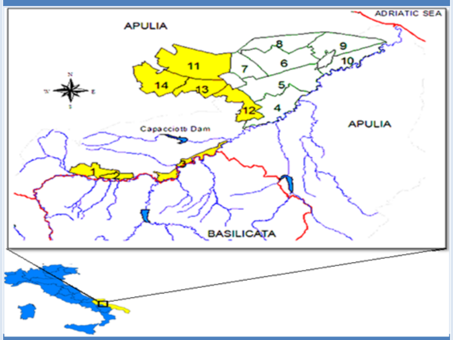
Sinistra Ofanto Irrigation Scheme, Italy

Meso-level Eco-efficiency Indicators to Assess Technologies & their Uptake in Water Use Sectors

Meso-level assessment of eco-efficiency improvements through innovative technologies in an agricultural water system

The Case Study at a glance

Case Study Area



General Characteristics

Location	Apulia Region, Italy
Main Crops	Grapes 14,503 ha Olives 7,335 ha Orchards 3,227 ha
Annual Water Used	36.5 Mm³ Surface Water 62.5 Mm³ Groundwater
Total Value Added	1.15 €/m³ used

Case Study Description

The Sinistra Ofanto irrigation scheme is located in Southern Italy, Apulia region, in the south-eastern part of the province of Foggia with a command area stretching along the left side of the Ofanto River, for a total of 40,500 ha, out of which 38,815 ha are irrigable lands and 28,165 ha are actually under irrigation.

Environmental Characteristics

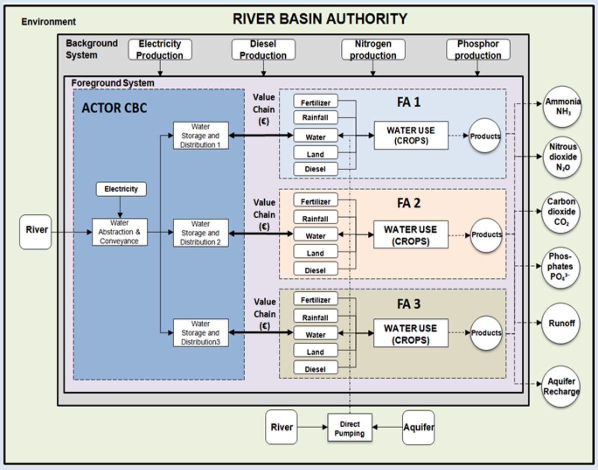
- The excessive exploitation of water resources
- High GHG emissions are released in atmosphere due to intensive irrigation, fertilizer application and management practices

Economic Characteristics

- High economic significance in the Region
- The added value per hectare of irrigated farms is 4 folds higher than that of non irrigated farms

Directly Involved Actors

- The Irrigation Consortium – WUO (CBC) in charge of water storage, delivery and distribution
- The Farmer's Associations which manage on-farm water supply
- The Apulian Regional River Basin authority, responsible for monitoring and control of water resources use and management



Baseline Eco-efficiency Performance

Indicator	Value
Climate Change	1081 €/tn$CO_{2,eq}$
Eutrophication	109 €/kg$PO_4^{-3}{}_{,eq}$
Acidification	82.6 €/kg$SO_2^{-}{}_{,eq}$
Human Toxicity	19.9 €/kg1,4-Db_{eq}
Aquatic Ecotoxicity	74.5 €/kg1,4-Db_{eq}
Terrestrial Ecotoxicity	3866 €/kg1,4-Db_{eq}
Photochemical Ozone Formation	8417 €/kg$C_2H_{4,eq}$
Respiratory Inorganics	3007 €/kg$PM_{10,eq}$
Mineral Depletion	7948 €/kgFe_{eq}
Fossil Fuel Depletion	0.12 €/MJ
Freshwater Resource Depletion	7 €/m³

Identified Environmental Weaknesses

- Freshwater Resource Depletion due to irrigation (Excessive depletion of aquifers)
- Climate Change impact due to direct emissions from fertilizer and fuel consumption
- Eutrophication of groundwater and surface water due to NO_3^- and PO_4^{3-} leaching

Case Study Contact Person

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EcoWater Details

A Collaborative Research Project of the 7th Framework Programme

Theme: ENV.2011.3.1.9-2

Development of eco-efficiency meso-level indicators for technology assessment

Project Duration: 01/11/2011 - 31/12/2014

Technology Scenario Assessment

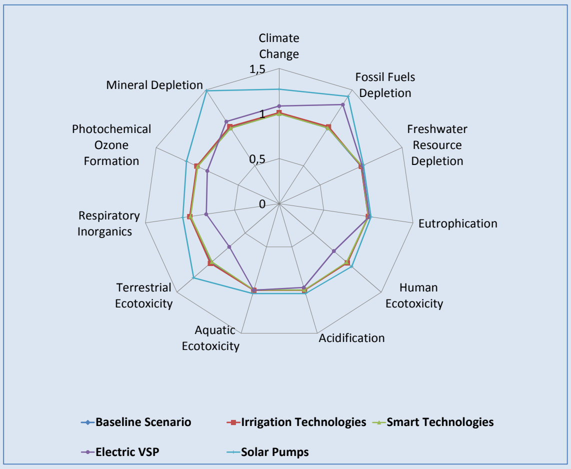
Alternative Technology Scenarios

Technology Scenario	Technologies	Stage/Process	Objective
...towards Resource Efficiency	Drip & Sub-surface drip Irrigation Technology	Water Use	Reduction of water consumption
	Smart Technologies	Water Abstraction & Fertilizer Application	Reduction of water and fertilizer consumption
...towards Pollution Prevention	Electric Variable Speed Pumps (On field)	Water Abstraction	Reduction of energy use
	Solar Pumps (On field)	Water Abstraction	Reduction of energy use

(a) Environmental Performance Assessment

Environmental Performance Indicators	Scenario			
	Irrigation Technologies	Smart Technologies	Electric VSP	Solar Pumps
Water Abstracted	- 2.5%	- 4.8%	0%	0%
GHG Emissions	- 1%	- 2.9%	- 6.6%	- 19%
Energy Used	- 2.6%	- 3.3%	+ 47%	- 38%
Fertilizer Used	0%	- 3.2%	0%	0%

(b) Eco-efficiency Assessment

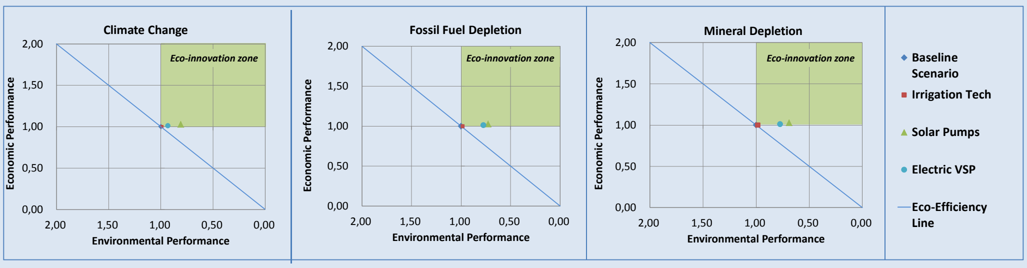


(c) Distributional issues among the involved actors

Variations of their Net Economic Output

Actors	Scenario			
	Irrigation Technologies	Smart Technologies	Electric VSP	Solar Pumps
Consortium (CBC)	0%	0%	0%	0%
Farmer's Association 1	0%	0%	0%	+1%
Farmer's Association 2	- 3.1%	+1.95%	+1.95%	+4.8%
Farmer's Association 3	0%	+1.25%	+1.25%	+3%

(d) Identification of Eco-innovative Solutions



Meso-level Eco-efficiency Indicators to Assess Technologies & their Uptake in Water Use Sectors

Monte Novo Irrigation Scheme, Portugal

Meso-level assessement of the environmental and economic impacts and the eco-efficinecy performance associated with the water value chain in the Monte Novo case study

The Case Study at a glance

Case Study Area

General Characteristics

Location	Alentejo region, Portugal
Main Product	Olives, maize and pastures
Annual Water Used	21 Mm^3 Surface Water
Total Value Added	0.09 €/m^3 used

Case Study Description

The Monte Novo irrigation perimeter provides water for irrigation to an area of more than 7,800ha. This perimeter is integrated in the Alqueva Multipurpose Project, an important source of irrigation water.

Environmental Characteristics

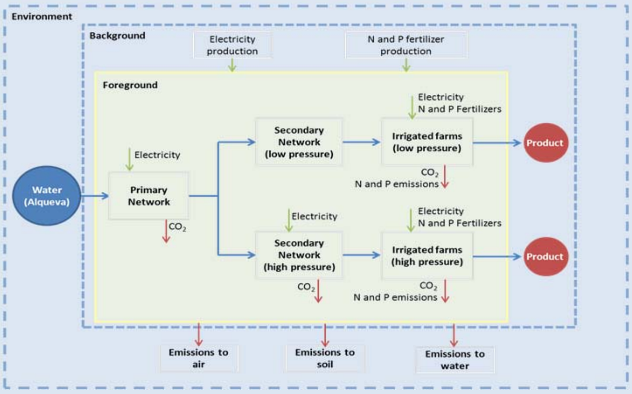
- The Alqueva reservoir provides a large amount of water, changing the paradigm from rainfed agricultural practices to irrigation

Economic Characteristics

- Recent perimeter (began operating in 2009) with subsidized water prices until 2017
- High potential of the area to develop agricultural activities, especially with the Alqueva project. Currently, the agricultural activities have a very low competitiveness, with reduced productivity and incomes are greatly supported by public support, including subsidies

Directly Involved Actors

- EDIA (Empresa para o Desenvolvimento das Infraestruturas de Alqueva), responsible for the management and development of the Alqueva multipurpose project, including the operation of primary and secondary irrigation network where the Monte Novo irrigation perimeter is located
- AB Monte Novo (Associação de Beneficiários de Monte Novo), representing all the farmers which are connected to the Alqueva water distribution system from EDIA
- Farmers that will benefit from the irrigation networks



Baseline Eco-efficiency Performance

Indicator	Value
Climate Change	186 €/$tCO_{2,eq}$
Eutrophication	15.4 €/$kgPO_4^{-3}{}_{,eq}$
Acidification	21.8 €/$kgSO_2^{-}{}_{,eq}$
Human Toxicity	1.68 €/$kg1,4\text{-}DB_{eq}$
Aquatic Ecotoxicity	10.9 €/$kg1,4\text{-}DB_{eq}$
Terrestrial Ecotoxicity	106 €/$kg1,4\text{-}DB_{eq}$
Photochemical Ozone Formation	518 €/$kgC_2H_{4,eq}$
Respiratory Inorganics	143 €/$kgPM10_{eq}$
Mineral Depletion	923 €/$kgFe_{eq}$
Fossil Fuels Depletion	0.02 €/MJ
Freshwater Resource Depletion	0.63 €/m^3

Identified Environmental Weaknesses

- Freshwater Resource Depletion, due to high amount of water abstracted for irrigation
- Eutrophication, due to the use of fertilizers (Nitrogen and Phosphorus)
- Fossil Fuels Depletion, due to the energy production

Case Study Contact Person

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Technology Scenario Assessment

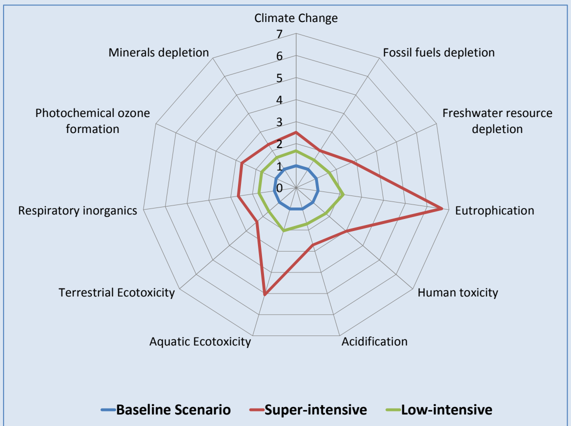
Alternative Technology Scenarios

Technology Scenario	Technologies	Stage/Process	Objective
...towards Resource Efficiency	Regulated deficit Irrigation (RDI)	Water Use	Reduction of water consumption
	Sub-surface drip irrigation (SDI)	Water Use	Increase of irrigation process efficiency
...towards Pollution Prevention	Use of sludge	Water Use	Reduction of chemical fertilizers use
	Use of organic fertilizers	Water Use	Reduction of chemical fertilizers use
... other	New energy price	Water Use	Reduction in water costs

(a) Environmental Performance Assessment

Environmental Performance Indicators	Scenario	
	Super-intensive	Low-Intensive
Water Abstracted	- 32%	- 18%
CO_2 Emissions	- 36%	- 20%
Energy Used	- 40%	- 18%

(b) Eco-efficiency Assessment



Super-intensive: organic fertilizers + sludge + RDI

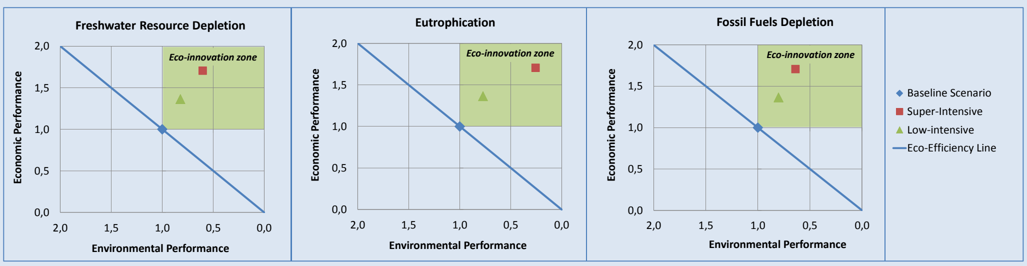
Low-intensive: same options but only for high pressure areas

(c) Distributional issues among the involved actors

Variations of their Net Economic Output

Actors	Scenario	
	Super-intensive	Low-Intensive
EDIA	+ 40%	+ 17%
AB Monte Novo	+ 92%	+ 237%
Farmers	+ 56%	+ 28%

(d) Identification of Eco-innovative Solutions



EcoWater Details

A Collaborative Research Project of the 7th Framework Programme

Theme: ENV.2011.3.1.9-2

Development of eco-efficiency meso-level indicators for technology assessment

Project Duration: 01/11/2011 - 31/12/2014

Urban Water Supply System, Sofia, Bulgaria

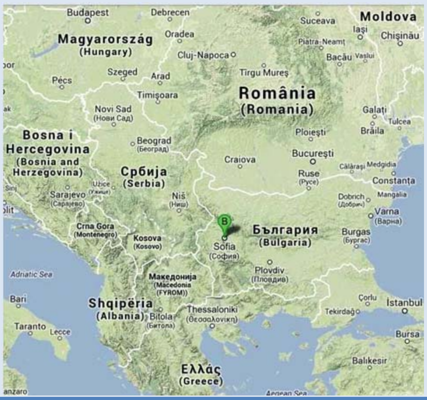
Meso-level assessment of eco-efficiency improvements through innovative technologies in urban water systems

EcoWater

Meso-level Eco-efficiency Indicators to Assess Technologies & their Uptake in Water Use Sectors

The Case Study at a glance

Case Study Area



General Characteristics

Location	Sofia, Bulgaria
Main Product	Water service
Annual Water Abstracted	206,2 Mio m^3
Total Value Added	79 Mio €

Baseline Eco-efficiency Performance

Indicator	Value
Climate Change	94 €/$tnCO_{2,eq}$
Stratospheric Ozone Depletion	542,751 €/kgCFC-11_{eq}
Eutrophication	41.7 €/$kgPO_4^{-3}{}_{,eq}$
Acidification	4.4 €/$kgSO_2^{-}{}_{,eq}$
Human Toxicity	1.11 €/kg1,4-DB_{eq}
Aquatic Ecotoxicity	13.3 €/kg1,4-DB_{eq}
Terrestrial Ecotoxicity	513 €/kg1,4-Db_{eq}
Photochemical Ozone Formation	111 €/$kgC_2H_{4,eq}$
Respiratory Inorganics	22.5 €/$kgPM10_{eq}$
Mineral Depletion	42.4 €/$kgFe_{eq}$
Fossil Fuels Depletion	0.0074 €/MJ
Freshwater Resource Depletion	1.04 €/m^3

Identified Environmental Weaknesses

- Freshwater Resource Depletion, due to water losses in the water distribution network and extensive amount of water used in households
- Climate Change and Fossil Fuel Depletion, due to sludge transportation
- Significant impact in most of the environmental categories, due to conventional energy production

Case Study Contact Person

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EcoWater Details

A Collaborative Research Project of the 7th Framework Programme

Theme: ENV.2011.3.1.9-2

Development of eco-efficiency meso-level indicators for technology assessment

Project Duration: 01/11/2011 - 31/12/2014

Case Study Description

The case study deals with the urban water system of Sofia - the capital and largest city of Bulgaria.

Environmental Characteristics

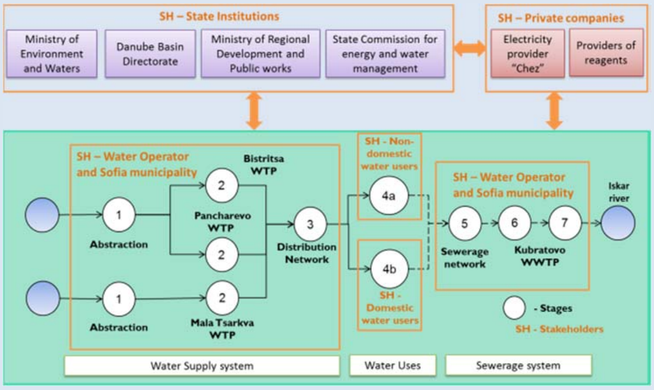
- Increased freshwater intake due to high water losses in water distribution network
- Increased freshwater intake due to inefficient water appliances
- Low energy efficiency

Economic Characteristics

- Willingness to pay for water services
- Difficulties in estimation the TVA from non-domestic water users

Directly Involved Actors

- The water operator, responsible for water supply and collection and treatment of the generated wastewater
- The water users
- The private companies, which provide energy and materials to the system



Technology Scenario Assessment

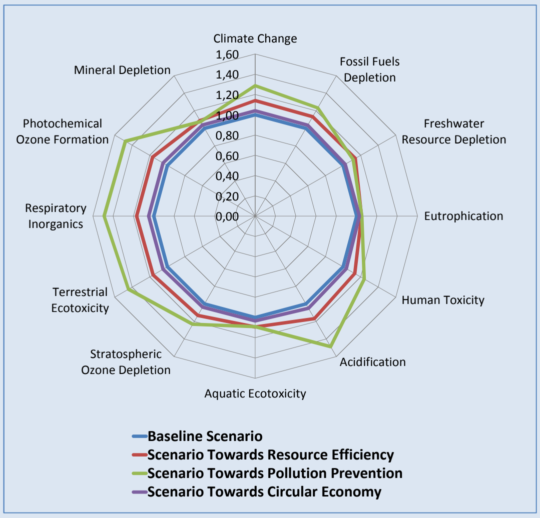
Alternative Technology Scenarios

Technology Scenario	Technologies	Stage/Process	Objective
...towards Resource Efficiency	Water saving appliances	Water Use Stage	Reduction of water consumption
	Pressure reduction turbines	Water Distribution Network	
...towards Pollution Prevention	Water and energy saving appliances	Water Use Stage	Reduction of the impact from energy production through reducing the energy demand
	Drain water heat recovery	Water Use Stage/Water heating	
	Solar water heating	Water Use Stage/Water heating	
	Pressure reduction turbines	Water Distribution Network	
	Hydro power plant	Water Treatment Plant	
...towards Circular Economy	Solar sludge drying	WWTP	Energy recovery and utilization of potential by-products
	Pressure reduction turbines	Water Distribution Network	
	Hydro power plant	Water Treatment Plant	

(a) Environmental Performance Assessment

Environmental Performance Indicators	Scenario		
	Resource Efficiency	Pollution Prevention	Circular Economy
Water Abstracted	- 9%	- 9%	0%
Greenhouse Gas Emissions	- 10%	- 22%	- 1%
Energy Used	- 8%	- 14%	- 1%

(b) Eco-efficiency Assessment

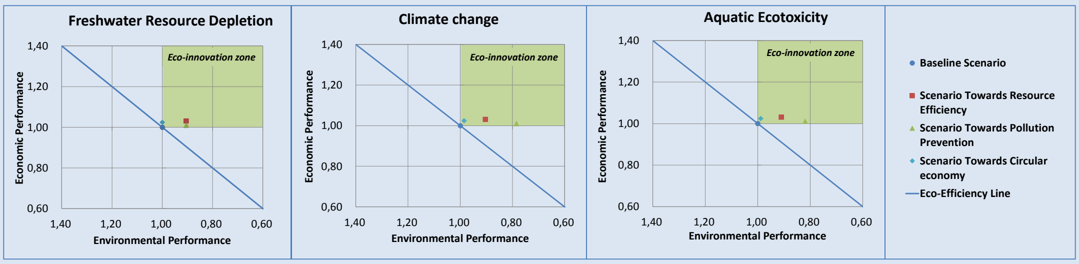


(c) Distributional issues among the involved actors

Variations of their Net Economic Output

Actors	Scenario		
	Resource Efficiency	Pollution Prevention	Circular Economy
Water operator	-21%	-20%	+ 9%
Domestic water users	+ 13%	+ 10%	0%
Non-domestic water users	0%	0%	0%
TVA	+ 3%	+ 1%	+ 2%

(d) Identification of Eco-innovative Solutions



Urban Water Supply System, Waedenswil, Switzerland

Meso-level Eco-efficiency Indicators to Assess Technologies & their Uptake in Water Use Sectors

Meso-level assessment of eco-efficiency improvements through innovative technologies for urban water use systems

The Case Study at a glance

Case Study Area

General Characteristics

Location	Waedenswil, Switzerland
Population	20,000 inhabitants
Annual Water Used	2.5 Mm^3 Surface and Groundwater
Total Value Added	2.5 Mio €/y 1.6 €/m^3 used

Case Study Description

The municipality of Waedenswil is located in Canton Zurich, which is the Canton with the highest population (1.4 million inhabitants) in Switzerland.

Environmental Characteristics

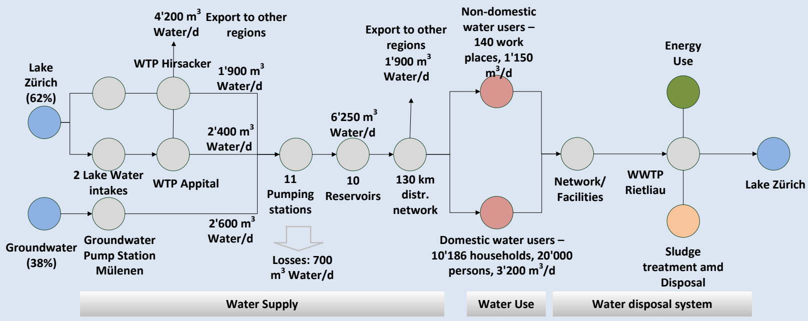
- Water supply sources in the Canton of Zurich: mainly groundwater and lakes, partly spring water
- Lake Zurich as an important provider of raw water, especially for communities along the lakeside
- In Waedenswil 62% of drinking water stems from the lake
- Applied waste water treatment in this area is technologically on an advanced standard

Economic Characteristics

- Canton of Zurich is an economically important part of the country

Directly Involved Actors

- Office of Waste, Water, Energy and Air of Canton Zurich (AWEL)
- Association of municipalities for water treatment Hirsacker-Appital
- Municipality Waedenswil (networks owner and owner of WWTP Rietliau)
- Domestic water users
- Non-domestic water users



Baseline Eco-efficiency Performance

Indicator	Value
Climate Change	373 €/$tCO_{2,eq}$
Stratospheric Ozone Depletion	2,476,632 €/kgCFC-11_{eq}
Eutrophication	4.96 €/$kgPO_{4,eq}$
Acidification	215 €/$kgSO_{2,eq}$
Human Toxicity	4.49 €/kg1,4-DB_{eq}
Aquatic Ecotoxicity	15.6 €/kg1,4-DB_{eq}
Terrestrial Ecotoxicity	6,002 €/kg1,4-DB_{eq}
Photochemical Ozone Formation	8,822 €/$kgC_2H_{4,eq}$
Respiratory Inorganics	1,257 €/$kgPM_{10,eq}$
Micropollutants emissions	41,810 €/kg
Fossil Fuels Depletion	0.03 €/MJ
Freshwater Resource Depletion	31.6 €/m^3

Identified Environmental Weaknesses

- Climate change and Fossil Fuel Depletion due to water heating with fossil resources such as gas and oil
- No measures to reduce micropollutants emissions
- Freshwater Resource Depletion, due to water use in households

Technology Scenario Assessment

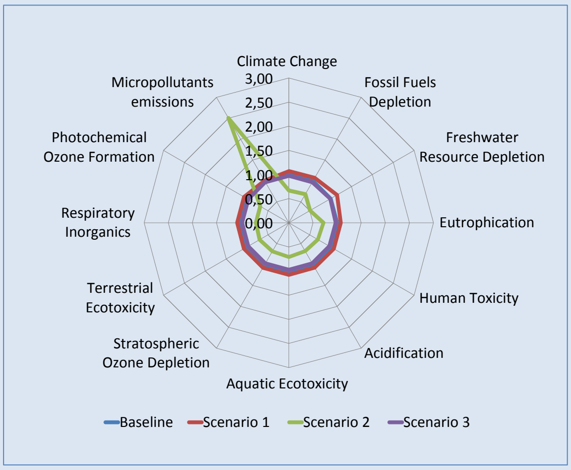
Alternative Technology Scenarios

Technology Scenario	Technologies	Stage/Process	Objective
…towards Resource Efficiency (S1)	Water saving appliances (warm water)	Water Use	Reduction of water and energy consumption
	Water saving appliances (cold water)	Water Use	Reduction of water consumption
	Water reuse and recycling technologies	Water Use	Reduction of water consumption
…towards Pollution Prevention (S2)	Water saving appliances (warm water)	Water Use	Reduction of water consumption
	Solar water heating	Water Use	Reduction of energy consumption
	Micropollutants removal technologies	Wastewater Treatment	Reduction of micropollutant emissions
	Smart pumps	Water Distribution	Reduction of energy consumption
…towards Circular Economy (S3)	Water reuse and recycling technologies	Water Use	Reduction of water consumption
	Advanced phosphorus recovery	Wastewater Treatment	Resources recovery

(a) Environmental Performance Assessment

Environmental Performance Indicators	Scenario		
	Resource Efficiency	Pollution Prevention	Circular Economy
Water Resource Depletion	-13%	-1%	-2 %
Climate Change	-6%	-25%	0%
Micropollutants Emissions	0%	-80%	0%

(b) Eco-efficiency Assessment

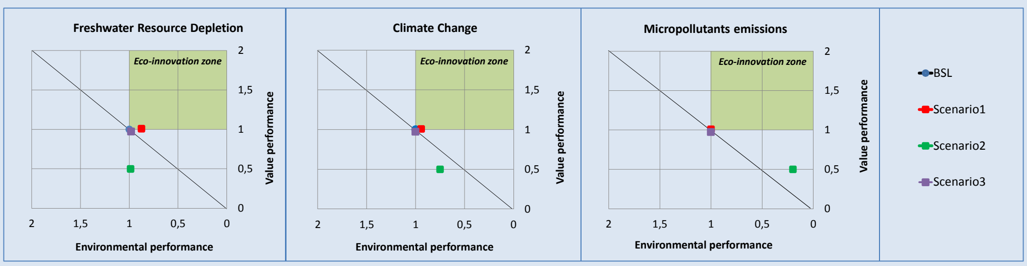


(c) Distributional issues among the involved actors

Variations of their Net Economic Output

Actors	Scenario		
	Resource Efficiency	Pollution Prevention	Circular Economy
Zweckverband	- 1%	0%	0%
Municipality	- 17%	- 48%	- 3%
Dom. water users	+ 19%	- 2%	0%
TVA	+ 1%	- 50%	- 3%

(d) Identification of Eco-innovative Solutions



Case Study Contact Person

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EcoWater Details

A Collaborative Research Project of the 7th Framework Programme

Theme: ENV.2011.3.1.9-2

Development of eco-efficiency meso-level indicators for technology assessment

Project Duration: 01/11/2011 - 31/12/2014

Textile Industry, Biella, Italy

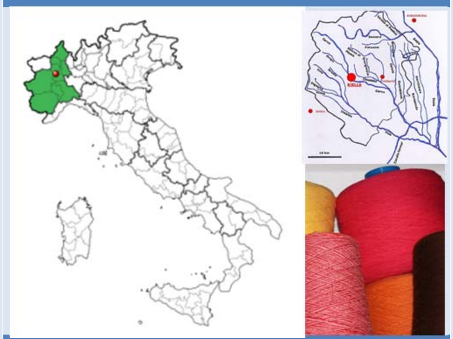
EcoWater

Meso-level Eco-efficiency Indicators to Assess Technologies & their Uptake in Water Use Sectors

Meso-level assessment of eco-efficiency improvements through innovative technologies for wastewater treatment in the textile industry

The Case Study at a glance

Case Study Area



General Characteristics

Location	Biella , Italy
Main Product	890 t chemically dyed wool 100 t naturally dyed wool
Annual Water Used	0.95 Mm³ Surface Water 0.75 Mm³ Groundwater
Total Value Added	18.36 €/m³ used

Case Study Description

Biella is one of the most distinguished centers of wool processing and production in Europe. It produces fine yarns of good wool, cashmere and vicuna.

Environmental Characteristics

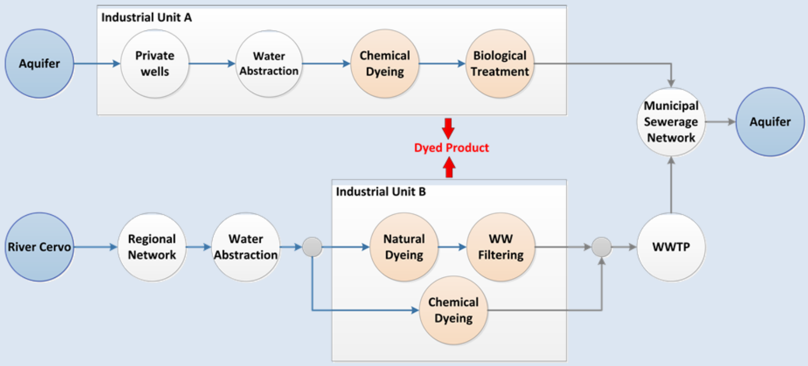
- Uses large amounts of freshwater during wet processing operations (e.g. dyeing)
- Its wastewater is rated as extremely polluting, considering its volume and composition (heavy metals, BOD, COD)

Economic Characteristics

- High economic significance on textile commerce and the local workforce
- Economic crisis has resulted in closing down half of the factories

Directly Involved Actors

- The regional authorities, responsible for the water survey and river basin control
- The textile industry
- The municipalities' consortium, responsible for water supply and wastewater collection & treatment and the sewage disposal network



Baseline Eco-efficiency Performance

Indicator	Value
Climate Change	1351 €/tn$CO_{2,eq}$
Eutrophication	1,025 €/kg$PO_4^{-3}$$_{,eq}$
Acidification	366 €/kg$SO_2^{-}$$_{,eq}$
Human Toxicity	6,8 €/kg1,4-DB_{eq}
Aquatic Ecotoxicity	0.8 €/kg1,4-DB_{eq}
Terrestrial Ecotoxicity	9.5 €/kg1,4-DB_{eq}
Photochemical Ozone Formation	6,959 €/kg$C_2H_{4,eq}$
Freshwater Resource Depletion	122 €/m³

Identified Environmental Weaknesses

- Freshwater Resource Depletion, due to the extensive amount of water used during dyeing processes
- Aquatic and Terrestrial Ecotoxicity, due to the chemicals used in the dyeing process and the related pollutants in the effluents

Technology Scenario Assessment

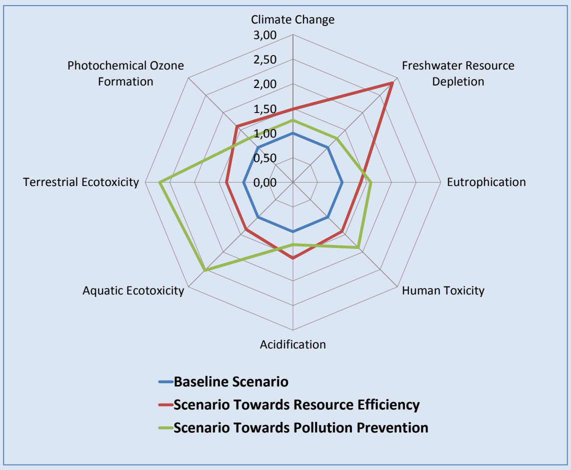
Alternative Technology Scenarios

Technology Scenario	Technologies	Stage/Process	Objective
…towards Resource Efficiency	Smart Pumping Systems	Water Abstraction	Reduction of water consumption
	Automatic Dye and Chemical Dispensing	Chemical Dyeing	Reduction of dyes consumption
	Low-Liquor-Ratio Jet Dyeing Machines	Chemical Dyeing	Reduction of water consumption
…towards Pollution Prevention	Use of Natural Dyes	Chemical Dyeing	Reduction of heavy metals
	Advanced Oxidation Process	Wastewater Treatment Plant	Reduction of COD
	Membrane Bioreactor	Wastewater Treatment Plant	Reduction of BOD

(a) Environmental Performance Assessment

Environmental Performance Indicators	Scenario	
	Resource Efficiency	Pollution Prevention
Water Abstracted	- 52%	0%
Greenhouse Gas Emissions	- 9%	- 1%
Energy Used	- 15%	- 1%
Toxic Pollutants	0%	- 50.1%

(b) Eco-efficiency Assessment

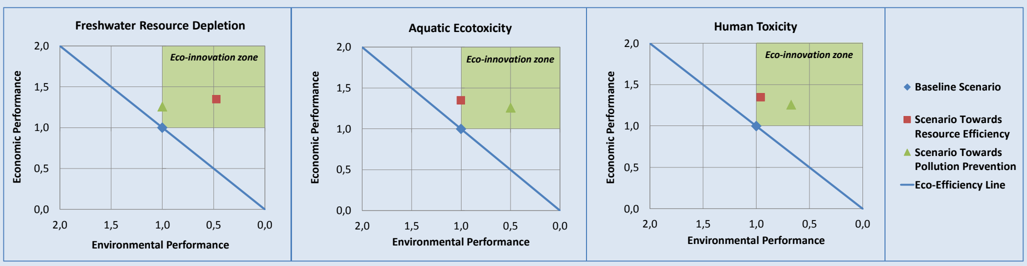


(c) Distributional issues among the involved actors

Variations of their Net Economic Output

Actors	Scenario	
	Resource Efficiency	Pollution Prevention
Regional Authorities	0%	0%
Municipalities' Consortium	0%	+ 6.7%
Industrial Unit A	+ 149%	- 6.8%
Industrial Unit B	+ 11%	+ 34%

(d) Identification of Eco-innovative Solutions



Case Study Contact Person

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EcoWater Details

A Collaborative Research Project of the 7th Framework Programme

Theme: ENV.2011.3.1.9-2

Development of eco-efficiency meso-level indicators for technology assessment

Project Duration: 01/11/2011 - 31/12/2014

Cogeneration of Heat and Electrical Power, Netherlands

Effects of innovative technologies on systemic eco-efficiency of thermal and electrical power cogeneration

Meso-level Eco-efficiency Indicators to Assess Technologies & their Uptake in Water Use Sectors

The Case Study at a glance

Case Study Area

General Characteristics	
Location	Amsterdam / Almere / Diemen
Main Product	Thermal and electrical energy
Annual Surface Water Used	65 Mm^3 for cooling
Total Value Added	1,35 €/m^3

Case Study Description

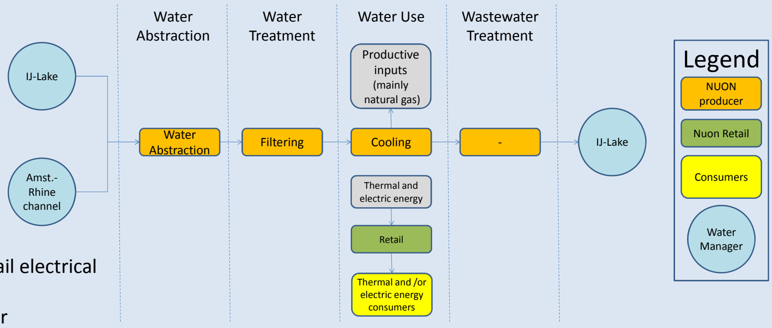
NUON, part of Vattenfall, is a both an energy producer and retailer. At the Diemen production site both electrical power and thermal energy for district heating are produced using two gas-fired combined heat-power plants and heat-only boilers. The current district heating system connects 90000 homes. Main water use concerns cooling water.

Environmental Characteristics

- Burning natural gas produces a number of emissions to air, and thermal waste both to air and surface water. Increasing efficiency should reduce such emissions.
- Production is not within an area of cooling

Economic Characteristics

- Profitability of energy production for the production site is very dependent on the wholesale energy market.
- Profitability of thermal energy production is determined by state determined prices and efficiency of production.



Actors

- NUON, for production and retail electrical and thermal energy;
- Municipality of Amsterdam, for district heating regulations;
- Waternet, the potable water provider.

Baseline Eco-efficiency Performance

Indicator	Value
Climate Change	78.8 €/$tCO_{2,eq}$
Acidification	104.5 €/$kgSO_2{}^{-}{}_{,eq}$
Human Toxicity	38.8 €/$kg1,4\text{-}Db_{eq}$
Aquatic Ecotoxicity	10 635 €/$kg1,4\text{-}Db_{eq}$
Terrestrial Ecotoxicity	2 907 €/$kg1,4\text{-}Db_{eq}$
Photochemical Ozone Formation	808 €/$kgC_2H_{4,eq}$
Respiratory Inorganics	21 305 €/$PM10_{eq}$
Fossil Fuels Depletion	0.0034 €/MJ
Water Thermal Pollution	32.4 €/MJ

Identified (Environmental) Weaknesses

- High thermal pollution due to large amounts of waste heat rejected to the surface water through cooling water.
- Consumption of natural gas and high amount of the relevant emissions to air (both greenhouse gases and toxic substances) due to electricity production.
- Decreasing eco-efficiency mainly due to economics with respect to total added value.

Case Study Contact Person

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EcoWater Details

A Collaborative Research Project of the 7th Framework Programme

Theme: ENV.2011.3.1.9-2

Development of eco-efficiency meso-level indicators for technology assessment

Project Duration: 01/11/2011 - 31/12/2014

Technology Scenario Assessment

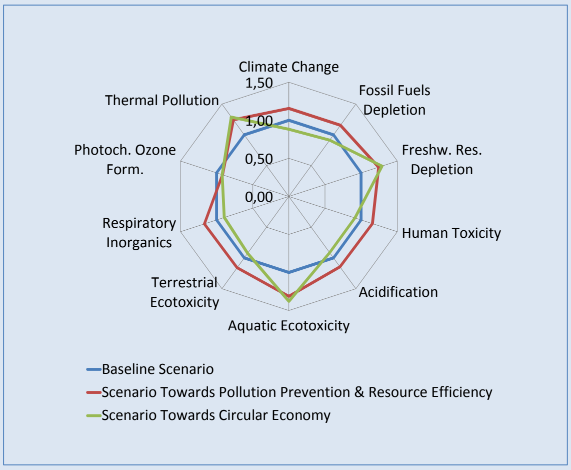
Alternative Technology Scenarios			
Technology Scenario	**Technologies**	**Stage**	**Objective**
…towards Resource Efficiency & Pollution Prevention	(1) Heat-only boilers	Water use	Shave thermal energy demand peaks during times of non-profitable electricity production
	(2) Thermal energy buffer	Water use	Shave thermal energy demand peaks, increase efficiency
	(3) Micro-CHP (a)	*Water use*	*Assess effects of popular technology*
…towards Circular Economy	(4) Additional thermal energy users (b)	Water use	Make better use of available thermal energy
	(5) Potable water preheating (a)	*Water use*	*Make better use of available thermal energy*

Notes: *(a) Only technological options (1), (2) and (4) have been currently assessed.*
(b) Scenario towards circular economy presupposes also the application of technological options (1) and (2).

(a) Environmental Performance Assessment

Environmental Performance Indicators	Scenario	
	Resource Efficiency & Pollution Prevention	Circular Economy
GHG Emissions	-11%	+3%
Natural Gas Use	-11%	0%
Thermal Pollution	-18%	-30%

(b) Eco-efficiency Assessment

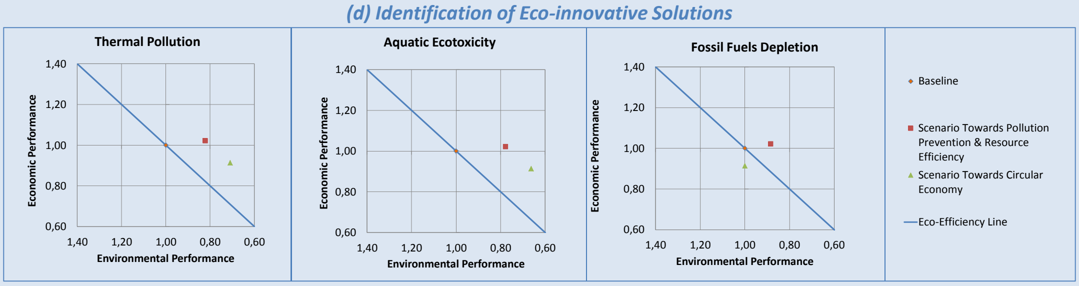


(c) Distributional issues among the involved actors

Variations of their Net Economic Output in the system

Actors	Scenario	
	Resource Efficiency & Pollution Prevention	Circular Economy
NUON Producer	+10%	-0,5%
NUON Retail	+2.3%	+6.2%
Consumers	0%	-11%

(d) Identification of Eco-innovative Solutions



Dairy Industry, Denmark

Meso-level assessment of eco-efficiency improvements through innovative technologies for water use processes in the dairy industry

Meso-level Eco-efficiency Indicators to Assess Technologies & their Uptake in Water Use Sectors

The Case Study at a glance

Case Study Area

General Characteristics	
Location	Holstebro, Denmark
Main Product	17,000 ton Milk-powder
Annual Ground Water Used	531,000 m^3
Total Value Added	57 €/m^3 used

Case Study Description

HOCO – the milkpowder producing dairy is part of ARLA Group in Denmark. The dairy produces milk-powder and specialised food ingredients. The Danish dairy sector also comprises milk, milk product and cheese producing dairies.

Environmental Characteristics

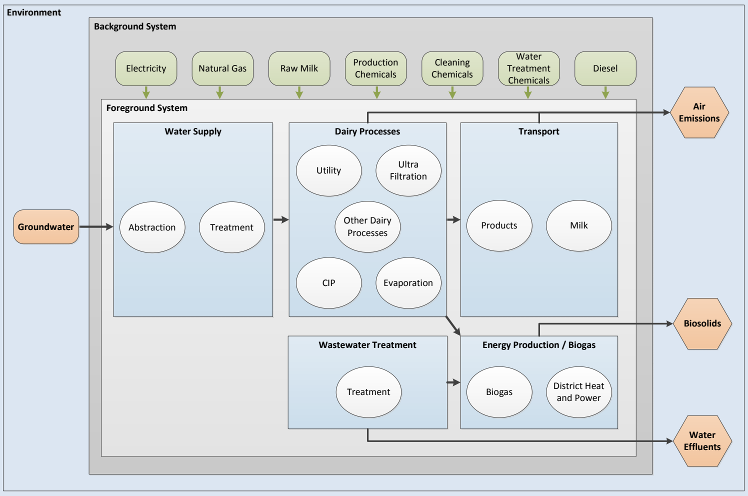
Significant water and energy uses in the dairy plant has led to focus on reduction of water use and climate gas emission, and the potential to use water contained in the milk.

Economic Characteristics

- Value products are milk powder and food ingredients
- Raw milk is the main cost factor

Directly Involved Actors:

- HOCO milk powder producing dairy
- Vestforsyning A/S water supply utility
- Vestforsyning A/S Wastewater utility
- Biogas Plant (Maarbjerg Biorefinery)
- Private transport companies



Baseline Eco-efficiency Performance

Indicator	Value
Climate Change	30 €/tCO_2,eq
Eutrophication	0.99 €/kgPO_4^{-3},eq
Acidification	3.14 €/kgSO_2-,eq
Human Toxicity	28.5 €/kg1,4-Db_{eq}
Aquatic Ecotoxicity	737 €/kg1,4-Db_{eq}
Terrestrial Ecotoxicity	630 €/kg1,4-Db_{eq}
Photochemical Ozone Formation	3271 €/kgC_2H_4,eq
Freshwater Resource Depletion	203 €/m^3

Identified Environmental Weaknesses

- The wastewater treatment plant reduces environmental impacts to a low level
- Pressures on water resources are moderate
- Climate Change, background impact due to energy use for process heating and circulation pumps

Technology Scenario Assessment

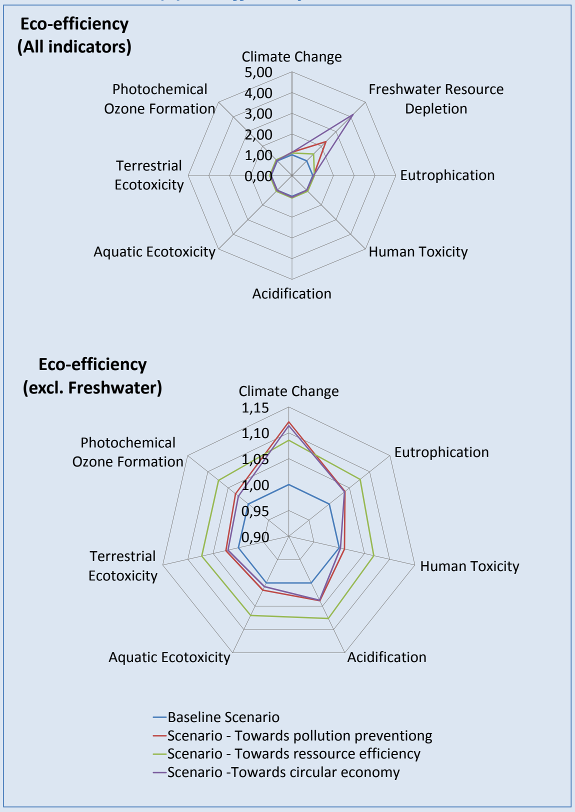
Alternative Technology Scenarios

Technology Scenario	Technologies	Stage	Objective
…towards Resource Efficiency	Product and water recovery from CIP	Dairy	Increase product recovery and reduce water use
	Cleaning and reuse of condensate	Dairy	Reuse condensate from evaporation of water
…towards Pollution Prevention	Anaerobic digester	Dairy	Reduce organic load and produce biogas
	Product and water recovery from CIP	Dairy	Increase product recovery and reduce water use
	Advanced oxidation and UV	Dairy	Enable use of water content in the milk
…towards Circular Economy	Advanced oxidation and UV	Dairy	Enable use of water content in the milk
	Cleaning and reuse of condensate	Dairy	Reuse condensate from evaporation of water

(a) Environmental Performance Assessment

Environmental Performance Indicators	Scenario		
	Resource Efficiency	Pollution Prevention	Circular Economy
Water Abstracted Tot	- 47%	- 133%	- 316%
Greenhouse Gas Emissions	- 2%	- 12%	- 11%

(b) Eco-efficiency Assessment

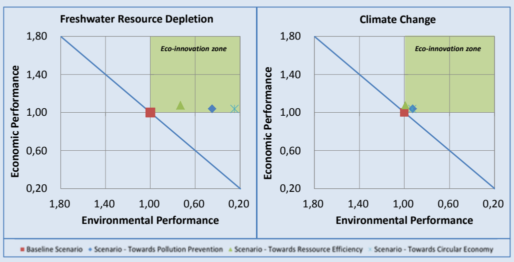


(c) Distributional issues among the involved actors

Variations of their Net Economic Output in the system

Actors	Scenario		
	Resource Efficiency	Pollution Prevention	Circular Economy
Dairy	+10%	+10%	+10%
Water utility	-55%	-26%	-75%
Wastewater utility	-42%	-6%	-41%
Biogas plant	-18%	-3%	-17%

(d) Identification of Eco-innovative Solutions



Case Study Contact Person

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EcoWater Details

A Collaborative Research Project of the 7th Framework Programme

Theme: ENV.2011.3.1.9-2

Development of eco-efficiency meso-level indicators for technology assessment

Project Duration: 01/11/2011 - 31/12/2014

Meso-level Eco-efficiency Indicators to Assess Technologies & their Uptake in Water Use Sectors

Automotive Industry, Sweden

Meso-level assessment of eco-efficiency improvements through innovative technologies for water use processes in the automotive industry

The Case Study at a glance

Case Study Area

General Characteristics

Location	Umeå and Gothenburg, Sweden
Main Product	30,000 Truck cabins
Annual Surface Water Used	0.025 Mm^3 for processing 0.38 Mm^3 for cooling
Total Value Added	71 €/m^3 used

Case Study Description

Volvo Trucks, of the Volvo Group, is one of the world's leading manufacturers of trucks. The Umeå site produces truck cabins and the Gothenburg site produces frame beams, both of which are used in the assembly of final trucks in Gothenburg. The main water use, apart from cooling water, is in the metal surface treatment process and in painting lines using liquid coatings.

Environmental Characteristics

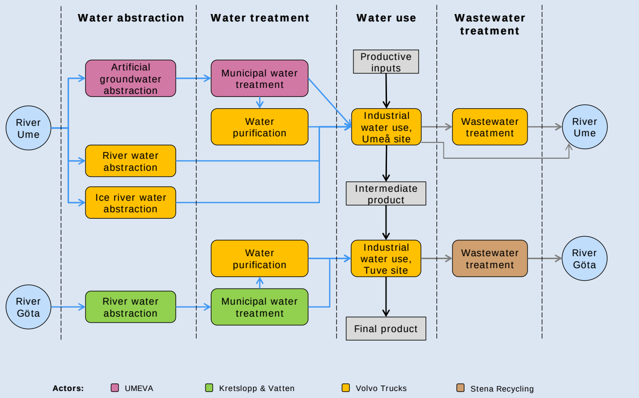
- Corrosion protection, as part of the metal surface treatment, results in wastewater and sludge containing phosphorus and heavy metals (Zn and Ni)
- Production is **not** within an area of water scarcity, but water saving technologies are still of interest to the industry

Economic Characteristics

- High value industrial product
- Only Volvo Trucks' share of services supplied by the water and wastewater companies are included in the evaluation

Directly Involved Actors

- The municipal water suppliers UMEVA and Kretslopp & Vatten
- Volvo Trucks, of the Volvo Group
- The private wastewater treatment company, Stena Recycling, responsible for treatment of wastewater from the Vovlo site in Gothenburg



Baseline Eco-efficiency Performance

Indicator	Value
Climate Change	44,000 €/$tCO_{2,eq}$
Stratospheric Ozone Depletion	47,000 €/tCFC-11_{eq}
Eutrophication	42,000 €/kg$PO_4{}^{-3}{}_{,eq}$
Acidification	15,000 €/kg$SO_2{}^{-}{}_{,eq}$
Human Toxicity	2,000 €/kg1,4-DB_{eq}
Aquatic Ecotoxicity	1,800 €/kg1,4-DB_{eq}
Terrestrial Ecotoxicity	130,000 €/kg1,4-DB_{eq}
Photochemical Ozone Formation	220,000 €/kg$C_2H_{4,eq}$
Abiotic Resource Depletion	29,000 €/kgSb_{eq}
Freshwater Resource Depletion	17,000 €/m^3

Identified Environmental Weaknesses

- Eutrophication, due to the phosphorus in wastewater after the corrosion protection process
- Aquatic Ecotoxicity, due to the heavy metals in wastewater after the corrosion protection process
- Climate Change, background impact due to energy use for process heating and circulation pumps

Case Study Contact Person

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EcoWater Details

A Collaborative Research Project of the 7th Framework Programme

Theme: ENV.2011.3.1.9-2

Development of eco-efficiency meso-level indicators for technology assessment

Project Duration: 01/11/2011 - 31/12/2014

Technology Scenario Assessment

Alternative Technology Scenarios

Technology Scenario	Technologies	Stage	Objective
...towards Resource Efficiency	Silane-based corrosion protection	Water Use	Reduction of energy, water, and chemical consumption
	Recycling of process water and chemicals	Water Use	Reduction of water and chemical consumption
...towards Pollution Prevention	Membrane distillation	Water Treatment	Cleaner water before use in process
	Silane-based corrosion protection	Water Use	Reduction of P, Zn and Ni in wastewater
	Recycling of process water and chemicals	Water Use	Reduction of P, Zn and Ni in wastewater
...towards Circular Economy	Membrane distillation	Water Treatment	Switch to energy from district heating
	Recycling of process water and chemicals	Water Use	Increased internal recycling

(a) Environmental Performance Assessment

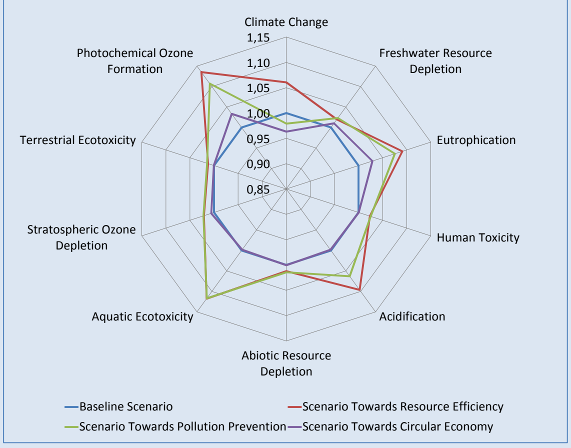
Environmental Performance Indicators	Scenario		
	Resource Efficiency	Pollution Prevention	Circular Economy
Water Abstracted Total (Process Water)	-1.1% (- 16%)	-1.5% (- 22%)	-1.3% (- 19%)
Greenhouse Gas Emissions	- 5.7%	+ 2.0%	+ 3.6%
Energy Used	-2.8%	+ 3.9%	+ 4.4%

(c) Distributional issues among the involved actors

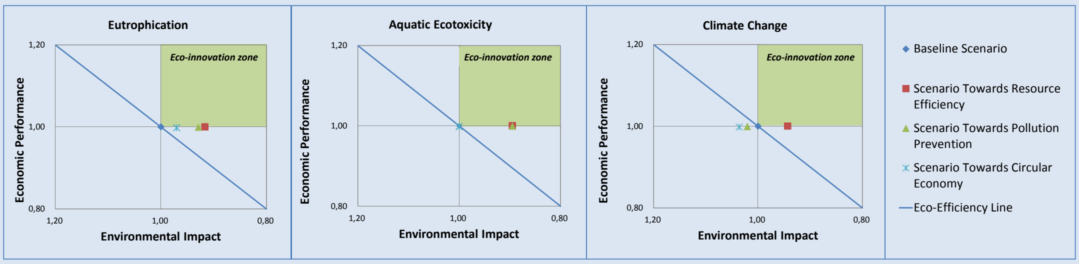
Variations of their Net Economic Output in the system

Actors	Scenario		
	Resource Efficiency	Pollution Prevention	Circular Economy
UMEVA	0%	- 12%	- 12%
Kretslopp & Vatten	- 57%	- 57%	0%
Volvo Trucks	+ 0.3%	+ 0.3%	+ 0.2%
Stena Recycling	- 57%	- 57%	0%

(b) Eco-efficiency Assessment



(d) Identification of Eco-innovative Solutions



EcoWater Case Studies

Urban - The city of Sofia, BG

A system of ageing infrastructure (more than 100 years old), serving the capital and largest city of Bulgaria. The main directly involved actors of the system are:

- The Water and Sewage Utility ("Sofiyska voda");
- Domestic water users; and Non-domestic water users.

Industrial - Textile Industry, Biella, IT

Two representative units of the textile industry are considered:

- A unit with in-house wastewater treatment plant, where the dyeing process is done by using standard chemical methods;
- A unit which uses both standard chemical dyes and natural herbal dyes and is connected to the municipal wastewater network.

Industrial - Cogeneration Plant, Amsterdam, NL

The case study examines a river water system, which provides cooling water for two cogeneration plants (Diemen 33 and Diemen 34). The studied system also includes the heat storage and distribution network and the domestic consumers of heat & electricity.

Industrial - Dairy Industry, Holstebro, DK

The case study examines the production chain of the Arla dairy in Holstebro (HOCO), one of the company's milk powder plants, receiving milk from farmers and producing caseinates, hydrolisates and milk minerals.

Industrial - Automotive Industry, Umea & Tuve, SE

Two separate water value chains are examined, linked together by the industrial actor Volvo Trucks, having production sites both in Umeå and Tuve. Additional actors in the system are the municipal water providers (UMEVA and Kretslopp & Vatten) and the wastewater treatment company (Stena Recycling).

EcoWater Consortium

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EcoWater

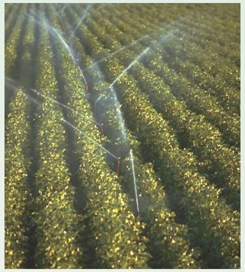
Meso-level eco-efficiency indicators
to assess technologies
and their uptake
in water use sectors

2011 - 2014

A Collaborative Research Project of the 7th Framework Programme

Theme: Development of eco-efficiency meso-level indicators for technology assessment

Background



Eco-efficiency, the development of more economically valuable goods and services, while using fewer resources and generating less waste and pollution, is the major pathway towards a more efficient Europe. Although eco-efficiency metrics are commonly used at the micro- and macro-levels, the corresponding indicators for the system level are not well-established. **Meso-level** assessment focuses on the dynamic behavior of product and service systems, analyzing interdependencies and heterogeneity among actors, also supporting policies towards sustainable production and consumption.

EcoWater addresses the gap in eco-efficiency metrics by adopting a systems' approach for developing meso-level indicators and for assessing the performance of innovative technologies. The analysis is directed to the eco-efficiency of water use systems, and is motivated by:

(i) The importance of water as production input, (ii) The significant environmental impact and costs entailed in making water suitable for different water-related innovative purposes, (iii) The need for holistic approaches in assessing the performance of different water-related innovative technologies, and (iv) The fact that the uptake of water-related innovations remains primarily regulatory-driven.

The Project methods and tools are tested in 8 distinct water use systems (in agricultural, industrial and urban settings); by studying the corresponding value chains, as well as the (economic) actors involved and their interactions, EcoWater has investigated how technological changes in water use systems interrelate, and influence the economic and environmental profile of water use in different sectors.

Objectives & Results

The **research objectives** delineating the EcoWater approach include:

1. Selection of eco-efficiency indicators, suitable for assessing the system-wide eco-efficiency;
2. Development and integration of assessment methods and tools into a coherent modeling environment;
3. A system-wide environmental and economic assessment of water use systems;
4. Selection and testing of innovative technologies and practices for improving system-wide eco-efficiency of water use systems and assesment of distributional effects and policies.

The main EcoWater **results** include:

1. A validated and tested framework online platform (EcoWater Toolbox) which can be used for the eco-efficiency assessment of a system;
2. An improved understanding of the socio-technical dynamics that influence technology uptake and implementation, and insight on policies to foster eco-efficiency improvements, focusing on different sectors of water use.
3. A range of values for each eco-efficiency indicator:
    - Identification of opportunities for upgrading value chain;
    - Highlighting the weak stages along the water supply chain.
5. Inter-comparison of stages/processes across sectors.
6. Identification of the most eco-efficient technology options and scenarios for each water use system.
7. Prioritization of policy actions (e.g. subsidies for eco-innovation uptake).

The **integration and synthesis** of Project components elaborates and develops step-wise methodological guidelines and policy recommendations for the uptake of eco-innovations in water use systems.

EcoWater has fostered operational **science-industry-policy** links with relevant EU initiatives, policy actors and industry representatives interested in the Eco-Water results.

Case Studies

Agricultural - Sinistra Ofanto Irrigation Scheme, IT

Important agricultural district and irrigation system, located within Ofanto River Basin, in the Apulia region. Water is supplied to the farmers through three different water supply chains:

- Gravity-fed conveyance and distribution by pumping;
- Gravity-fed water conveyance and distribution;
- Conveyance by lifting and distribution by gravity.

The main directly involved actors of the system are:

- Consortium per la Bonifica dela Capitanata;
- Farmers' Association;
- Regional River Basin Authority.

Agricultural - Monte Novo Irrigation Scheme, PT

Newly developed agricultural district (operation started in 2010), built as part of the Alqueva infrastructure project, located within the Guadiana River Basin in the Alentejo region. The water supply chain consists of a primary and a secondary distribution network (with both low and high pressure irrigation heads) that delivers water to farmers.

The main directly involved actors of the system are:

- Alqueva's Development and Infrastructures Company;
- Association of Monte Novo Irrigation Scheme Users;
- Farmers.

Urban - The municipality of Waedenswil, CH

Lake Zurich plays an important role as provider of raw water and the quality of water should be maintained in high level. Thus, the drinking water treatment plant has been rebuilt in 2012 and is equipped with modern membrane filtration technology, and the applied waste water treatment process is technologically on an advanced standard.

The main directly involved actors of the system are:

- Association of municipalities for water treatment;
- Municipality Waedenswil responsible for water supply;
- Domestic and non-domestic water users.