PERIODICAL REPORT ABOUT DISSEMINATION

Reporting Date

30/09/2017

Ljubljana, September 2017

Responsible beneficiaries:

- **Municipality of Šentrupert**
- **ZAG**

This study was prepared within the scope of the LIFE + RusaLCA project, which is financially supported by the European Union, LIFE + programme.

Table of Contents

Dissemination 3

RusaLCA concluding conference and a meeting of project participants with the stakeholders on 03-04/10/2016 (Ljubljana, Šentrupert, Slovenia) 7

Lecture at the conference Planet Earth, 22/04/2016, Ljubljana, Slovenia 9

Posters at the LIFE Water Platform meeting,24-25/05/2016, Manchester, United Kingdom . 10

A meeting of project participants with the local stakeholders, 09/06/2016, Šentrupert, Slovenia. 11

A short lecture at the International conference on materials and technology, 28-30/09/2016, Portorož, Slovenia 13

A lecture at the aRAWness workshop, 20/10/2016, Ljubljana, Slovenia 18

A lecture at the LCA workshop, 27/10/2016, Ljubljana, Slovenia 40

Lecture for students of Faculty of Nova Gorica: " Life cycle assessment - methodology and examples from practice", 14/04/2016, Faculty of Nova Gorica, Vipava, Slovenia 67

Lecture for students Polytechnic University of Madrid: " Recycling of ferrous slags for construction purposes ", 18/02/2017 97

Lecture for students of Faculty of Nova Gorica: " Eco-innovative technologies in construction sector and quantification of their environmental impacts ", 05/05/2017, Faculty of Nova Gorica, Vipava, Slovenia 107

Lecture at elementary school 117

An invited lecture at the concluding conference of LIFE PharmaDegrade project, 24-25/11/2016 126

List of technical papers 130

Contributions to non-technical journals and the media 134

List of scientific articles 137

List of dissemination events 138

Dissemination at conferences, workshops and lectures 139

Dissemination

Although dissemination activities have already been briefly described in this report within the scope of Action D.1, a more detailed description is given here. Most of the planned activities of Action D.1 have already been implemented. The dissemination activities that were implemented during previous reporting periods (from 01/07/2013 to 31/03/2017) are briefly summarized here.

The dissemination tasks of the RusaLCA project began to be implemented with the initiation of the official website www.rusalca.si, on 25/10/2013 (translated into the English language on 07/03/2017). A press release about the scopes and objectives of the RusaLCA project was drawn up and sent to multiple local media of the Central Slovenian and Dolenjska region on 17/12/2013. The project was also disseminated and presented within the scope of activities of the project LIFE Rebirth during 2013 and 2014. An introductory round table with the local community was held in Šentrupert on 12/03/2014, where a total of 53 people participated and exchanged opinions.

During the implementation of the project, it was noticed that the irresponsible behaviour of some individuals had caused a certain level of malfunctioning of the biological treatment of municipal waste water at the SWTP. This was a consequence of the release of harmful substances into a sewage system. A public campaign was therefore organized by the Municipality of Šentrupert during 2014 and 2015, with the aim of explaining to the local community what can and what should not be released into the sewage system.

During first year of the project various flags, info-labels, and self-fixing stickers with LIFE and RusaLCA logos were prepared in order to disseminate the project at every step of the project, and to satisfy the requirements of the Grant Agreement. Mark-up posters were designed in B.2 dimensions that were delivered to the associated beneficiaries so that they could display them at their premises. Roll-up posters were also designed and put on display at different events (conferences, networking, and dissemination activities) at ZAG and at the premises of the Municipality of Šentrupert. An information board was erected at the location of the SWTP and the pilot remediation system after they was erected in March 2015. The board contains the main information about the remediation system and all required elements of the LIFE project. All the described dissemination elements were presented as annexes to the Inception Report (2014), the Midterm Report (2015) and the Progress Report (2016).

During the previous reporting period (from 31/03/2015 to 31/03/2016) the dissemination activities were intensified. Two presentations were made in a form of posters at scientific conferences. A poster entitled "LIFE RusaLCA - An advanced system for nanoremediation of waste waters for sustainable water management" was presented at the 22nd conference of Slovenian geologists (held on 30/11/2015). A poster entitled "LIFE+ RusaLCA – An innovative Prototype System for the remediation of Municipal Waste Water" was presented at the 23rd International Conference on Materials and Technology (held on 28/09/2015).

Two lectures were given to students of the University of Ljubljana. Students of geology from the Faculty of Natural Sciences attended a lecture entitled "Research in the field of innovative technologies for water remediation" at ZAG on 10/12/2015. A second lecture that was organised at ZAG for students of the Faculty of Civil and Geodetic Engineering, on 14/012016, was entitled "RusaLCA – Nanoremediation of water from waste water treatment plants".

Within this reporting period a number of different dissemination activities were implemented. Most of them were presentations at different international workshops and conferences.

Two posters with the content describing the expected outcomes of the project were presented at the LIFE Water Platform meeting which was held in Manchester, UK on 24-25/05/2016. The activities of the project were also presented at the workshop "Knowledge and activities for a sustainable future: the environmental aspect" on 03/06/2016. A contribution in the form of a short lecture was made at the International conference on materials and technology, which was held at Portorož, Slovenia, on 28-30/09/2016. The lecture was entitled "An advanced water purification method with the utilization of zero-valent iron nanoparticles" and represented the dissemination of the scientific background, which was closely connected with the optimization of the pilot remediation system at Šentrupert. A lecture entitled "Closing the loops and use of secondary resources in the construction sector" was given at the workshop aRAWness, which was held at the Geological Survey of Slovenia on 20/10/2016. This lecture was an opportunity for the dissemination of the expected outcomes of the project RusaLCA from the point of view of the circular economy. The LCA aspects of the RusaLCA project were presented at a workshop which was organized within the scope of the CEL.KROG project at ZAG on 27/10/2016. An invited lecture with a presentation of the scientific data and expected outcomes of the RusaLCA project was given at the concluding conference of the LIFE PharmDegrade project on 24-25/11/2016. This lecture was entitled "Nanoremediation of effluent water from a small wastewater treatment plant and its challenges from the point of view of the treatment of micro-pollutants; the RusaLCA project". RusaLCA activities were also presented at the "Nature-Health" Fair on 24-27/11/2016 in Ljubljana.

However, the two most important dissemination events of the previous year were the Regional RusaLCA project presentation, and the two-day International RusaLCA conference.

The regional presentation of the project was held at Šentrupert on 09/06/2016. This was an event where the objectives, processes and technology of the project were presented to the general public. The mayors of municipalities from the wider Dolenjska region were invited to participate, as well as the representatives of companies for municipal services and experts in the field of water remediation. The agenda of the regional presentation was the following. The participants were first addressed by the Mayor of Šentrupert, Rupert Gole, who stressed his satisfaction with the fact that the municipality has demonstrated its progressiveness by participation in such projects, which are supported by the European Commission through the LIFE+ programme. At the presentation, the importance of the project and the technologies that have been developed for the treatment of municipal water, were presented by Ana

Mladenović and Primoz Oprčkal from ZAG, whereas Peter Geršič illustrated the importance of the project for the local community. In the second part of the meeting, the participants viewed the pilot remediation system. The presentation of the project was a good opportunity to exchange experience in the management of similar projects and in water management in the south-east Slovenia.

The two-day International RusaLCA conference, which was held on 03-04/10/2016 at ZAG, Ljubljana, was the most important dissemination event. We presented the progress of the project, its objectives, and the innovative technology for the cleaning of municipal waste water by means of the SWTP and the pilot remediation system and the use of water for secondary purposes, to approximately 50 participants. Visiting lecturers presented different approaches to the management of waste water in Spain, Greece, Montenegro, Macedonia and Bosnia and Herzegovina. Here is a list of the lecturers, along with the titles of their presentations:

-Ana Mladenovič, ZAG – Presentation of the LIFE RusaLCA project;

-Damia Barcelo Culleres, Spain – The EU GLOBAQUA project on Multiple Stressors on Aquatic Ecosystems under Water Scarcity and Global Change. A Reconnaissance Study in Selected European River Basins;

-Andreas Angelakis, Greece – Evolution of Water Supply and Waste- and Storm-Waters Management in Urban Areas Focusing in Hellenic Cities;

-Radmila Milačič, IJS – The use of different zero-valent iron nanoparticles for the remediation of effluent water from a small biological wastewater treatment plant;

-Primož Oprčkal, ZAG – Water purification technology of a pilot remediation system with the utilization of nanoscale zero-valent iron;

-Alenka Mauko Pranjić, Janez Turk, ZAG – Life cycle analysis of the RusaLCA system;

-Anka Ilc, Structum – Use of sediment from the nanoremediation process in cement composites;

-Peter Geršič, RusaLCA – Challenges of water distribution and support to the project by the local community;

-Vesna Mislej, VOKA Ljubljana – Mission of the Central WWTP Ljubljana – the release of treated wastewater back into nature and on-site preparation of the excess sewage sludge for its final utilization;

-Snežana Didanović, Montenegro – Waste water treatment in Montenegro with focus on the use of aquatic plants for wastewater purification;

-Sanja Bosiljčić Pandur, BiH – Small Waste Water Treatment Plants WWTP – Technical aspects and cost estimation of pilot plants;

-Janko Urbanc, GeoZS – Chemical status of Slovenian ground waters and drinking water resources;

-Kasam Zeqiri, Macedonia – Sector policy of water resources management in the Republic of Macedonia;

-Rupert Gole, Municipality of Šentrupert – Presentation of the Municipality of Šentrupert.

The meeting was also an opportunity to exchange knowledge and experience in the field of water management and between different projects (e.g. the FP 7 project GLOBAQUA). Participants visited the pilot remediation system at Šentrupert.

An important dissemination element was also the informational leaflet, which contains all the basic information about the project. It was prepared in May 2016 and was distributed at different formal and informal events at ZAG and at the Municipality of Šentrupert. Up to this time a total of 21 lay and expert articles had been published in local and international journals and media.

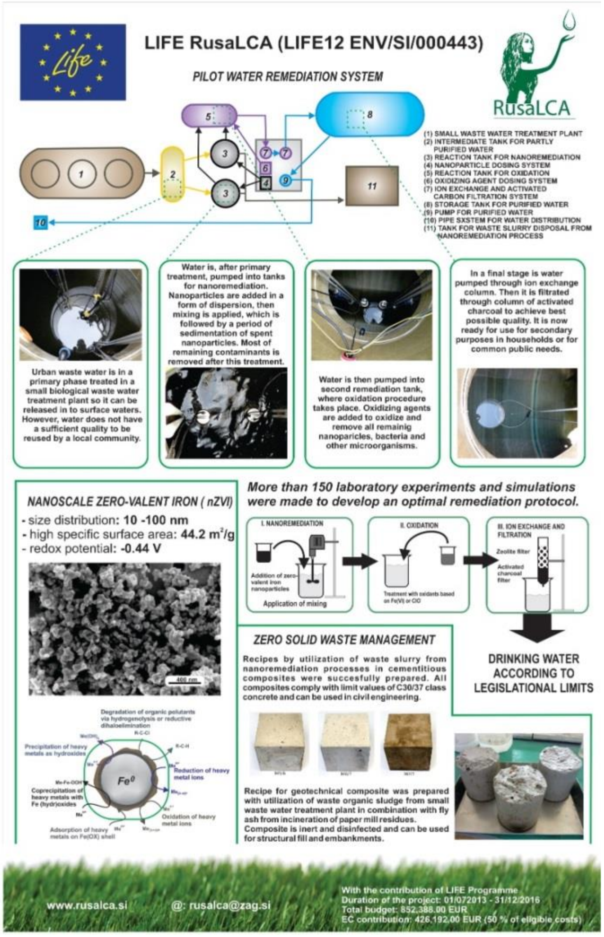
Dissemination among local inhabitants - stakeholders, which are included in the project through the consumption of the remediated water, was also intensified in this reporting period. This was especially due to a fact that some individuals had showed a very negative attitude to the project. In order to encourage them to use remediated water the Municipality has offered and distributed free-of-charge 1m^3 large containers for the temporary storage of remediated water to local stakeholders. The containers were marked with the LIFE and RusaLCA logos. During dry seasons of the year (spring, summer) the containers will be filled with remediated water from the pilot remediation system, and thus benefits of the LIFE RusaLCA project will be further disseminated as a positive contribution to the local community.

RusaLCA concluding conference and a meeting of project participants with the stakeholders on 03-04/10/2016 (Ljubljana, Šentrupert, Slovenia)


Life

Lecture at the conference Planet Earth, 22/04/2016, Ljubljana, Slovenia

Posters at the LIFE Water Platform meeting,24-25/05/2016, Manchester, United Kingdom



A meeting of project participants with the local stakeholders, 09/06/2016, Šentrupert, Slovenia.


Tehnologije in inovacije
projekta RusaLCA
RusaLCA
Life

A short lecture at the International conference on materials and technology, 28-30/09/2016, Portorož, Slovenia

ZAG ZAVOD ZA GRADBENIŠTVO SLOVENIJE SLOVENIAN NATIONAL BUILDING AND CIVIL ENGINEERING INSTITUTE

LIFE+ RusaLCA

An advanced water purification method with utilization of zero–valent iron nanoparticles

Ana Mladenovič[1], Primož Oprčkal[1], Peter Nadrah[1], Andrijana Sever Škapin[1], Janez Ščančar[2], Radmila Milačič[2], Janja Vidmar[2] and Alenka Mauko Pranjič[1]

[1] Slovenian National Building and Civil Engineering Institute
[2] Jožef Stefan Institute

Portorož, 29th September 2016
24th International Conference on Materials and Technology

Mladenovič et al. | 24th ICMT

Drinking water

- Not in abundance
- Why use drinking water where such quality is not necessary?
- Recycle water?

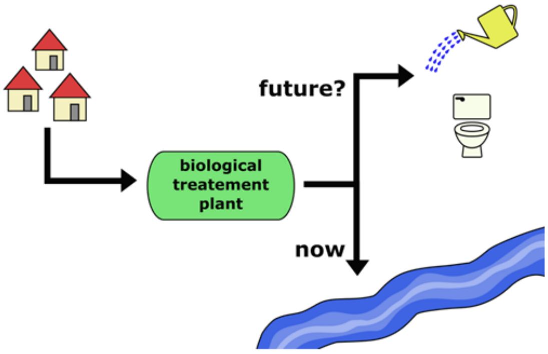
en.wikipedia.org/wiki/Drinking_water

www.zag.si

Mladenovič et al. | 24th ICMT

The situation and a solution

Municipal wastewater is cleaned in small aerobic wastewater treatment plant and discarded into rivers.

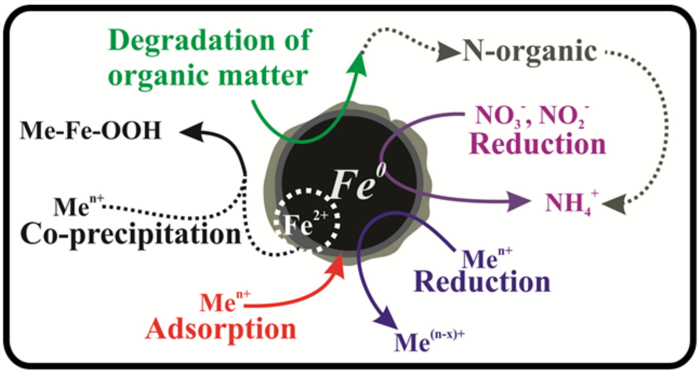


IDEA: Purify this water further and return it to the households for secondary purposes.

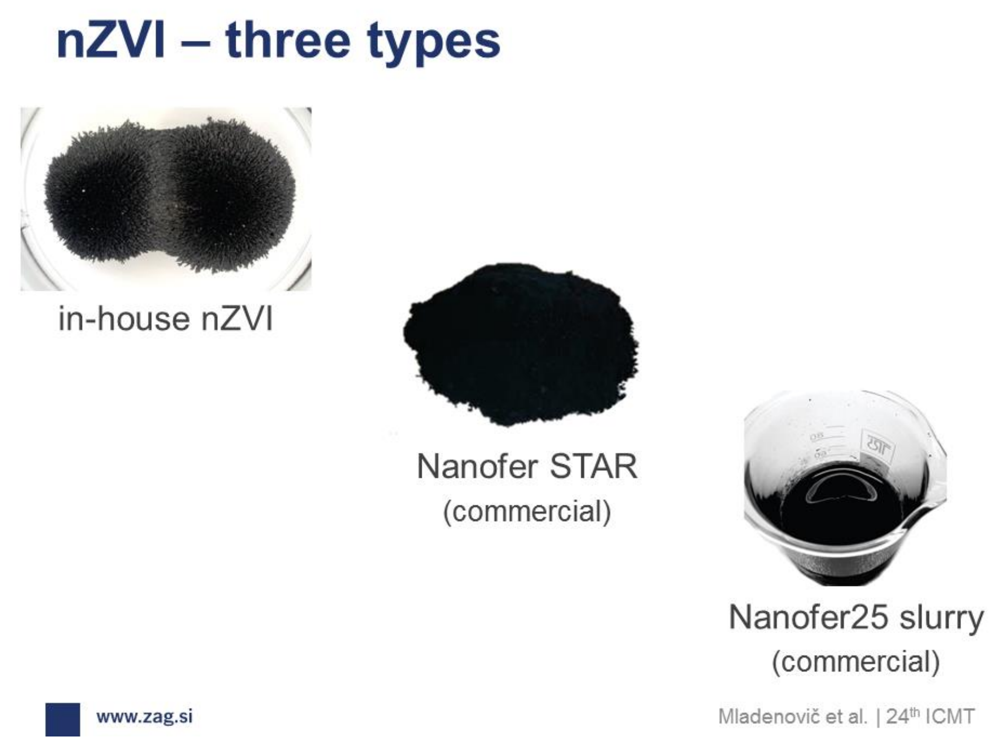
www.zag.si Mladenovič et al. | 24th ICMT

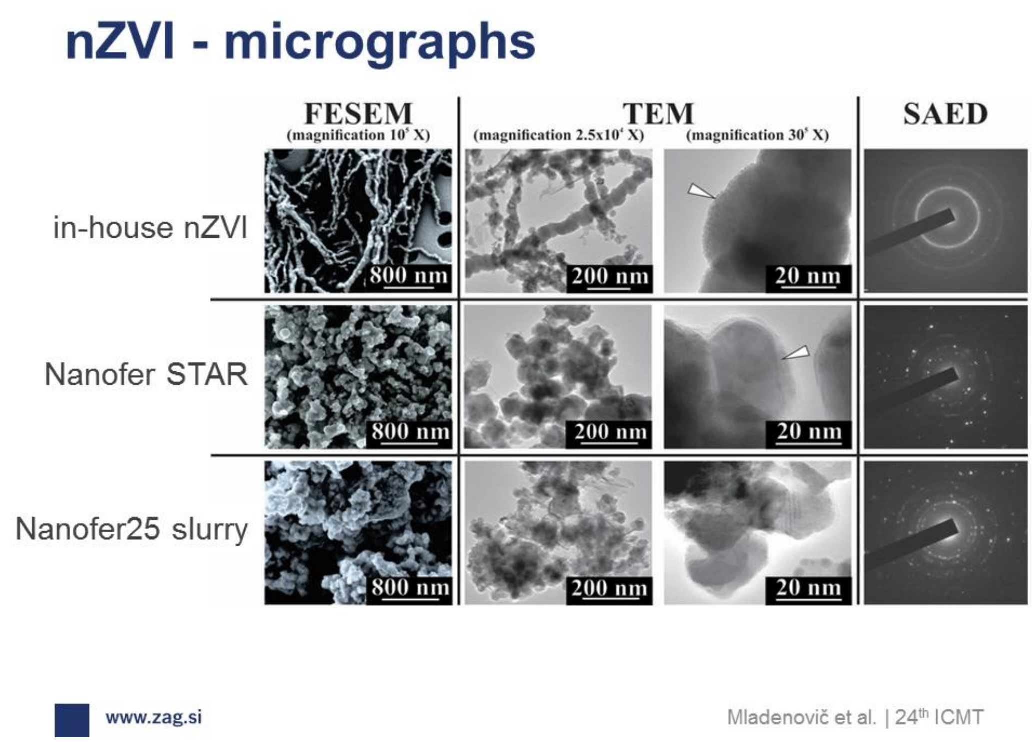
Nano zero-valent iron - nZVI

- high surface area
- reduction of organic material
- adsorption and coprecipitation of metals



www.zag.si Mladenovič et al. | 24th ICMT


nZVI – three types
in-house nZVI
Nanofer STAR
(commercial)
Nanofer25 slurry
(commercial)
www.zag.si
Mladenovič et al. | 24th ICMT

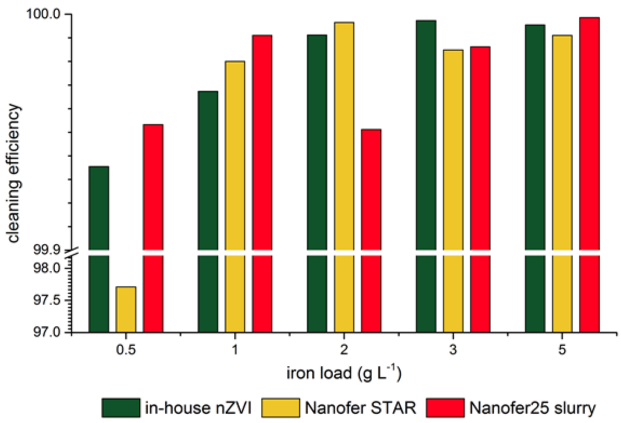

nZVI - micrographs
FESEM
(magnification 10⁵ X)
TEM
(magnification 2.5x10⁴ X)
(magnification 30⁵ X)
SAED
in-house nZVI
Nanofer STAR
Nanofer25 slurry
800 nm
200 nm
20 nm
www.zag.si
Mladenovič et al. | 24th ICMT

nZVI – characteristics

	in-house nZVI	Nanofer STAR	Nanofer25 slurry
Size (nm)	30 - 100	30 - 80	20 - 80
Shell thickness (nm)	4 - 6	5 - 8	4 - 6
BET ($m^2 g^{-1}$)	83.0 ± 4.1	17.0 ± 0.8	44.0 ± 2.2
Available Fe^0 (wt. %)	88.0 ± 4.4	69.0 ± 3.4	85.0 ± 4.2

www.zag.si Mladenovič et al. | 24th ICMT

nZVI – antimicrobial effect



It is important to get as close to 100 % as possible.

www.zag.si Mladenovič et al. | 24th ICMT

Remediation plant in Šentrupert, Dolenjska

www.zag.si Mladenovič et al. | 24th ICMT

Acknowledgements

Partners:

ZAG

IJS

Structum

PKG

NACIONALNI LABORATORIJ ZA ZDRAVJE, OKOLJE IN HRANO

ESPLANADA

RusaLCA

rusalca.si

Life

www.zag.si Mladenovič et al. | 24th ICMT

A lecture at the aRAWness workshop, 20/10/2016, Ljubljana, Slovenia

ZAG
ZAVOD ZA GRADBENIŠTVO SLOVENIJE
SLOVENIAN NATIONAL BUILDING AND CIVIL ENGINEERING INSTITUTE

Closing the loops and use of secondary resources in construction sector

Zapiranje zank in uporaba sekundarnih surovin v gradbeništvu

Alenka Mauko Pranjić (Ph.D. Geol.)
Asist. Prof. Dr. Ana Mladenovič (Ph.D. Geol.)
Vesna Zalar (Ph.D. Geol.)
Primož Oprčkal (B.Sc. Geol.)
Vilma Ducman (Ph. D. Geol.)

aRAWness WARE

GeoZS, 20/10/2016

ZAG – who we are?

eit RawMaterials

ZAG SLOVENIAN NATIONAL BUILDING AND CIVIL ENGINEERING INSTITUTE

www.zag.si

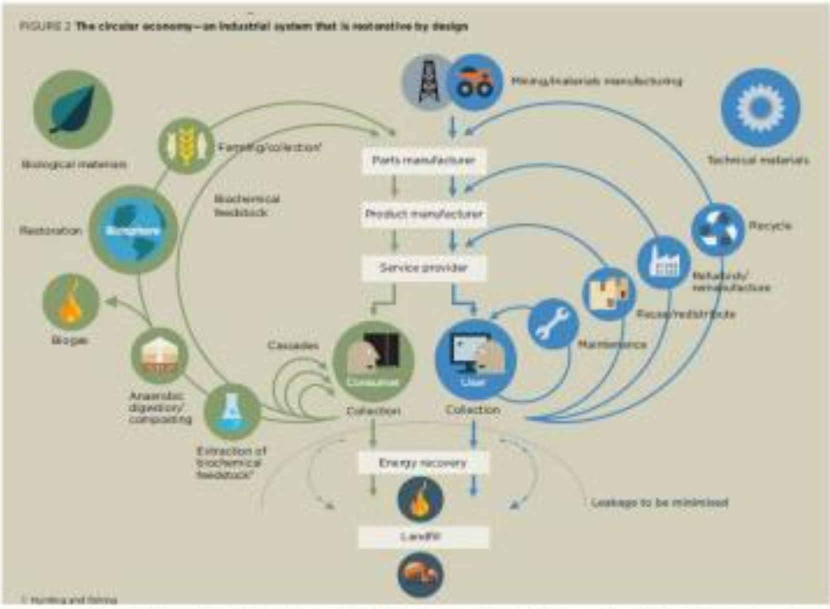
Public research institute, 181 employees, 5 departments: Materials, Building Physics, Construction, Road Infrastructure, Metrology, annual turnover: app. 8-10 mio €

www.zag.si 2

Laboratory for Concrete, Stone and Recycled Materials

- Applicative researches work as well as expert work, consultancy and supervision in the following area:
  - Concretes (green concretes)
  - Aggregate
  - Stone (natural, agglomerated)
  - Recycling and green technologies (water and soil remediation)
  - Life cycle assessment (E-LCA, S-LCA, LCC)
  - Mineralogical analysis (e.g. asbestos, dust in working environments…)
  - Cultural heritage
  - 3D microscopy (microXCT and confocal microscopy)

CE – „recycling on steroids“?



Source: Ellen MacArthur Foundation Towards the Circular Economy vol.1

Closing the loop

- EU action plan Cloosing the loop – An EU action plan for the Circular Economy
- „Primary raw materials, including renewable materials, will continue to play an important role in production processes, even in a circular economy"
  - Introducing/revitalizing **SECONDARY RAW MATERIAL**
  - Promoting BAT in BREF documents
  - Industrial symbiosis…

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Recycling is not enough if it does not end with a product!

- End-of-waste criteria
- Legislation for secondary raw material based products
- Connecting legislation in practice
  - Directive 2008/98/EC on waste and repealing certain Directives, Annex 2 – Recovery operation
    - R 5 Recycling/reclamation of other inorganic materials (***)

*** This includes soil cleaning resulting in recovery of the soil and recycling of inorganic construction materials.

www.zag.si 6 aRAWness workshop, GeoZS, 20/10/2016


PRODUCT (NON-WASTE)
PREVENTION
WASTE
PREPARING FOR RE-USE
RECYCLING
RECOVERY
DISPOSAL
Directive 2008/98/EC on waste (Waste Framework Directive)
www.zag.si
7


ReBirth
Odpadek je začetek novega!
Waste
Environmental legislation
Construction product
Construction legislation
Promotion of the Recycling of Industrial Waste and Building Rubble for the Construction Industry.
Life

Construction sector – large consumption of (secondary) RM

- The RERM* includes the following milestone for improving buildings[1]

„By 2020 the renovation and construction of buildings and infrastructure will be made to high resource efficiency levels. The Life-cycle approach will be widely applied; all new buildings will be nearly zero-energy and highly material efficient and policies for renovating the existing building stock will be in place so that it is cost-efficiently refurbished at a rate of 2% per year. 70% of non-hazardous construction and demolition waste will be recycled"

*Roadmap to Resource Efficient Europe

[1] COM(2011) Final Communication from the Commission: Roadmap to a Resource Efficient Europe

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Construction Product Regulation[1]

- 7. BRCW*: Sustainable use of natural resources
  - The construction works must be designed, built and demolished in such a way that the use of natural resources is sustainable and in particular ensure the following:
    - (a) reuse or recyclability of the construction works, their materials and parts after demolition;
    - (b) durability of the construction works;
    - (c) use of environmentally compatible raw and secondary materials in the construction works.

1 EU no. 305/2011

* Basic Requirements for construction works

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Sustainble construction is not just energy efficiency!

www.zag.si 11 3rd Workshop on aRAWness Project, GeoZS, 20/10/2016

It‘s about resource efficiency…

- …and using what we have at hand

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SOLID MATERIAL USE
NOW TO EXAMPLES!
LAND USE [1]
Source: Ellen MacArthur Foundation Towards the Circular Economy vol.1
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13
3rd Workshop on aRAWness Project, GeoZS, 20/10/2016


ReBirth project (2011-2014)
• LIFE+ projekt Promocija recikliranja industrijskih in gradbenih odpadkov in njihove uporabe v gradbeništvu
Promotion of the Recycling of Industrial Waste and Building Rubble for the Construction Industry
ReBirth
Odpadek je začetek novega!
• Total budget: 845.543,00 EUR (50% EC, 20% MOP)
Life
REPUBLIC OF SLOVENIA
MINISTRY OF THE ENVIRONMENT AND SPATIAL PLANNING

ZAG · Gospodarska zbornica Slovenije · HL-PRO · MAYER MCCANN · Structum

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- **Main objective:**
  - contribute to the increased and better recycling of industrial waste and construction/demolition waste in the construction sector.

↑	10 %	15 %	1,5 %		70 %
Continuous growth of the recycling rate for both C&D waste and industrial waste.	**Up to a 10% increase** in the recycling rate for C&D waste.	**Up to a 15% increase** in the recycling rate for inert industrial waste.	Natural material **savings of 1.5%**.	**Reversal of the trend** of illegal dumping of C&D waste.	**Contribution to the goal of a 70 % recycling rate by 2020.**

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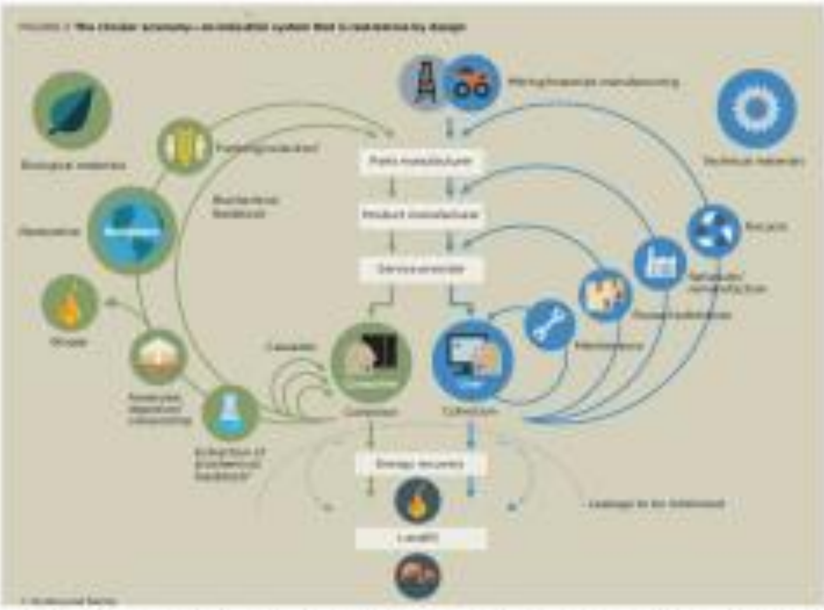
ReBirth
RAWness Project, GeoZS, 20/10/2016


Use of Carbon Steel Slag in Road Rehabilitation, Podbrdo, 14.6.2012
EAF slag
Steel
industry
Aggregate
Construction
Industrial symbiosis

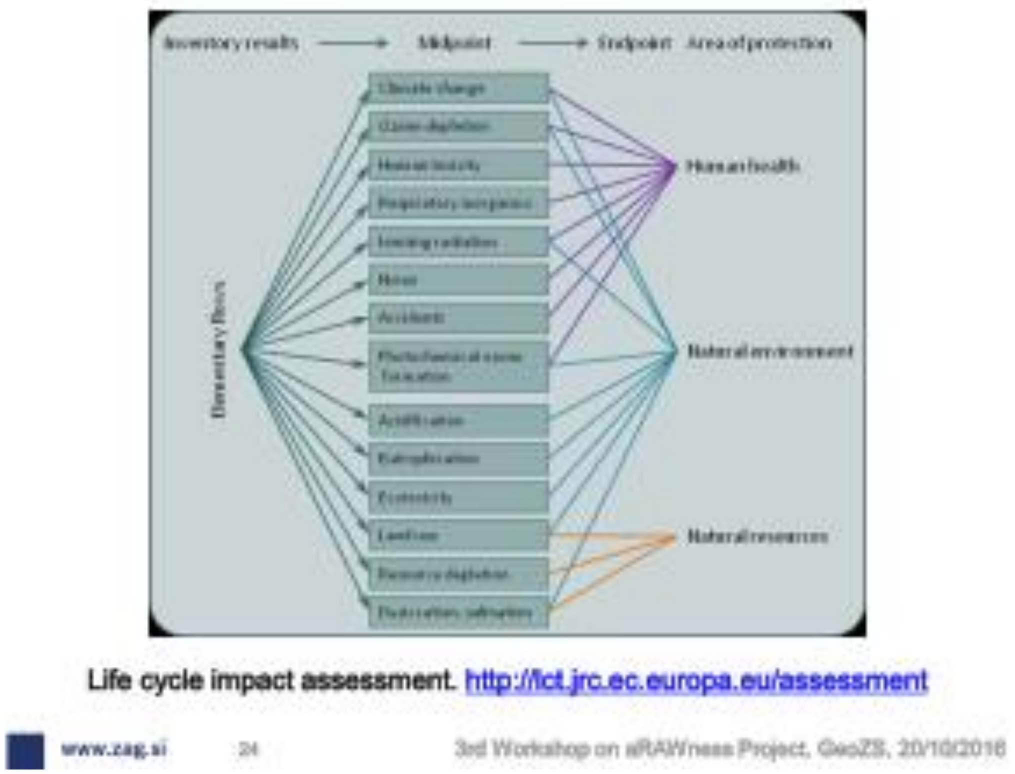

Selective demolishing and use of recycled aggregate, Maribor - Pesnica, 25.04.2013
Selective demolishing
Eco-design


Cold-in-place recycling in road reconstruction, Bača – Dolenja Trebuša, 11. 7. 2014
In-place-recycling
Maintenance/reuse/refurbish /remanufacture



Source: Ellen MacArthur Foundation Towards the Circular Economy vol.1


The life cycle approach
Life Cycle Thinking
Resource Use, e.g.
Health & Environment Impacts, e.g.
Energy
Materials
Land Use
Climate Change
Eutrophication
Toxic Pressure
www.zag.si


Inventory results
Midpoint
Endpoint
Area of protection
Human health
Natural environment
Natural resources
Life cycle impact assessment. http://lct.jrc.ec.europa.eu/assessment
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24
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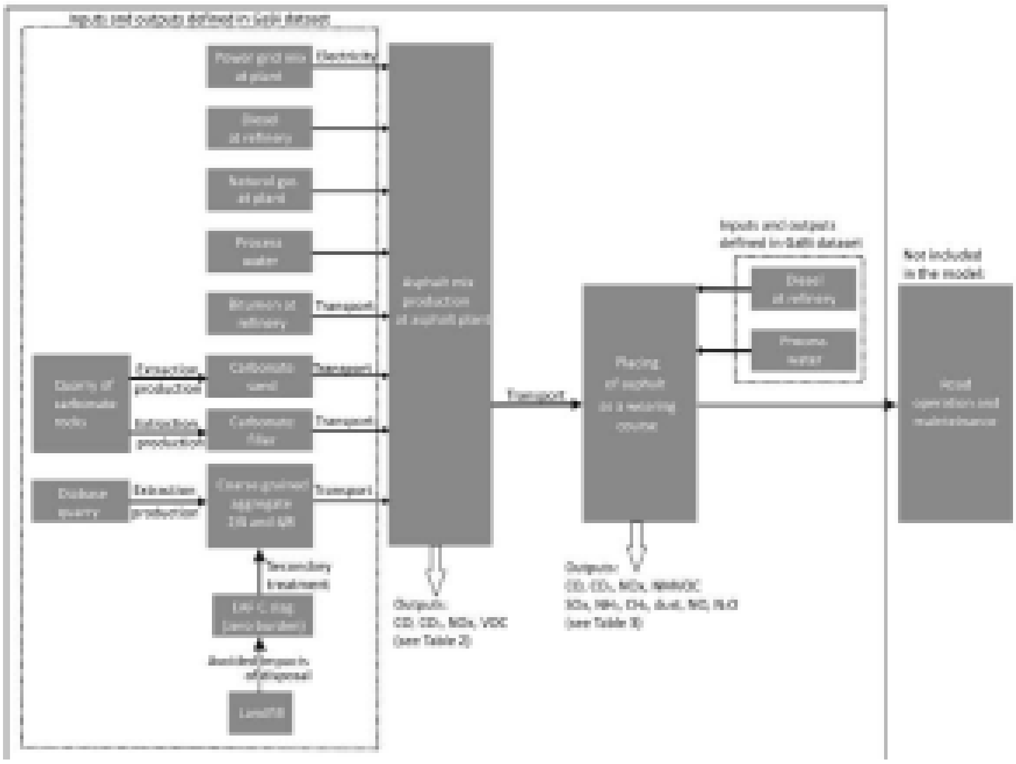
LCA in circle economy



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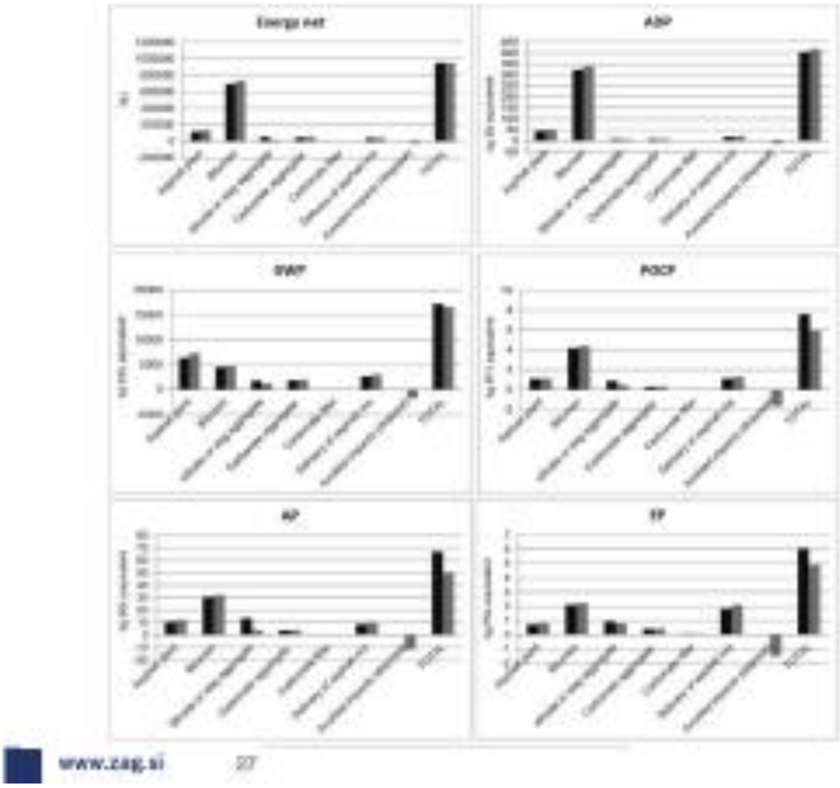
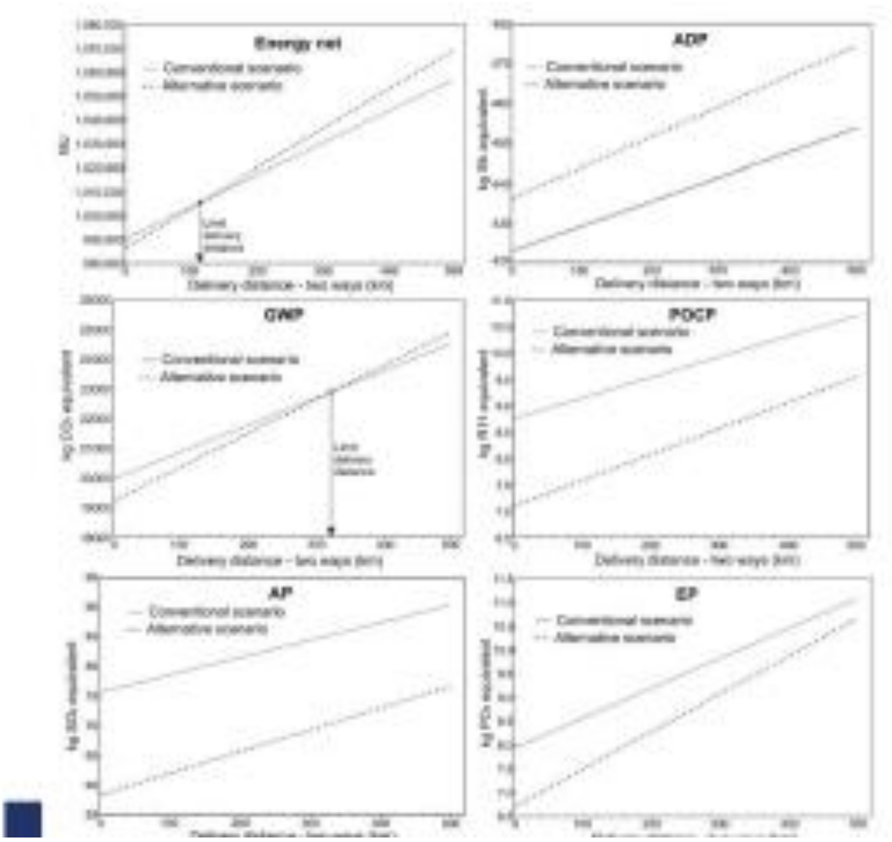
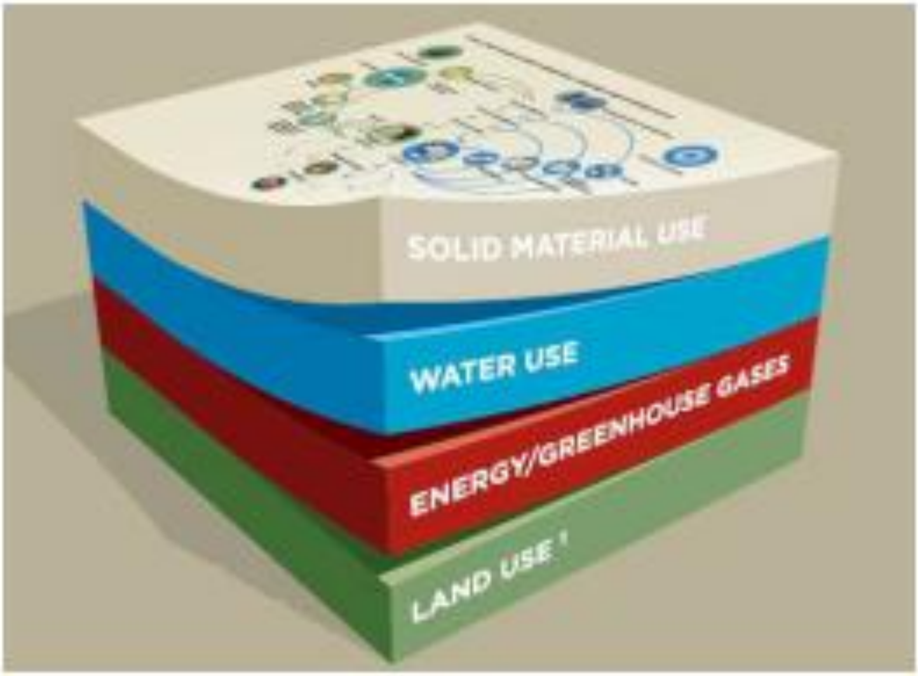

Energy net
ADP
GWP
POCP
AP
EP
www.zag.si


Energy net
ADP
GWP
POCP
AP
EP



Source: Ellen MacArthur Foundation Towards the Circular Economy vol.1

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CE and water use

- EU action plan Cloosing the loop – An EU action plan for the Circular Economy
- 4 ch: From waste to resources: boosting the market for secondary raw materials and water reuse
  - „The Commission will take a series of actions to promote the reuse of treated wastewater, including legislation on minimum requirements for reused water."

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RusaLCA project
RusaLCA
Life
LIFE RusaLCA LIFE12 ENV/SI/000443: Nanoremediation of water from small waste water treatment plants and reuse of water and solid remains for local needs www.rusalca.si
Total budget: 852.388 EUR (50% EC financing)
Beneficiaries: ZAG, IJS, Šentrupert Municipality, NLZOH, Structum, PKG


Th
E-L
C
SUSTAINABLE
COMMUNITY DEVELOPMENT
Economic Prosperity
Cultural Vitality
Social Equity
Environmental Sustainability
Venn diagram of sustainable development: at the confluence of three constituent parts

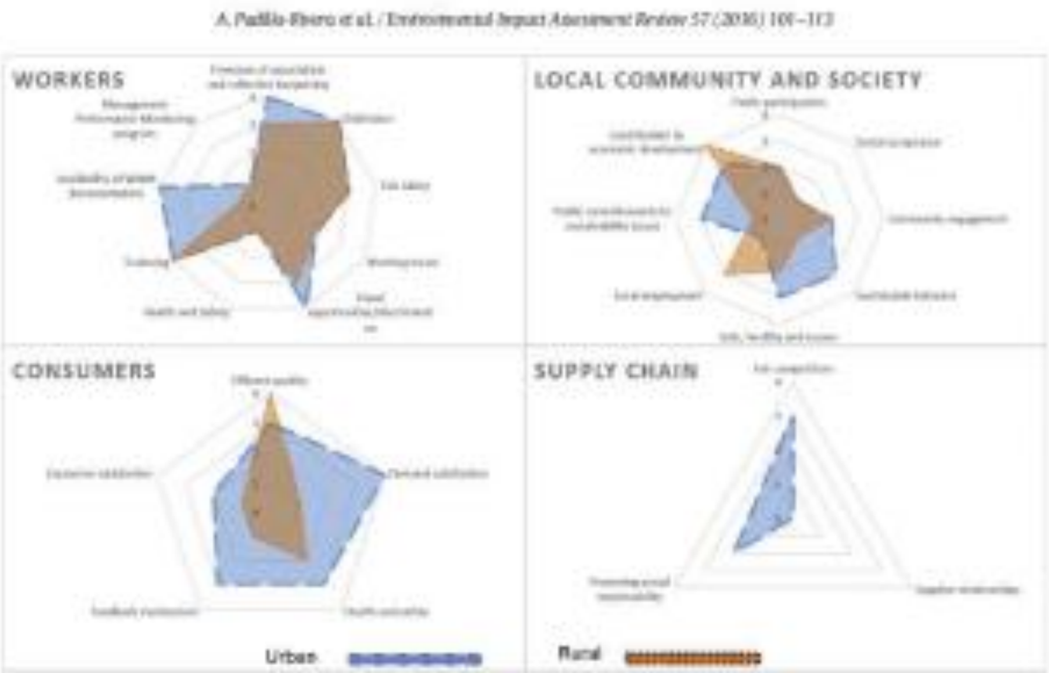

Fig. 2. Performance evaluation of the 20 indicators grouped for the four stakeholders considered in the facilities under study.

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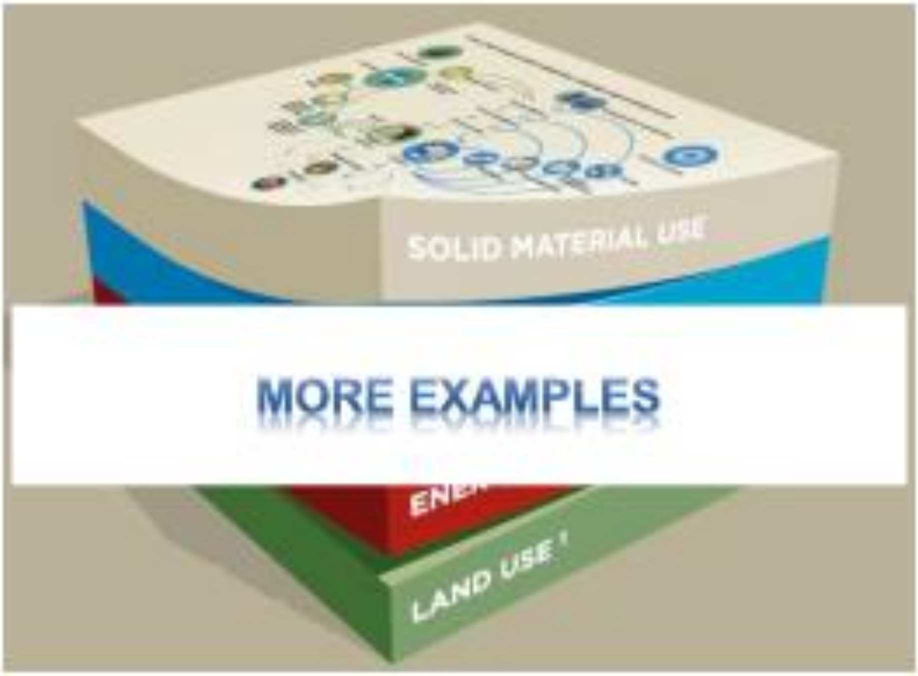

Source: Ellen MacArthur Foundation Towards the Circular Economy vol.1

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EAF-S and SMS slags

Disintegration of unstable dicalcium silicates → dust.

$\beta\ C_2S \rightarrow \gamma\ C_2S$

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Immobilization of toxic components

	Element	Cement (mg/kg)	Bela žlindra (mg/kg)	Mejne vrednosti parametra izlužka za inertnost (mg/kg)*
9 x	Cr(celotni)	3,52	0,389	0,5
7 x	Cr(VI)	2,52	0,357	/
	Cu	0,050	0,0061	2
	Zn	0,41	0,44	4
	Ni	< 0,046	< 0,046	0,4
	Pb	0,002	0,005	0,5
	Ba	11,3	11,9	20
	Cd	< 0,014	< 0,014	0,04
	Mo	0,011	0,250	0,5
	V	< 0,029	< 0,029	/
	As	< 0,025	< 0,025	0,5
	Sb	< 0,004	0,008	0,06
	Se	0,060	< 0,05	0,1
	Hg	< 0,014	< 0,014	0,01

www.zag.si 37

ARTICLE IN PRESS

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

Recycling of ladle slag in cement composites: Environmental impacts

Vesna Zalar Serjun, Ana Mladenović, Breda Mirtič, Anton Meden, Janez Ščančar, Radmila Milačič

www.zag.si

More examples/projects

- Smart specialization: Reserch program in circular economy domein: SPS NMP (ZAG project partner)

www.zag.si 39 3rd Workshop on aRAWness Project, GeoZS, 20/10/2016

EIT Raw Materials projects

- 8/9 projects were improved in 2015:
  ResiduFlex (NoI – 2015), contact: vilma.ducman@zag.si
  EXTREME (NoI – 2015), contact: vilma.ducman@zag.si
  OREVAL, former R2R-AC+3DI (NoI – 2015), contact: alenka.mauko@zag.si
  STORM (NoI – 2015), contact: alenka.mauko@zag.si
  MIN-PET (Upscaling), contact: vilma.ducman@zag.si
  ACCHAIRSTU (WSL), contact: alenka.mauko@zag.si
  RMCONFDIF (WSL), contact: alenka.mauko@zag.si
  (IMPACT not approved)

- Total EIT KAVA: 74 151 EUR, Total KAVA own: 19 649 EUR, KCA: 329 200 EUR (348 849 EUR own contribution)

www.zag.si 40 3rd Workshop on aRAWness Project, GeoZS, 20/10/2016

- 6/14 project were approved in 2016:
  - FLAME - Upscalling, co. VITO (BE), ZAG contact: ana.mladenovic@zag.si
  - RECOVER - Upscalling, co. KU Lueven (BE), ZAG contact: vilma.ducman@zag.si
  - VISUAL3D – NOI, co. LTU (FI) ZAG partner, alenka.mauko@zag.si
  - MuniMine – WSL, co. TU DELFT (NL), ZAG contact: ana.mladenovic@zag.si
  - DIM ESEE - WSL, co. UZ (CRO), ZAG contact: ana.mladenovic@zag.si
  - VIRTUAL MINE - WSL, co. Cuprum (PL), ZAG contact: mateja.golez@zag.si

www.zag.si 41 3rd Workshop on aRAWness Project, GeoZS, 20/10/2016

Thank you!

Alenka Mauko Pranjić
alenka.mauko@zag.si

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There are no new paths,
only new ways of walking them.

With the pain of the dispossessed,
the dark dreams
of the child who sleeps with hunger –
I have learned:
this Earth does not belong to me alone.

And I have learned, in truth,
that the most important thing
is to work, while we still have life,
to change what needs changing,
each in our way, each where we are.

(Amadeu Thiago de Mello, Brasil's poet, activist for protection of the Amazonian rainforest)

A lecture at the LCA workshop, 27/10/2016, Ljubljana, Slovenia

REPUBLIKA SLOVENIJA
MINISTRSTVO ZA IZOBRAŽEVANJE, ZNANOST IN ŠPORT

EVROPSKA UNIJA
EVROPSKI SKLAD ZA REGIONALNI RAZVOJ
NALOŽBA V VAŠO PRIHODNOST

ZAG

KROŽNO GOSPODARSTVO IN VREDNOTENJE OKOLJSKIH ODTISOV

dr. Alenka Mauko Pranjić
doc. dr. Ana Mladenovič, dr. Janez Turk, dr. Aljoša Šajna, dr. Vesna Zalar Serjun, Primož Oprčkal, Vladimir Bras

Laboratorij za betone, kamen in reciklirane materiale

www.zag.si LCA DELAVNICA - Ljubljana, 27. oktober 2016 – dr. Alenka Mauko Pranjić

- Uvod
- Krožno gospodarstvo in razmišljanje o življenjskem ciklu (LCT)
- Prehod v krožno gospodarstvo – trenutni trendi in priložnosti za gospodarstvo
- Nekaj primerov vrednotenja vplivov na okolje na področju snovne učinkovitosti v gradbeništvu

www.zag.si LCA DELAVNICA - Ljubljana, 27. oktober 2016 – dr. Alenka Mauko Pranjić

ZAG – kdo smo?

ZAG SLOVENIAN NATIONAL BUILDING AND CIVIL ENGINEERING INSTITUTE

www.zag.si

Javna raziskovalna institucija, 181 zaposlenih

4 oddelki: Materiali, Gradbena fizika, Konstrukcije, Geotehnika in prometnice + Laboratorij za metrologijo, letni promet: ca. 8-10 mio €

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Laboratorij za betone, kamen in reciklirane materiale

- Aplikativne raziskave, strokovno delo, svetovanje in nadzor na področju:
  - Betonov (zeleni betoni)
  - Agregati (naravni, umetni, reciklirani)
  - kamen (naravni, aglomerirani)
  - Recikliranje, zelene tehnologije (remediacija vode in tal), zapiranje zank
  - Analiza življenjskega cikla (E-LCA, S-LCA, LCC)
  - Mineraloške analize (npr. azbest, prahovi v delovnem okolju…)
  - Kulturna dediščina
  - 3D in 4D mikroskopija (mikroCT, konfokalna mikroskopija in 3D slikovna analiza)

Razmišljanje o življenjskem ciklu

- Life cycle thinking (LCT):
  - Sistemsko (holistično) razmišljanje o proizvodih, storitvah vzdolž verige vrednosti (življenjskega cikla) in o vplivih na okolje, družbo in gospodarstvo.
  - Poudarek na EoL: ponovna uporaba, recikliranje, energetska izraba, odlaganje kot zadnja rešitev)
  - Kvantifikacija učinkov

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Krožno gospodarstvo

- Circular economy (CE):
  - Sistemsko (holistično) razmišljanje o proizvodih, storitvah vzdolž verige vrednosti (življenjskega cikla) s poudarkom na ekonomskih učinkih ob hkratnem zmanjševanju okoljskih bremen
  - Večji poudarek na preprečevanju odpadkov, ekodizajnu, novih poslovnih modelih
  - Najprimernejša metoda za kvantifikacijo učinkov: LCA

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Vloga LCA v krožni ekonomiji

- Podpira in kvantificira okoljske izboljšave (LCC, S-LCA: ekonomske in socialne)
- Identificira potencialne premike okoljskih bremen
- Zagotavlja optimalni nivo (in omejitve) krožnosti iz okoljskega stališča
- S stališča podjetij: vodilo za odločanje glede izbire najbolj optimalnih materialov, transportnih poti, vrednostnih verig, poslovnih modelov…

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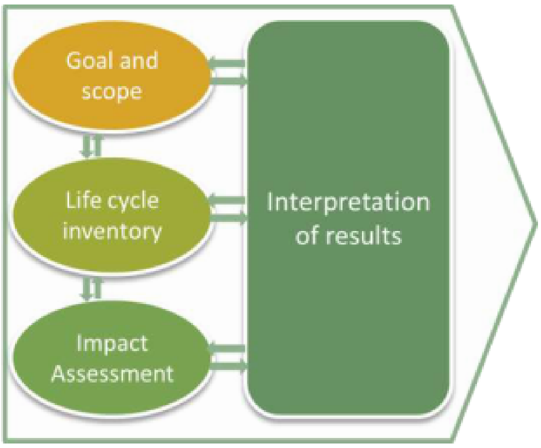
Izzivi



- Kvaliteta / posodobitev podatkov in kategorij vplivov (še posebej v primeru novih tehnologij, npr. vpliv nanotehnologij na okolje in zdravje)
- alokacija vplivov (odpadek, proizvod, stranski proizvod)
- orodja za večkriterijsko odločanje (upoštevanje tehnoloških, zakonodajnih, finančnih, okoljskih in socialnih vplivov)

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Prehod v krožno gospodarstvo

Direktiva o odpadkih (EC 98/2008)

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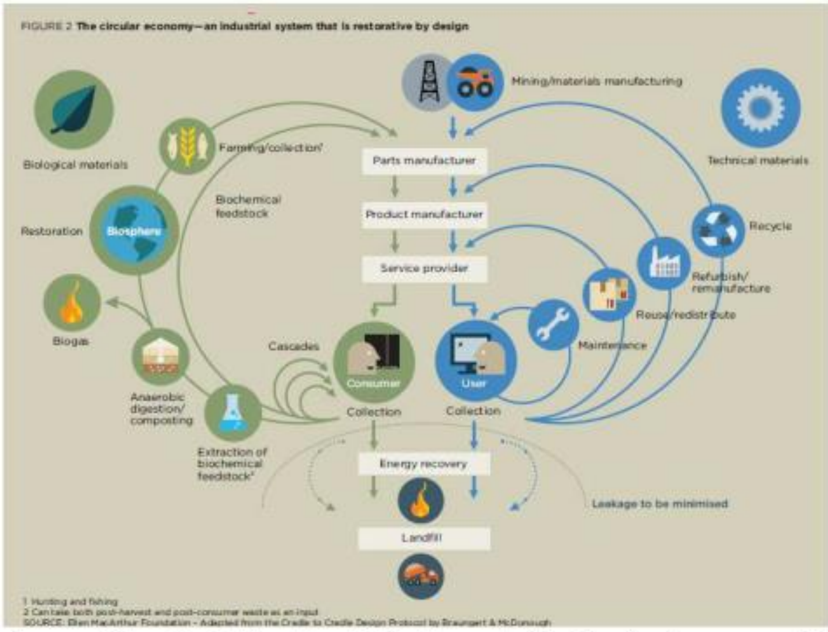
CE – „recikliranje na steroidih "?



Source: Ellen MacArthur Foundation Towards the Circular Economy vol.1

Zapiranje zank

- EU akcijski načrt Zaprtje zank – EU akcijski načrt za krožno gospodarstvo (2.12. 2015) do leta 2018
  - Podpora državam članicam in regijam za krepitev inovacij za krožno gospodarstvo s pametno specializacijo.
  - Sektorski ukrepi: **Plastika, Živilski odpadki, Kritične surovine, Gradbeništvo in rušenje, Biomasa in biosurovine**
  - Biomasa in biosurovine:
    - kaskadna uporaba biomase
    - skladnosti in sinergij s krožnim gospodarstvom pri preučevanju trajnosti bioenergije v okviru energetske unije

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Primarne in sekundarne surovine

- „Primarne surovine, vključno z obnovljivimi materiali, bodo še naprej igrale pomembno vlogo v proizvodnih procesih, tudi v krožnem gospodarstvu.“
  - Učinkovita raba virov
  - **Sekundarne surovine**
  - Promoviranje BAT v BREF dokumentih
  - Industrijska simbioza…

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Recikliranje / sekundarne surovine / proizvodi na osnovi sekundarnih surovin

- Recikliranje* ni dovolj, če se reciklat (sekundarna surovina) ne da na trg kot proizvod!
- Prenehanje statusa odpadka (EOW) kriteriji
- Gotovost glede kvalitete sekundarnih surovin
- Zakonodaja za proizvode na osnovi sekundarnih surovin

Direktiva 2008/98/EC, dodatek 2 – POSTOPKI PREDELAVE
R 5 Recikliranje/pridobivanje drugih anorganskih materialov (***)
*** To vključuje čiščenje tal, katerega rezultat je predelava zemlje in recikliranje anorganskih gradbenih materialov.

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Gradbeni sektor – velika poraba (sekundarnih) surovin

- Načrt za Evropo, gospodarno z viri* vključuje naslednje mejnike za gradbeništvo:

„By 2020 the renovation and construction of buildings and infrastructure will be made to high resource efficiency levels. The Life-cycle approach will be widely applied; all new buildings will be nearly zero-energy and highly material efficient and policies for renovating the existing building stock will be in place so that it is cost-efficiently refurbished at a rate of 2% per year. 70% of non-hazardous construction and demolition waste will be recycled“

*Roadmap to Resource Efficient Europe

[1] COM(2011) Final Communication from the Commission: Roadmap to a Resource Efficient Europe

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Uredba o gradbenih proizvodih[1]

- 7. osnovna zahteva za gradbene objekte: Trajnostna raba naravnih virov
- „Gradbeni objekti morajo biti načrtovani, grajeni in zrušeni tako, da je raba naravnih virov trajnostna in da se zagotovi predvsem naslednje:
  - ponovna uporaba ali možnost recikliranja gradbenih objektov, gradbenega materiala in delov po zrušenju;
  - trajnost gradbenih objektov;
  - uporaba okoljsko združljivih surovin in sekundarnih materialov v gradbenih objektih.

1 EU no. 305/2011

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Gre za snovno učinkovitost

- …in kvalitetne gradbene proizvode na osnovi sekundarnih surovin

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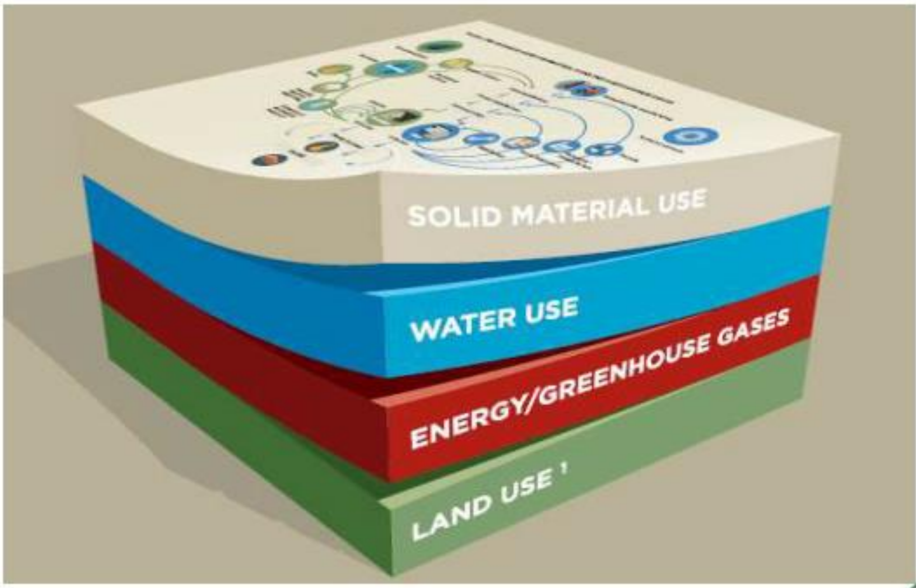
Zakaj snovna učinkovitost in ne energetska?



Vir: Ellen MacArthur Foundation Towards the Circular Economy vol.1

Trajnostni razvojni cilji ZN

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Izzivi krožne ekonomije

- Dolga, kompleksna pot do uspeha?
- Zakonodajne spremembe
- Spreminjanje miselnosti (novi poslovni modeli)
- Spreminjanje potrošniškega obnašanja
- Razvoj novih spretnosti/novih kadrov: T-oblikovani študentje)
- Merjenje učinkov

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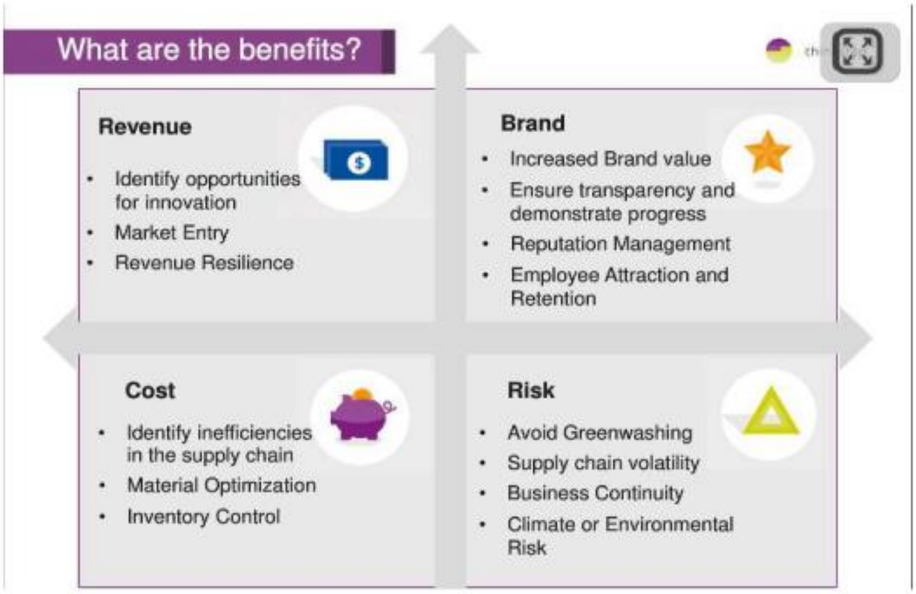
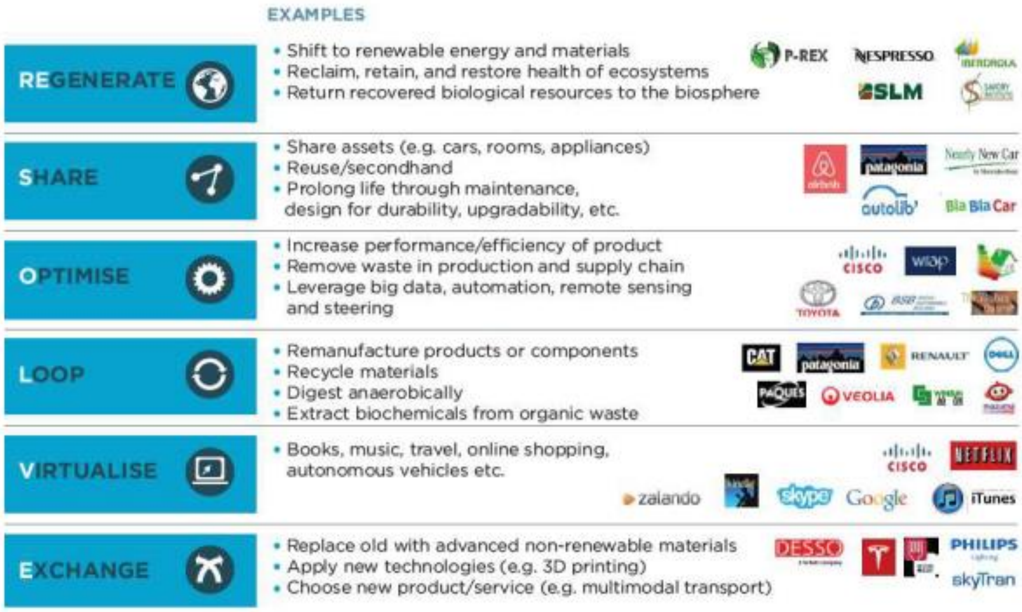
Priložnosti za podjetja

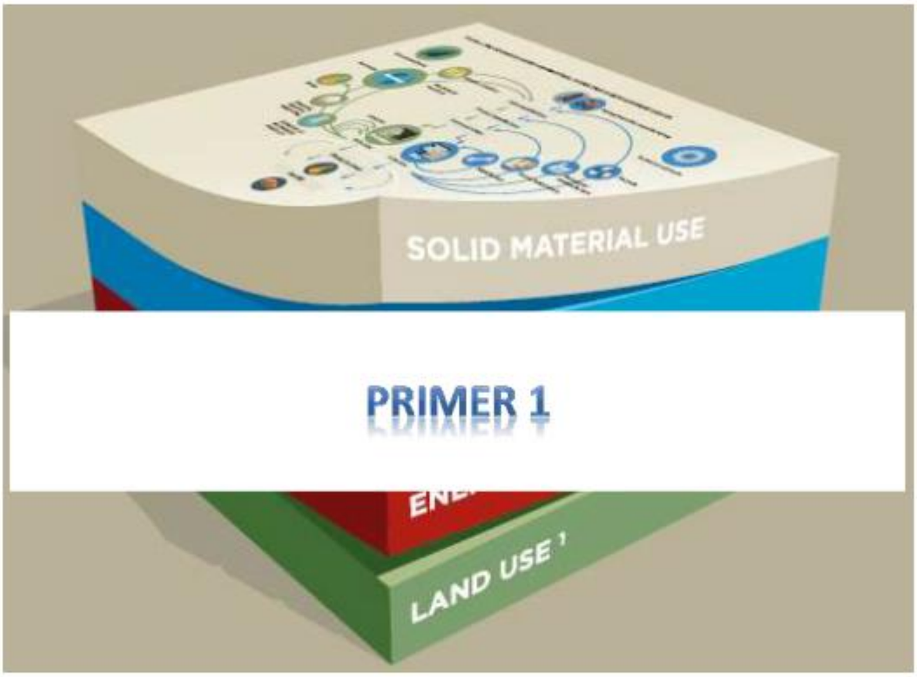


Vir: Lise Lyngfelt Molander and John Jewel: Circular Economy. Practical guide to drive bussinies value. Webinar, 26.10.2016, Sustainable brands

EMC 6 aktivnosti za prehod v CE (RESOLVE)



vir: GROWTH WITHIN: A Circular Economy Vision For A Competitive Europe. Ellen McArthur Foundation, 2015



Vir: Ellen MacArthur Foundation Towards the Circular Economy vol.1

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ReBirth project (2011-2014)

- LIFE+ projekt **Promocija recikliranja industrijskih in gradbenih odpadkov in njihove uporabe v gradbeništvu**

  Promotion of the **Re**cycling of Industrial Waste and **B**uilding **R**ubble for **th**e Construction Industry

ReBirth

Odpadek je začetek novega!

- Proračun projekta: 845.543,00 EUR (50% EC, 20% MOP)

REPUBLIC OF SLOVENIA
MINISTRY OF THE ENVIRONMENT AND SPATIAL PLANNING

ZAG Gospodarska zbornica Slovenije PKG KLARO spletna agencija MAYER McCANN Structum

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- **Glavni cilj**
  - Prispevati k povečanemu in boljšemu recikliranju industrijskih in gradbenih odpadkov ter odpadkov nastalih pri rušenju v gradbenem sektorju.

↑	10 %	15 %	1,5 %	◌	70 %
Continuous growth of the recycling rate for both C&D waste and industrial waste.	**Up to a 10% increase** in the recycling rate for C&D waste.	**Up to a 15% increase** in the recycling rate for inert industrial waste.	Natural material **savings of 1.5%.**	**Reversal of the trend** of illegal dumping of C&D waste. .	**Contribution to the goal of a 70 %** recycling rate by 2020.

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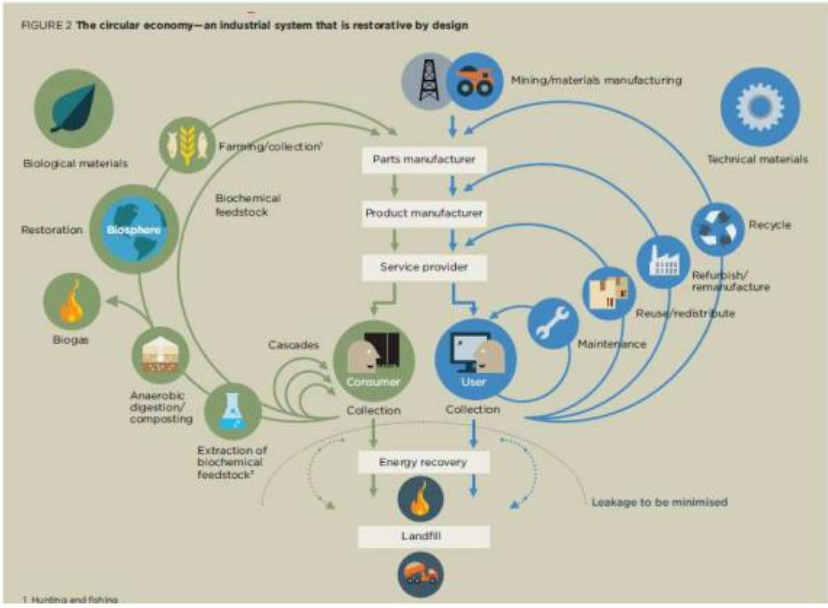
PRIROČNIKI
manuals
5
1720
MOBILNA RAZSTAVA
mobile exhibition
20
1.000
FILMI
films
4
6.365
2014
2 PLENARNI KONFERENCI
2 plenary conferences
19
215
ŠTUDIJA
study
360
DELAVNICE
workshops
8
334
2011
29
ReBirth
v številkah / in numbers
PRAKTIČNI PRIKAZI
on-site demonstrations
4
330
PREDAVANJA
lectures
12
500
E-NOVICE
newsletter
21
1097
SPLETNA STRAN
website
25.352
NAGRADNA IGRA
Raffle
1.386
95%
ReBirth
Odpadek je začetek novega!
enka Mauko Pranjić


Uporaba industrijskih odpaddkov pri gradnji cest, Podbrdo, 14.6.2012
EAF žlindra
Jeklarska
industrija
Umetni agregat
Industrijska simbioza

Selektivno rušenje in uporaba recikliranega agregata, Maribor - Pesnica, 25.04.2013

Obnova ceste po postopku hladne reciklaže na mestu, Bača – Dolenja Trebuša, 11. 7. 2014



Source: Ellen MacArthur Foundation Towards the Circular Economy vol.1

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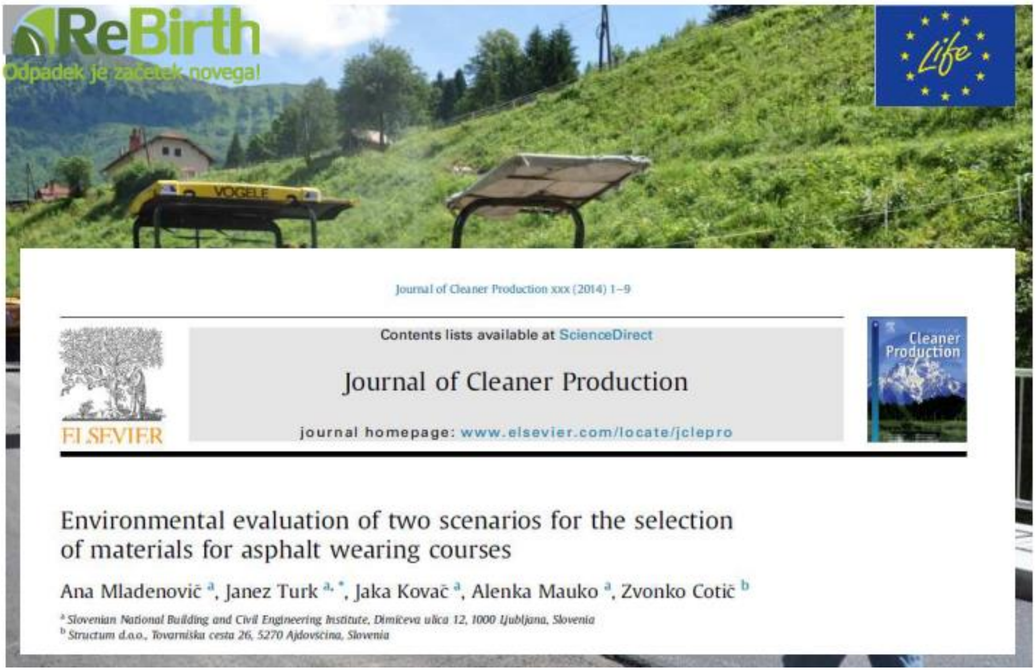
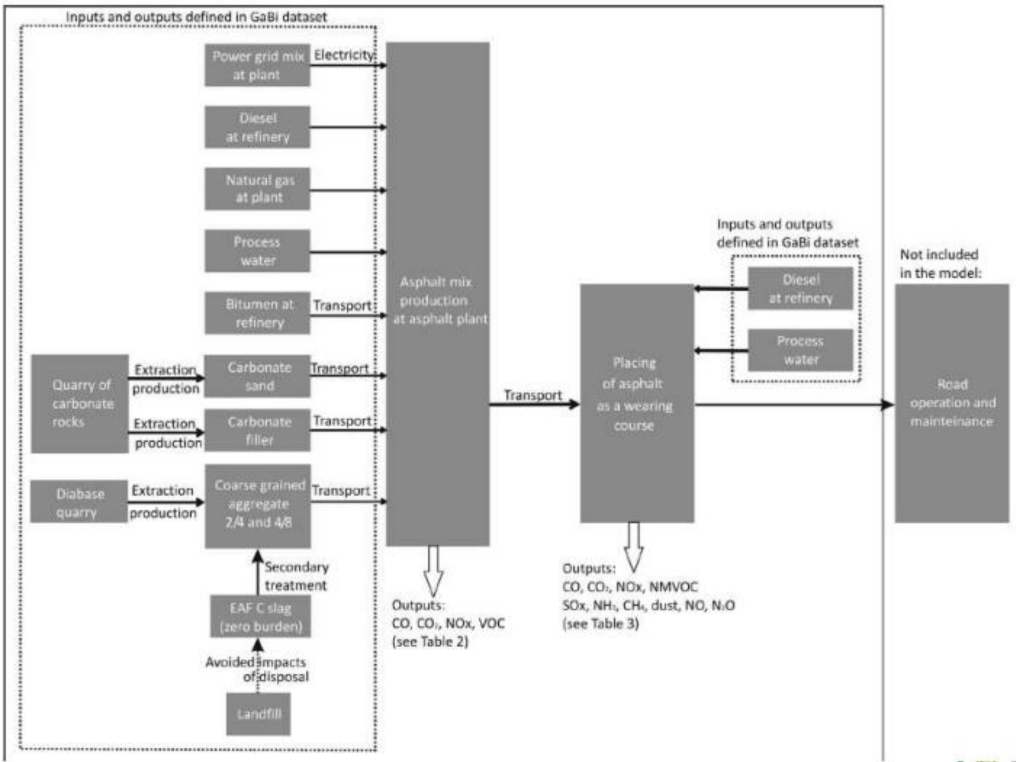
Primer LCA





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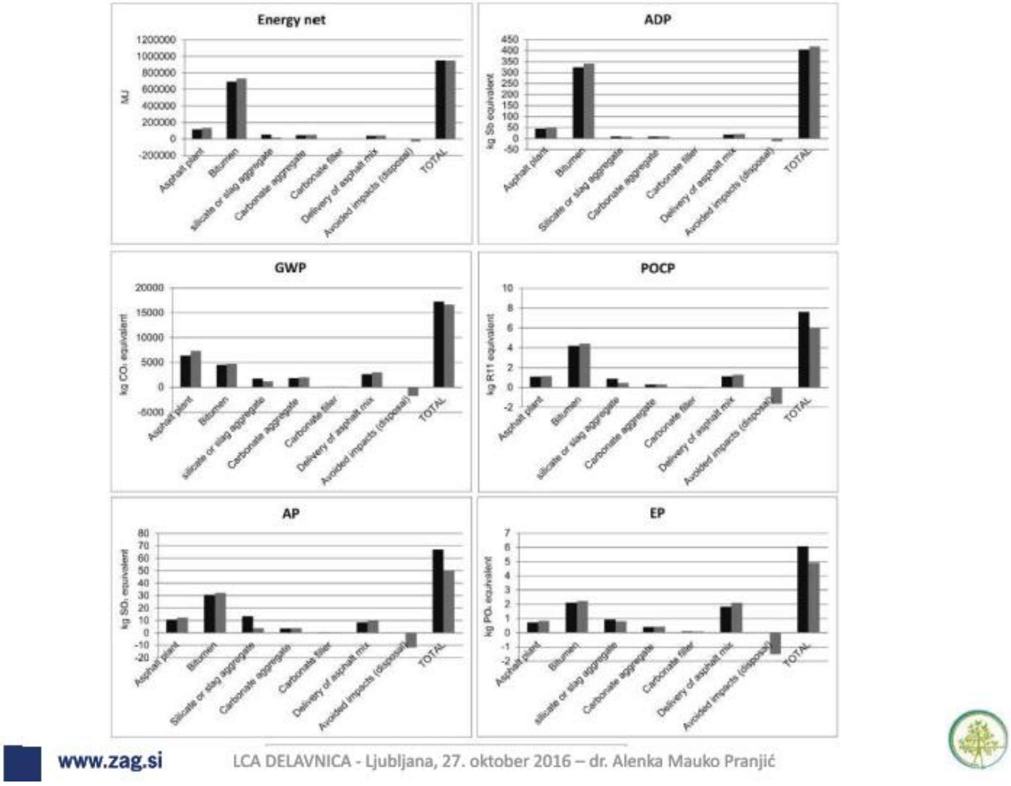
Energy net
MJ
ADP
kg Sb equivalent
GWP
kg CO2 equivalent
POCP
kg R11 equivalent
AP
kg SO2 equivalent
EP
kg PO4 equivalent
Asphalt plant
Bitumen
Silicate or slag aggregate
Carbonate aggregate
Carbonate filler
Delivery of asphalt mix
Avoided impacts (disposal)
TOTAL
www.zag.si
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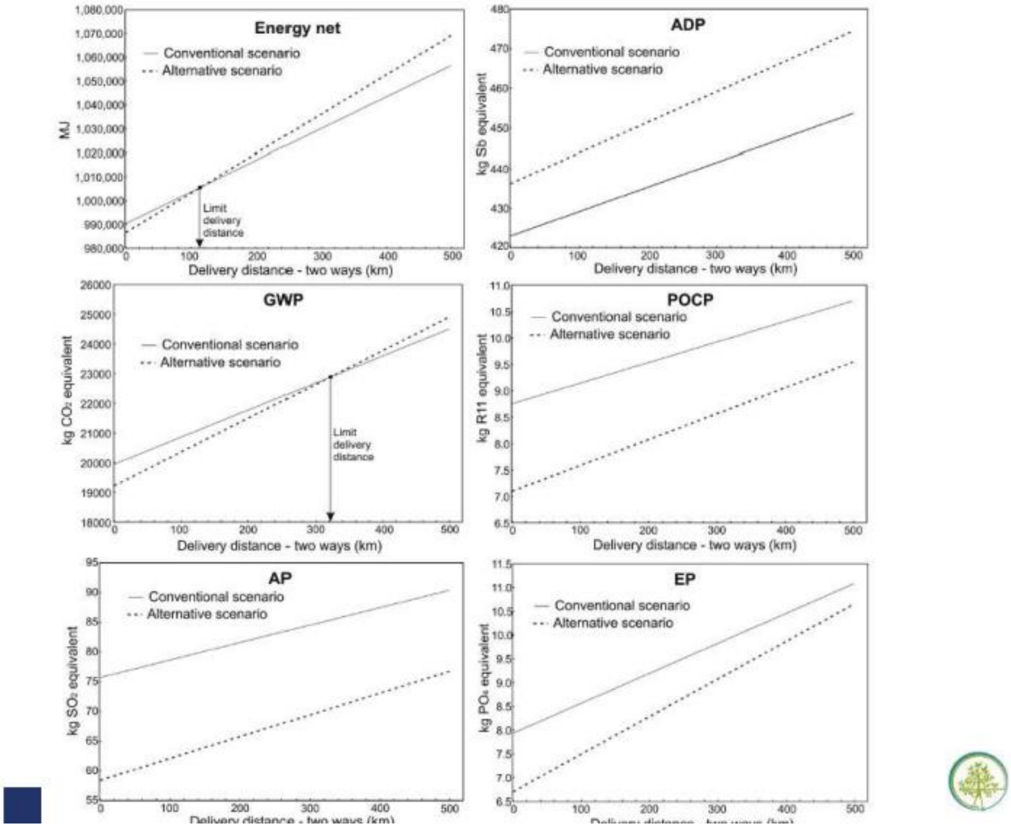

Energy net
ADP
GWP
POCP
AP
EP
Conventional scenario
Alternative scenario
Limit delivery distance
MJ
kg Sb equivalent
kg CO2 equivalent
kg R11 equivalent
kg SO2 equivalent
kg PO4 equivalent
Delivery distance - two ways (km)

Journal of Cleaner Production 121 (2016) 45–55

Contents lists available at ScienceDirect

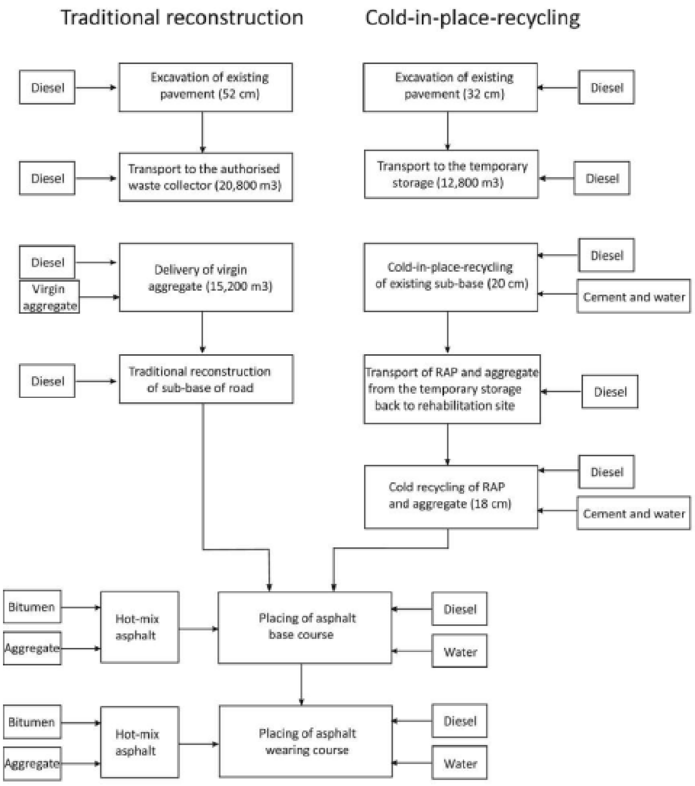
Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

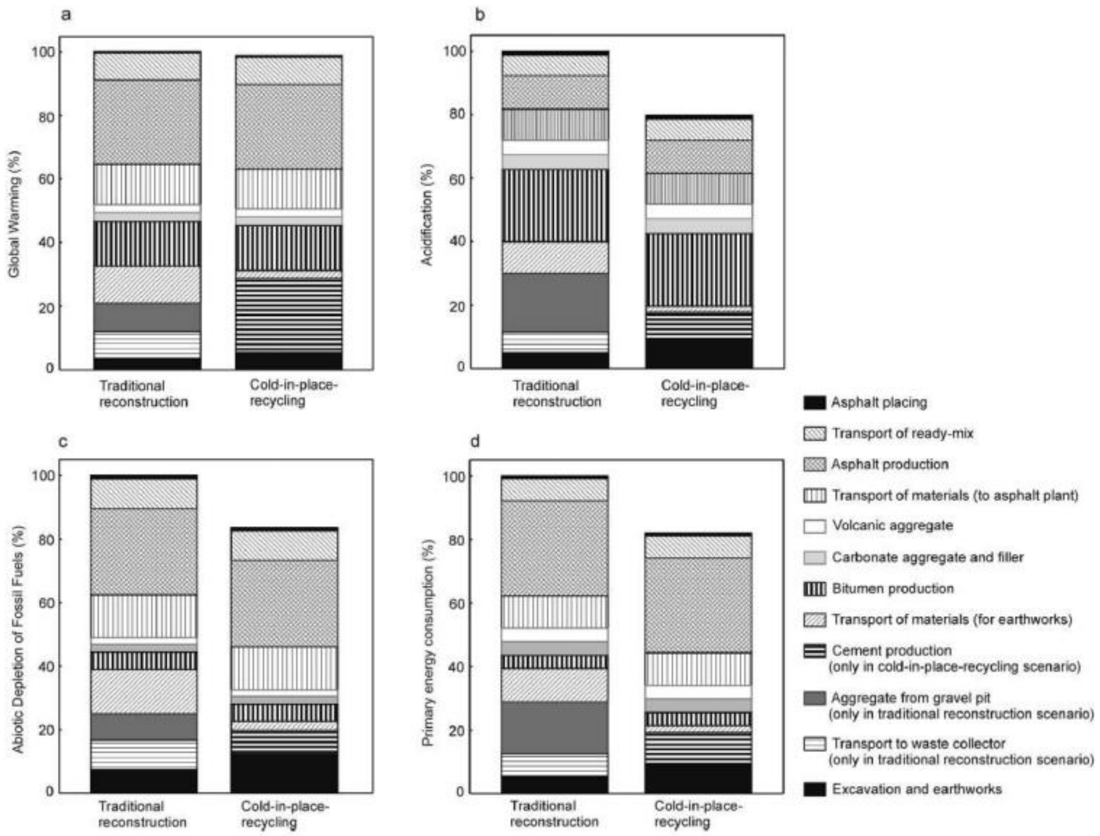
Environmental comparison of two alternative road pavement rehabilitation techniques: cold-in-place-recycling versus traditional reconstruction

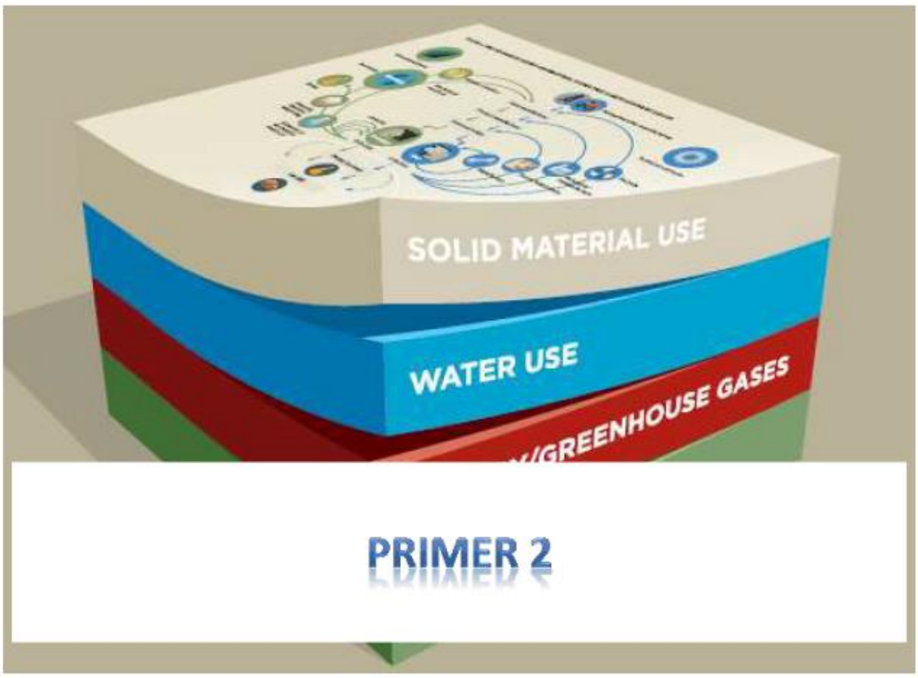
Janez Turk [a, *], Alenka Mauko Pranjić [a], Ana Mladenovič [a], Zvonko Cotič [b], Primož Jurjavčič [b]

[a] Slovenian National Building and Civil Engineering Institute, Dimičeva ulica 12, 1000 Ljubljana, Slovenia
[b] Structum d.o.o., Tovarniška cesta 26, 5270 Ajdovščina, Slovenia



www.zag.si





Vir: Ellen MacArthur Foundation Towards the Circular Economy vol.1

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CE in uporaba vode

- Zaprtje zanke – akcijski načrt EU za krožno gospodarstvo
- 4. Od odpadkov do virov: krepitev trga sekundarnih surovin in ponovna uporaba vode
  - „Poleg ukrepov za učinkovito porabo vode je ponovna uporaba prečiščene odpadne vode pod varnimi in stroškovno učinkovitimi pogoji dragocen način za povečanje oskrbe z vodo in zmanjšanje pritiska na prekomerno izkoriščanje vodnih virov v EU, vendar se ta premalo uporablja. Ponovna uporaba vode v kmetijstvu tudi prispeva k recikliranju hranil z nadomestitvijo trdnih gnojil. Komisija bo sprejela vrsto ukrepov za spodbujanje ponovne uporabe prečiščene odpadne vode, vključno z zakonodajo o minimalnih zahtevah za ponovno uporabljeno vodo."

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LIFE RusaLCA

- LIFE RusaLCA LIFE12 ENV/SI/000443: Nanoremediation of water from small waste water treatment plants and reuse of water and solid remains for local needs www.rusalca.si
- Proračun: 852.388 EUR (50% EC financing)
- Partnerji: ZAG, IJS, Šentrupert Municipality, NLZOH, Structum, PKG


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COMMUNITY DEVELOPMENT
Economic Prosperity
Cultural Vitality
Social Equity
Environmental Sustainability
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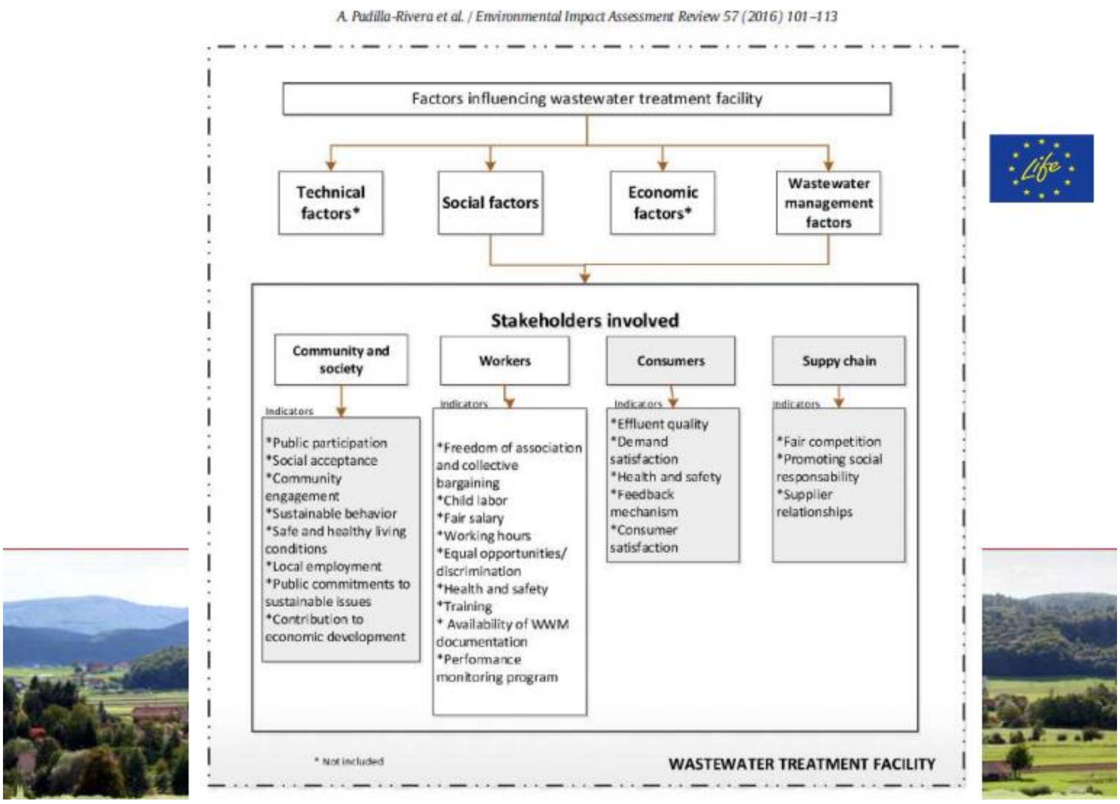
A. Padilla-Rivera et al. / Environmental Impact Assessment Review 57 (2016) 101–113
Factors influencing wastewater treatment facility
Technical factors*
Social factors
Economic factors*
Wastewater management factors
Stakeholders involved
Community and society
Workers
Consumers
Suppy chain
Indicators
*Public participation
*Social acceptance
*Community engagement
*Sustainable behavior
*Safe and healthy living conditions
*Local employment
*Public commitments to sustainable issues
*Contribution to economic development
*Freedom of association and collective bargaining
*Child labor
*Fair salary
*Working hours
*Equal opportunities/ discrimination
*Health and safety
*Training
* Availability of WWM documentation
*Performance monitoring program
*Effluent quality
*Demand satisfaction
*Health and safety
*Feedback mechanism
*Consumer satisfaction
*Fair competition
*Promoting social responsability
*Supplier relationships
* Not included
WASTEWATER TREATMENT FACILITY

A. Padilla-Rivera et al. / Environmental Impact Assessment Review 57 (2016) 101–113

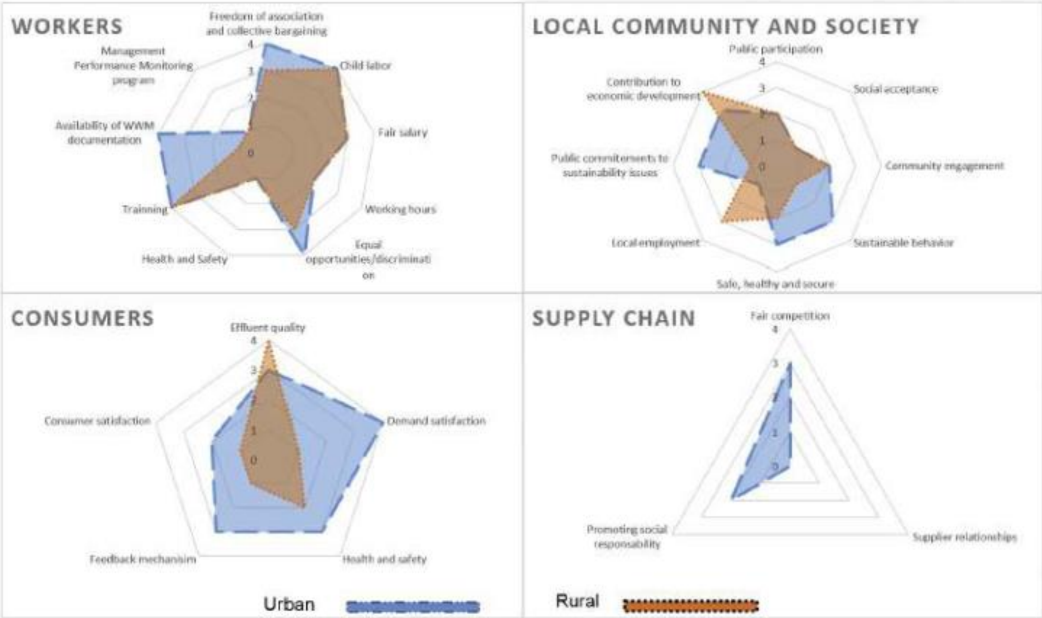

Fig. 2. Performance evaluation of the 26 indicators grouped for the four stakeholders considered in the facilities under study.

www.zag.si LCA DELAVNICA - Ljubljana, 27. oktober 2016 – dr. Alenka Mauko Pranjić

ŠE VEČ PRIMEROV…

Vir: Ellen MacArthur Foundation Towards the Circular Economy vol.1

www.zag.si LCA DELAVNICA - Ljubljana, 27. oktober 2016 – dr. Alenka Mauko Pranjić

Recikliranje in uporaba katranskega rezkanca

- Katranski rezkanec (17 03 01*bitumenske mešanice, ki vsebujejo premogov katran)
- 4500 ton - letališče Brnik: scenarij 1: sežig v Nemčiji, scenarij 2: nadomeščanje 40 mas% naravnega agregata

Journal of Cleaner Production 81 (2014) 201–210

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

ELSEVIER

Tar-containing reclaimed asphalt — Environmental and cost assessments for two treatment scenarios

Janez Turk [a,*], Ana Mladenović [a], Friderik Knez [a], Vladimir Bras [a], Aljoša Šajna [a], Andrej Čopar [b], Katja Slanc [a]

[a] Slovenian National Building and Civil Engineering Institute, Dimičeva ulica 12, 1000 Ljubljana, Slovenia

Zeleni betoni (TIGR projekt)

- „Zeleni betoni": recikliran ali umetni agregat, vezivo, dodatki ali kombinacija tega
- Livarski pesek, jeklarska žlindra in EFP
- Pozitivni učinki: preprečevanje odlaganja, ekstrakcija

Waste Management 45 (2015) 194–205

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

ELSEVIER

Environmental evaluation of green concretes versus conventional concrete by means of LCA

Janez Turk [a,*], Zvonko Cotič [b], Ana Mladenović [a], Aljoša Šajna [a]

[a] Slovenian National Building and Civil Engineering Institute, Dimičeva ulica 12, 1000 Ljubljana, Slovenia
[b] Structum d.o.o., Tovarniška cesta 26, 5270 Ajdovščina, Slovenia

EIT Raw Materials

- Evropski inštitut za inovacije in tehnologije
  http://eitrawmaterials.eu/
- Projekti na temo recikliranja/krožne ekonomije
  - ResiduFlex (NoI), contact: vilma.ducman@zag.si
  - EXTREME (NoI), contact: vilma.ducman@zag.si
  - STORM (NoI), contact: alenka.mauko@zag.si
  - OREVAL (NoI), contact: alenka.mauko@zag.si
  - MIN-PET (Upscaling), contact: vilma.ducman@zag.si
  - ACCHAIRSTU (WSL), contact: alenka.mauko@zag.si
  - RMCONFDIF (WSL), contact: alenka.mauko@zag.si
  - FLAME - Upscalling, co. VITO (BE), ZAG contact: ana.mladenovic@zag.si
  - RECOVER - Upscalling, co. KU Lueven (BE), ZAG contact: vilma.ducman@zag.si
  - MuniMine – WSL, co. TU DELFT (NL), ZAG contact: ana.mladenovic@zag.si
  - DIM ESEE - WSL, co. UZ (CRO), ZAG contact: ana.mladenovic@zag.si

Hvala!

Alenka Mauko Pranjić

alenka.mauko@zag.si

There are no new paths,
only new ways of walking them.

With the pain of the dispossessed,
the dark dreams
of the child who sleeps with hunger –
I have learned:
this Earth does not belong to me alone.

And I have learned, in truth,
that the most important thing
is to work, while we still have life,
to change what needs changing,
each in our way, each where we are.

(Amadeu Thiago de Mello, Brasil‘s poet, activist for protection of the Amazonian rainforest)

Lecture for students of Faculty of Nova Gorica: " Life cycle assessment - methodology and examples from practice", 14/04/2016, Faculty of Nova Gorica, Vipava, Slovenia

ZAG ZAVOD ZA GRADBENIŠTVO SLOVENIJE
SLOVENIAN NATIONAL BUILDING AND CIVIL ENGINEERING INSTITUTE

Life cycle assessment – Methodology and examples from practice

Alenka Mauko Pranjić (Ph. D. Geol.)
Laboratory for Concrete, Stone and Recycled Materials

UNG, School of Environmental Studies
14.4.2016, Vipava

ZAG – who we are?

ZAG SLOVENIAN NATIONAL BUILDING AND CIVIL ENGINEERING INSTITUTE

www.zag.si

Public research institute, 181 employees, 5 departments: Materials, Building Physics, Construction, Road Infrastructure, Metrology, annual turnover: app. 8-10 mio €

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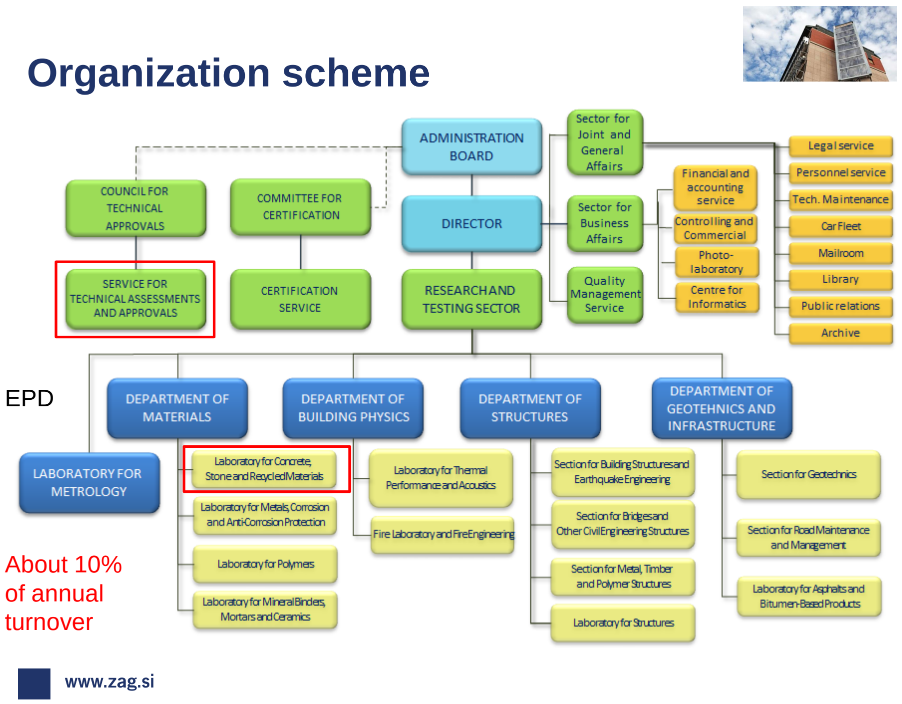
Organization scheme



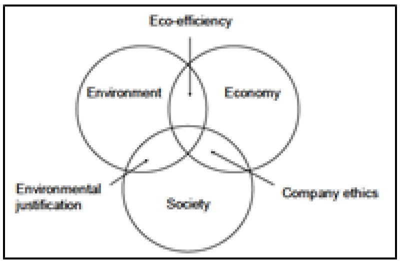
Laboratory for Concrete, Stone and Recycled Materials

- Applicative researches work as well as expert work, consultancy and supervision in the following area:
  - Concretes (incl. development of green concretes)
  - Aggregate (natural, recycled, artificial)
  - Stone (natural, agglomerated)
  - Recycling, development of sustainable construction products and remediation (water, soil)
  - Cultural heritage
  - Life cycle assessment (E-LCA, S-LCA, LCC)
  - Mineralogical analysis (e.g. asbestos, dust in working environments…)
  - 3D microscopy (microXCT and confocal microscopy)

The three pillars of sustainability

The Brundtland Commission of the United Nations 20/3/1987:

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."



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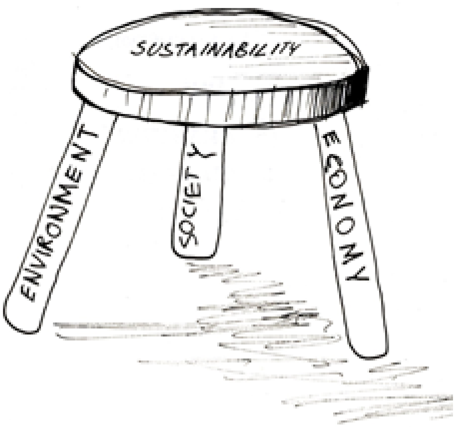
The three pillars of sustainability

- The **three pillar approach**
- **People**,
- Planet and
- Profit/Prosperity.
  - Life cycle perspective > PPP along **the whole supply chain**, from the extraction of raw material to the end of life



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Social LCA (S-LCA)

- The integration of additional social impacts in LCA (beyond the assessment of human health which is already common) is progressing.
  - UNEP: Guidelines for Social Life Cycle Assessment of Products (S-LCA), 2009
  - UNEP: The Methodological Sheets for Sub-categories in Social Life Cycle Assessment (S-LCA), 2013

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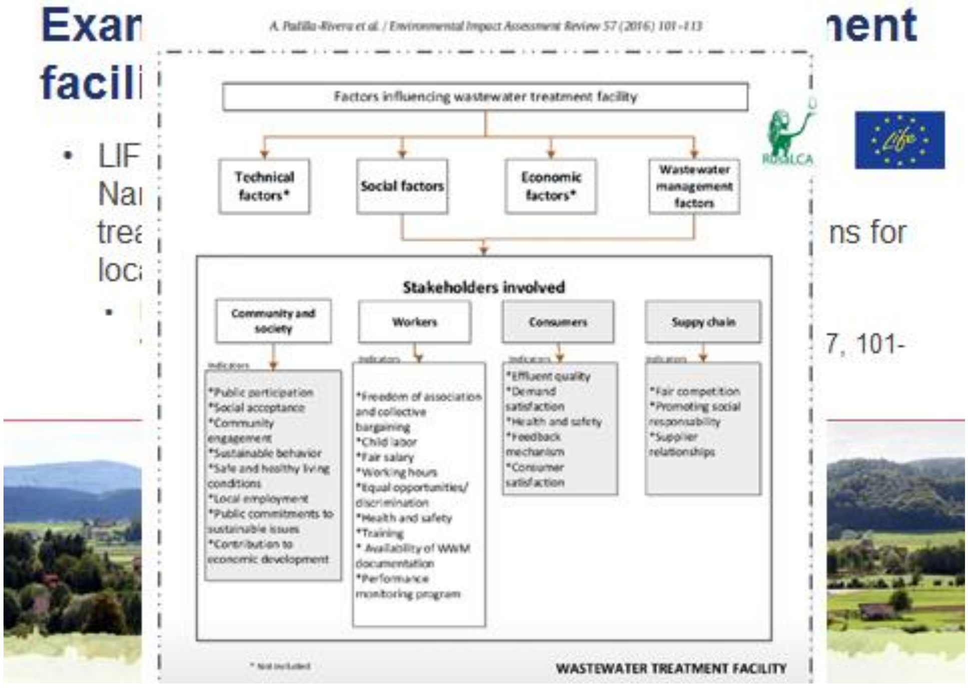
Example: Small Waste water treatment facility

- LIFE RusaLCA LIFE12 ENV/SI/000443: Nanoremediation of water from small waste water treatment plants and reuse of water and solid remains for local needs www.rusalca.si
  - Padilla-Rivera et al. 2016: Addressing social aspects with wastewater treatment facilities. Env. Imp. Asses. Review 57, 101-113



A. Padilla-Rivera et al. / Environmental Impact Assessment Review 57 (2016) 101–113

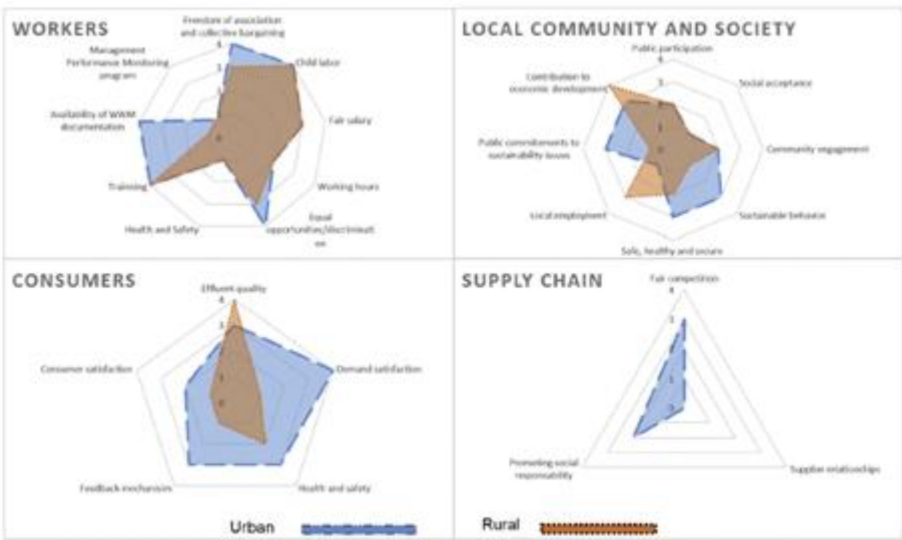


Fig. 2. Performance evaluation of the 26 indicators grouped for the four stakeholders considered in the facilities under study.

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Life cycle cost analysis (LCCA)

- An economic method of project evaluation in which all costs arising from owning, maintaining and ultimately disposing of a project are considered to be potentially important to that decision.
  - LCCA shares the life cycle dimension of LCA.
  - Much of the technology descriptions and flows required in LCA are also required in LCCA.

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- Integrated approach:
  - monetising environmental impacts on current or long term expected trading costs from greenhouse impacts, monetising health and environmental damage

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Life cycle thinking - LCT

- Before: **minimising pollution from single sources** (e.g. discharges into rivers and emissions from factories)

- Life Cycle Thinking (LCT): possible improvements to goods and services in the form of lower environmental impacts and the reduced use of resources **across all life cycle stages**.

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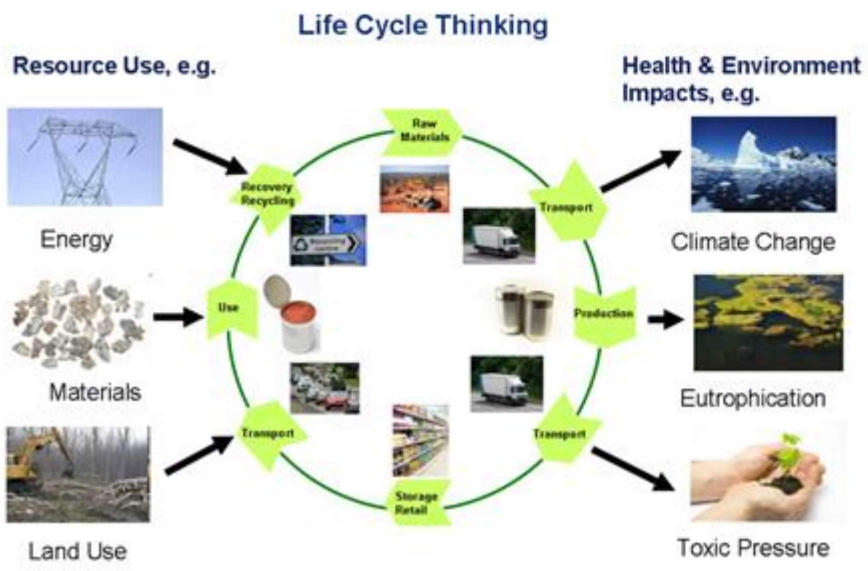

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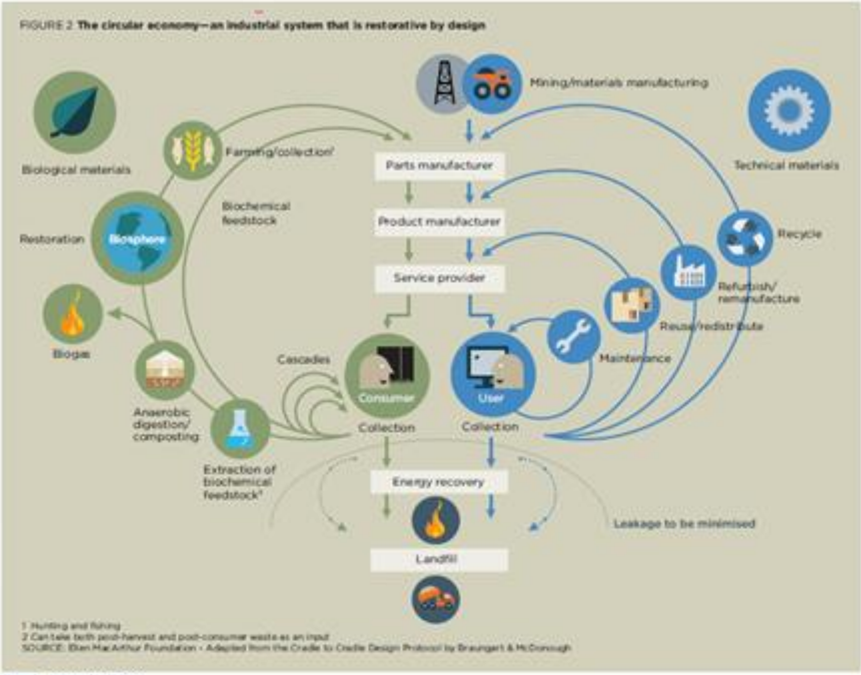

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- The key aim of LCT is **to avoid burden shifting**.
  - This means minimising impacts at one stage of the life cycle, or in a geographic region, or in a particular impact category, while helping to avoid increases in burdens elsewhere.

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- Taking a life cycle perspective requires:
  - a policy developer, environmental manager or product designer **to look beyond their own knowledge and in-house data**.
  - cooperation up and down the supply chain.
- At the same time, it also provides an opportunity to use knowledge that has been gathered to **gain significant economic advantages**.

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- Benefits for industry and society:
  - **Avoiding burden shifting**,
  - **Revealing the complexity of the system**, which is triggered by an action which can have several negative environmental effects,
  - **Connecting people more directly with the impacts of their life style** and demonstrating how each action has a reaction which is sometimes asymmetrically worse for the environment,
  - **Making companies more mindful of environmental impacts** of their operations.

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- Benefits for industry and society (continued):
  - Help identify **cost cutting possibilities**,
  - Help identify **less harmful operation strategies**,
  - Provide people with **a framework to make choices** that will have less environmental impact over a whole life cycle.
  - **Create a culture focused on sustainability** rather than short term gratification.

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Life cycle assessment - LCA

- A method for characterizing and quantifying environmental sustainability (only environmental!)
  - Measuring the inputs and outputs of a product or system
  - Example inputs: energy, water, materials
  - Example outputs: air emissions, waste
- Within the framework of sustainability, LCA is also called **Environmental LCA (E-LCA)**
- It is a structured and globally standardized method for the quantitative environmental evaluation of products (goods and services) - **ISO 14040 series**

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What is E-LCA?

- General standards set by the **ISO 14040 series**:
  - ISO 14040 Principles and Framework,
  - ISO 14044 Requirements and Guidelines,
  - ISO 14047 Impact Assessment

- lacks the detailed information needed for individual products and systems => Further details: the ILCD handbook and other literature.

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EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN ISO 14040

July 2006

English Version

Environmental management - Life cycle assessment - Principles and framework (ISO 14040:2006)

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History of LCA

- The precursors of LCA emerged in the late 1960s and early 1970s from concerns about limited natural resources, particularly oil.
  - They came in the form of global modeling studies and energy audits. They were referred to as Resource and Environmental Profile Analyses (REPA) and Net Energy Analyses.

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Life Cycle Thinking TIMELINE (adopted by „Making Sustainable Consumption and production a reality. A guide for bossiness and policy makers to Life Cycle Thinking and Assessment)	
1963	Early studies known as Resource and Environmental Profile Analyses (REPA).
1969	First comparative multi- criteria environmental study for Coca Cola - became basis for the current method for life cycle studies.
1991	The Society of Environmental Toxicology and Chemistry (SETAC) develops the Impact Assessment method for LCA.
1992	First European scheme on Ecolabels, established by the European Commission; World Business Council for Sustainable Development (WBCSD) founded by industry to address sustainability.
1995	SETAC develops Code of Practice for Life Cycle Assessment; first Life Cycle Assessment on a car – VW Golf.
1996	International Organization for Standardization (ISO) launches first standards on Life Cycle Assessment.
2001	European Commission releases Green Paper on Integrated Product Policy (IPP) building on Life Cycle Thinking.
2002	United Nations Environment Programme (UNEP) / SETAC Life Cycle Initiative launched.
2003	European Commission Communication on Integrated Product Policy.

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Life Cycle Thinking TIMELINE cont.	
2005	European Platform on Life Cycle Assessment established at the European Commission; EU Thematic Strategies on the prevention and recycling of waste and the sustainable use of natural resources published.
2006	First version of the Commission's European Reference Life Cycle Database (ELCD) goes online.
2007	Start of development of International Reference Life Cycle Data System (ILCD) Handbook.
2008	European Commission launches Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan. First public specification for carbon footprinting published (British PAS2050).
2009	ISO initiates development of first international standard for product carbon footprinting; the World Business Council for Sutainable Development (WBCSD) and the World Resources Institute (WRI) start drafting a Green House Gas (GHG) Protocol Product / Supply Chain Standard and life cycle based Scope 3 Corporate Standard.
2010	Launch of the ILCD Handbook by the European Commission.

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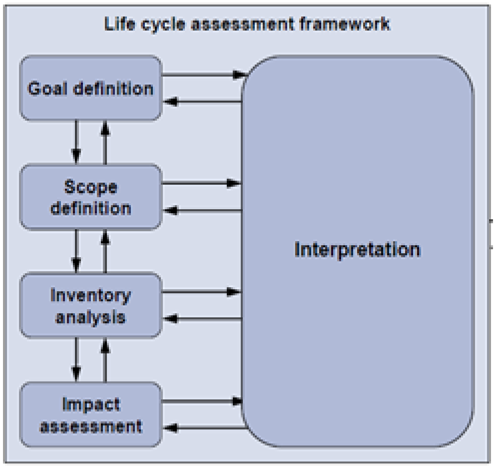
How do we carry out LCA?

- Four phases in an LCA study:
  - the goal and scope definition phase,
  - the inventory analysis phase,
  - the impact assessment phase, and
  - the interpretation phase.



Source: ISO 14040:2006

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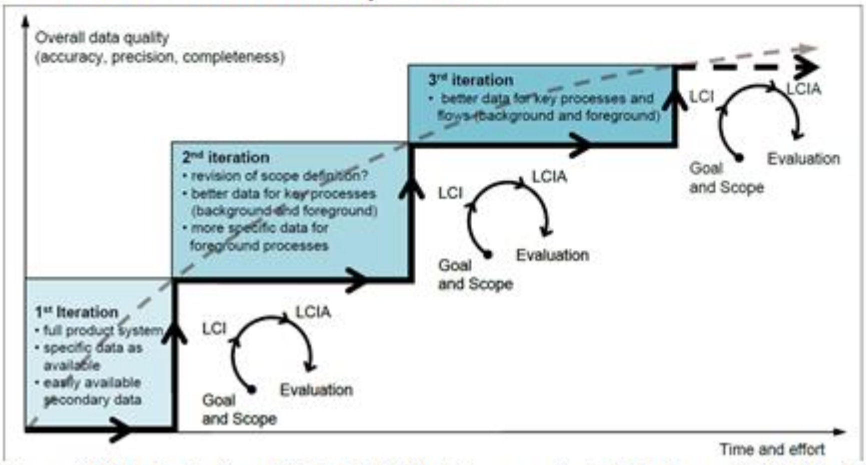
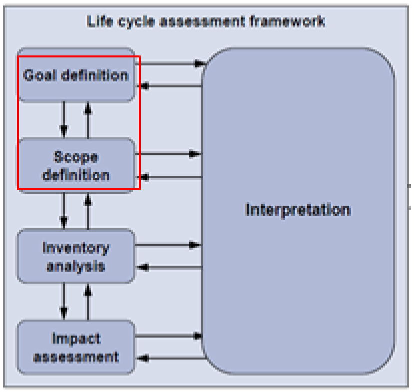
- LCA as an iterative process



Source: ILCD handbook. General Guide for Life Cycle Assessment – detailed guidance. JRC,2010, p. 25

Goal Definition and Scope

- Goal Definition and Scope
  - System boundary definition
  - What can be left out of LCA
  - Function and functional unit
  - Data requirements, assumptions, limitations…
- Defining goals and scope is an extremely important step!



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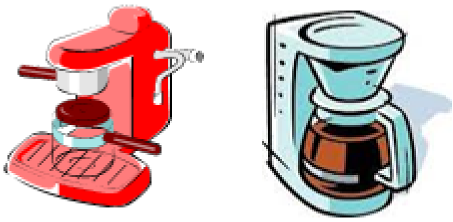

Let's look at an example!

- Example – definition of a functional unit for two coffee machines
- Indication that the more durable, heavily built of the two has the higher environmental impact, if the product comparison is based on the product level.

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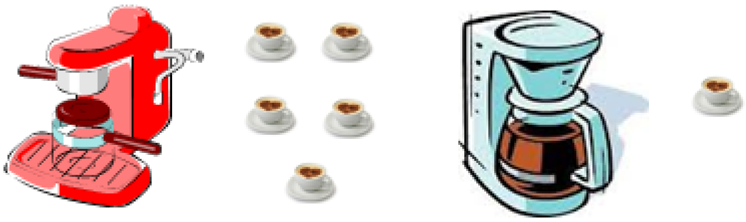

- If however it is based on the **FUNCTIONAL UNIT** level, we may find that the more durable product has a life span which enables it to produce five times as many cups of coffee over its lifetime.

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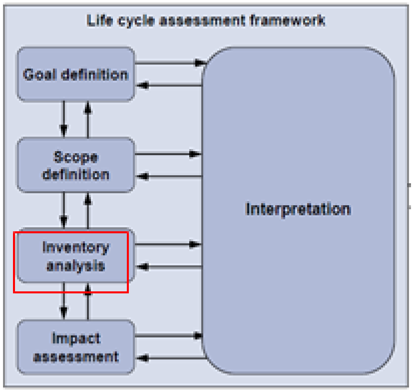
Life Cycle Inventory

- The **„accounting“ stage** for LCA => compiling all environmental flows, including resource use inputs and waste or pollution outputs.
  - The inputs and outputs associated with a product's life cycle are collated in a 'balance sheet', or life cycle 'inventory'.



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- **Data quality consideration**
  - We often rely on existing life cycle inventory datasets, rather than collecting new data
  - Considerations include:
    - The age of the datasets
    - Are the datasets in a study all collected and created with the same methodology?
    - Geography of the study versus geography of the data
    - Uncertainty in data
- Where do we get data?
  - Existing datasets (e.g. Ecoinvent, ELCD…)
  - Journal papers, research reports, industry data, government data…

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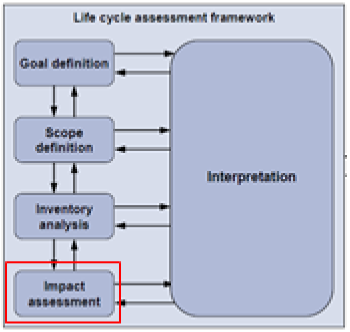
Impact assessment

- When an inventory of all the inputs and outputs has been made, they are grouped into **impact categories** (e.g. climate change, ozone depletion, eutrophication, acidification, human toxicity,..).
  - This can be grouped into three areas of protection: **human health**, **the natural environment**, and **natural resource use.**



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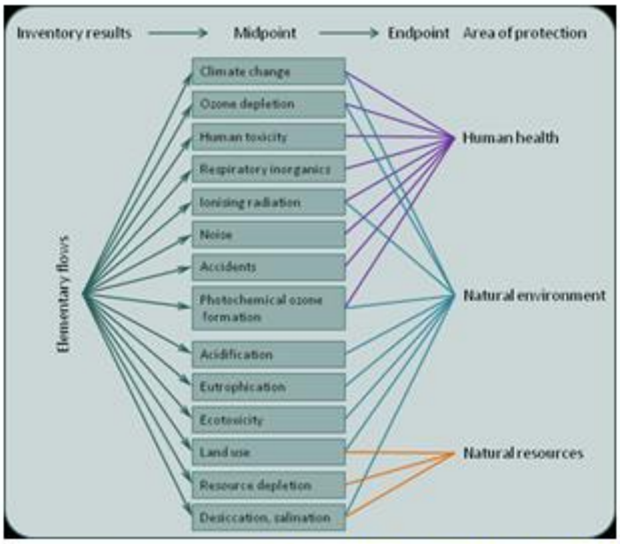

Life cycle impact assessment. http://lct.jrc.ec.europa.eu/assessment

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Examples of environmental impact categories (adopted by „Making Sustainable Consumption and production a reality. A guide for business and policy makers to Life Cycle Thinking and Assessment)	
Impact category	**Description**
Climate change	Carbon dioxide, methane and other greenhouse gases released into the environment allow sunlight to pass through the earth's atmosphere, but absorb the infrared rays that reflect off land and water. This inhibits their escape and therefore heats up the atmosphere
Human toxicity	Exposure to a chemical substance over a designated time period can cause adverse health effects to humans.
Ecotoxicity	Emissions of substances (residues, leachate, or volatile gases) that disrupt the natural biochemistry, physiology, behaviour and interactions of the living organisms that make up ecosystems. A distinction is made between different ecosystems, such as freshwater and terrestrial.

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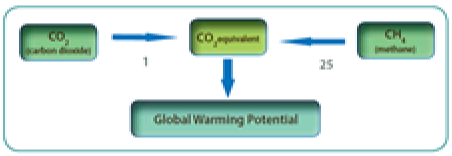
- The inputs and outputs are then converted into **indicators for each impact category** using models and scientific knowledge.
  - For example, all greenhouse gases are grouped under the the **'climate change' impact category**. In order to compare these and illustrate the contribution to climate change in the form of a single indicator (often known as the carbon footprint), all inputs are harmonised to an equivalent and then added together – in this case, as 'kg of CO_2 equivalents'.



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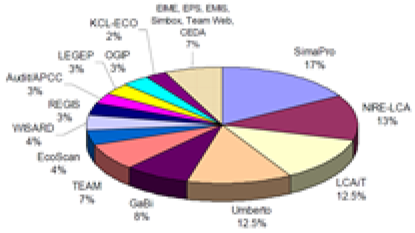
Dedicated LCA software

- In some cases standard software such as MS Excel or company specific software can be used, but most practitioners also use dedicated software (e.g. Gabi - thinkstep, SimaPro - PRé)



http://www.gabi-software.com/ce-eu-english/index/
http://www.pre-sustainability.com/
Image source: LCA Software Guide 2005. Market Overview – Software Portraits. ÖBU

Environmental Product Declarations (EPD)

- Type III environmental declaration provides **quantified environmental data** using predetermined parameters and, where relevant, additional environmental information
  - We know „what we are“ but we don't know how „good“ we are.
- Standardized procedure, making use of the international standard ISO 14025

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- EPD is:
  - Based on independently verified LCA data
  - Usually used for business-to-business communication, but can be also used for business-to-consumer communication
  - EPD for individual group of products based on a product category rule (PCR)
  - Improved market position and customer image through schemes

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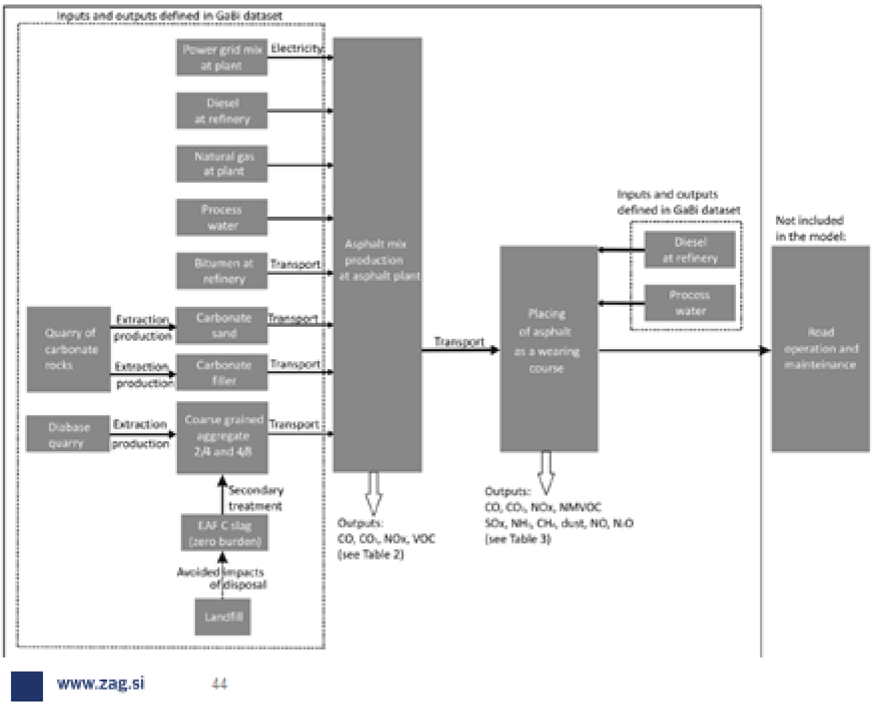
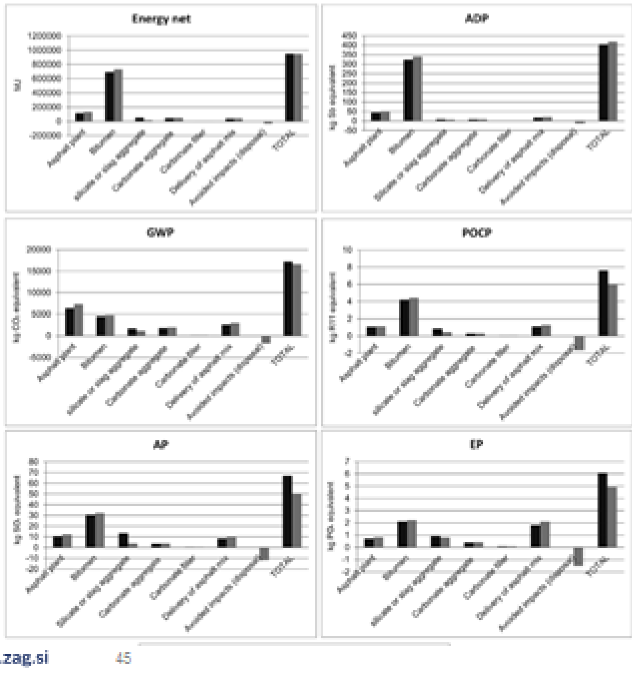
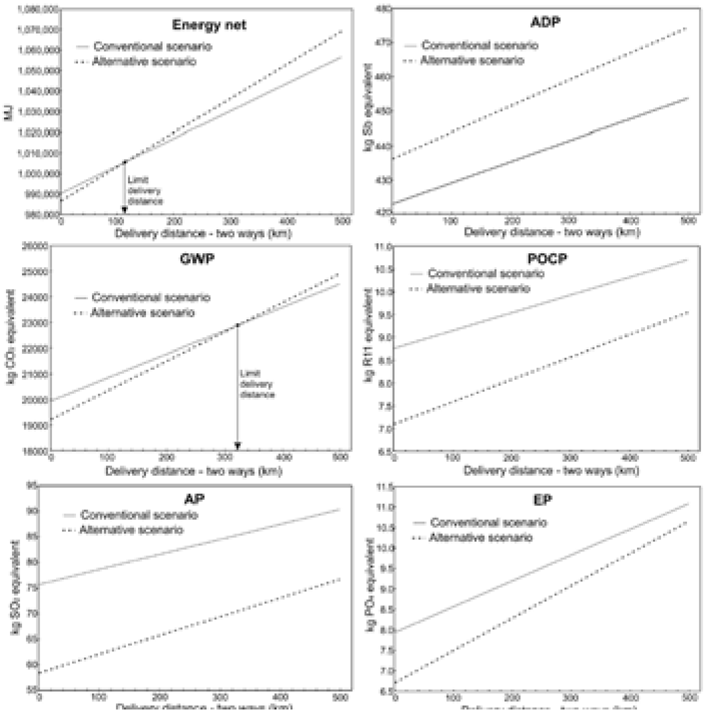
Example 1: Selection of material used for wearing course
ReBirth
Odpadek je začetek novega!
Life


Example 1: Selection of material used for wearing course
ReBirth
Odpadek je začetek novega!
Life
Journal of Cleaner Production xxx (2014) 1–9
Contents lists available at ScienceDirect
Journal of Cleaner Production
journal homepage: www.elsevier.com/locate/jclepro
ELSEVIER
Cleaner Production
Environmental evaluation of two scenarios for the selection of materials for asphalt wearing courses
Ana Mladenović [a], Janez Turk [a,*], Jaka Kovač [a], Alenka Mauko [a], Zvonko Cotič [b]
[a] Slovenian National Building and Civil Engineering Institute, Dimičeva ulica 12, 1000 Ljubljana, Slovenia
[b] Structum d.o.o., Tovarniška cesta 26, 5270 Ajdovščina, Slovenia


Inputs and outputs defined in GaBi dataset
Power grid mix at plant
Electricity
Diesel at refinery
Natural gas at plant
Process water
Bitumen at refinery
Transport
Quarry of carbonate rocks
Extraction production
Carbonate sand
Transport
Extraction production
Carbonate filler
Transport
Diabase quarry
Extraction production
Coarse grained aggregate 2/4 and 4/8
Transport
Secondary treatment
EAF C slag (zero burden)
Avoided impacts of disposal
Landfill
Asphalt mix production at asphalt plant
Outputs: CO, CO₂, NOx, VOC (see Table 2)
Transport
Inputs and outputs defined in GaBi dataset
Diesel at refinery
Process water
Placing of asphalt as a wearing course
Outputs: CO, CO₂, NOx, NMVOC SOx, NH₃, CH₄, dust, NO, N₂O (see Table 3)
Not included in the model:
Road operation and maintenance
www.zag.si
44


Energy net
MJ
ADP
GWP
POCP
AP
EP
Asphalt plant
Bitumen
Silicate or slag aggregate
Carbonate aggregate
Carbonate filler
Delivery of asphalt mix
Avoided impacts (disposal)
TOTAL
www.zag.si
45



Example 2: Two alternative road pavement rehabilitation techniques

Example 2: Two alternative road pavement rehabilitation techniques

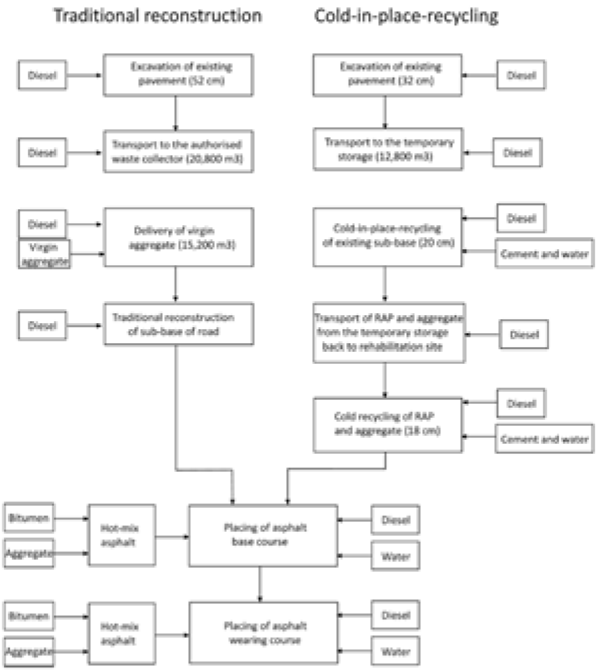


Fig. 1. The construction processes involved in the traditional reconstruction and the cold-in-place-recycling techniques.

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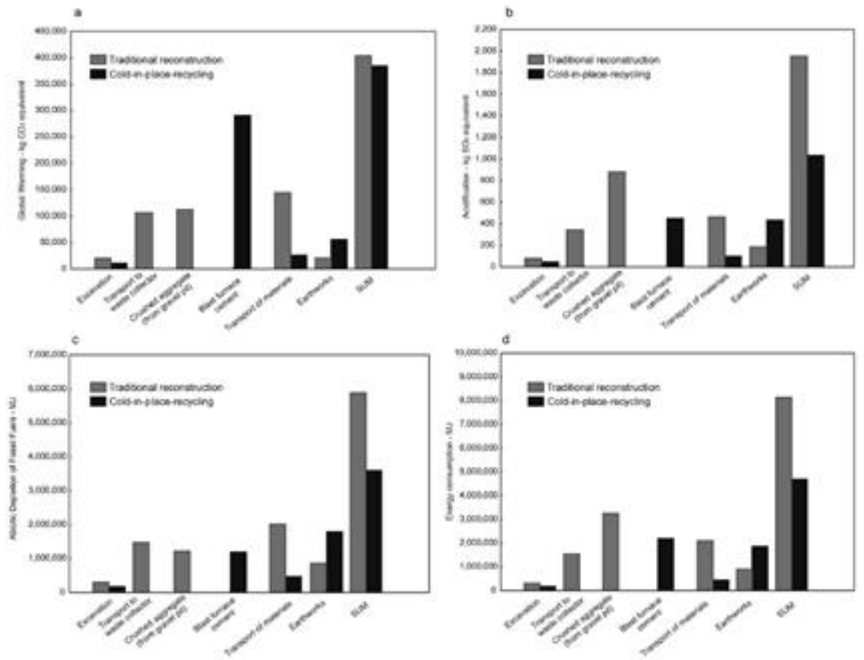

Fig. 2. Distribution of the studied impacts (a, b, c) between the different processes included in the cold-in-place-recycling and the traditional road reconstruction scenarios. Energy consumption is also indicated (d).

Decision making based on LCA

- LCA helps to decision support at three levels:
  - **Micro-level decision support** - Decision support, typically at the level of products
  - **Meso/macro level decision support** - Decision support for strategies with large-scale consequences in the background system or other systems.
  - **Accounting** - From a decision-making point of view, retrospective accounting / documentation of what has happened (or will happen based on the extrapolation of forecasts).

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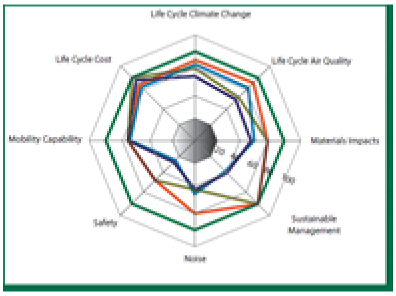
Multi-decision making

- Investors and consumers need to take into account different levels of products/processes through:
  - Functionality
  - Sustainability in all three pillars:
    - Planet,
    - Profit,
    - People.



- …through the whole life cycle

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Synergetic effect:
- Technical
- Environmental
- Social
- Financial
- Health and safety

  ….

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Current policies

DON'T WASTE YOUR WASTE!!!

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Waste = raw material

"waste" = "…any substance or object which the holder discards or intends or is required to discard…"

↓

" waste " = raw material for somebody else who has the suitable technology for re-use of the material, as well as the necessary knowledge and available markets.

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EU 2020 strategy

- SMART
- SUSTAINABLE
  A resource efficient Europe
- INCLUSIVE GROWTH

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Construction Products Regulations (CPR)

NEW! Basic requirement # 7
SUSTIANABLE USE OF NATURAL RESOURCES

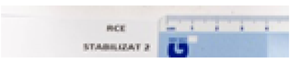
7. Sustainable use of natural resources

The construction works must be designed, built and demolished in such a way that the use of natural resources is sustainable and in particular ensure the following:

(a) reuse or recyclability of the construction works, their materials and parts after demolition;

(b) durability of the construction works;

(c) use of environmentally compatible raw and secondary materials in the construction works.



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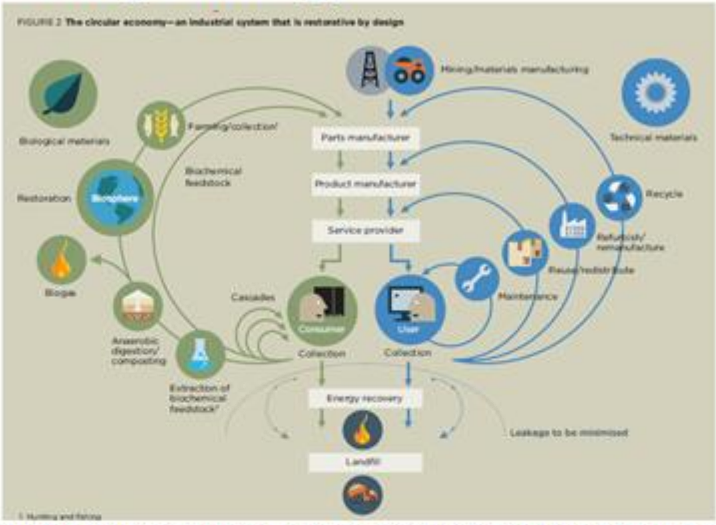
Closing the loop! Circular Economy Strategy



Source: Ellen MacArthur Foundation Towards the Circular Economy vol.1

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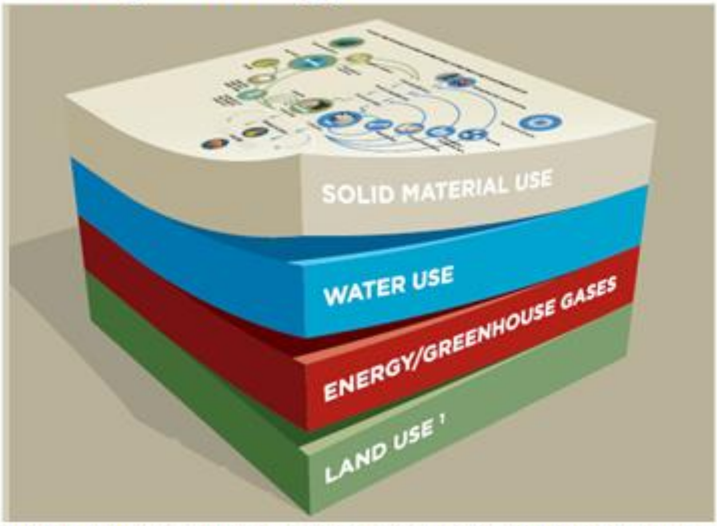

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Thank you!

Alenka Mauko Pranjić
alenka.mauko@zag.si

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There are no new paths,
only new ways of walking them.

With the pain of the dispossessed,
the dark dreams
of the child who sleeps with hunger –
I have learned:
this Earth does not belong to me alone.

And I have learned, in truth,
that the most important thing
is to work, while we still have life,
to change what needs changing,
each in our way, each where we are.

(Amadeu Thiago de Mello, Brasil's poet, activist for protection of the Amazonian rainforest)

Lecture for students Polytechnic University of Madrid: " Recycling of ferrous slags for construction purposes ", 18/02/2017

ZAG
ZAVOD ZA GRADBENIŠTVO SLOVENIJE
SLOVENIAN NATIONAL BUILDING AND CIVIL ENGINEERING INSTITUTE

eit RawMaterials

Recycling of ferrous slags for construction purposes

Alenka Mauko Pranjić (Ph. D. Geol)
Asist. Prof. Dr. Ana Mladenovič (Ph.D. Geol.)
Vesna Zalar Serjun (Ph. D. Geol.)

Department of Materials
Laboratory for Concrete, Stone and Recycled Materials

Madrid, 18th of February 2017

HERE INCLUDED ONLY SLIDES THAT REFER TO PRESENTATION OF RUSALCA PROJECT!!

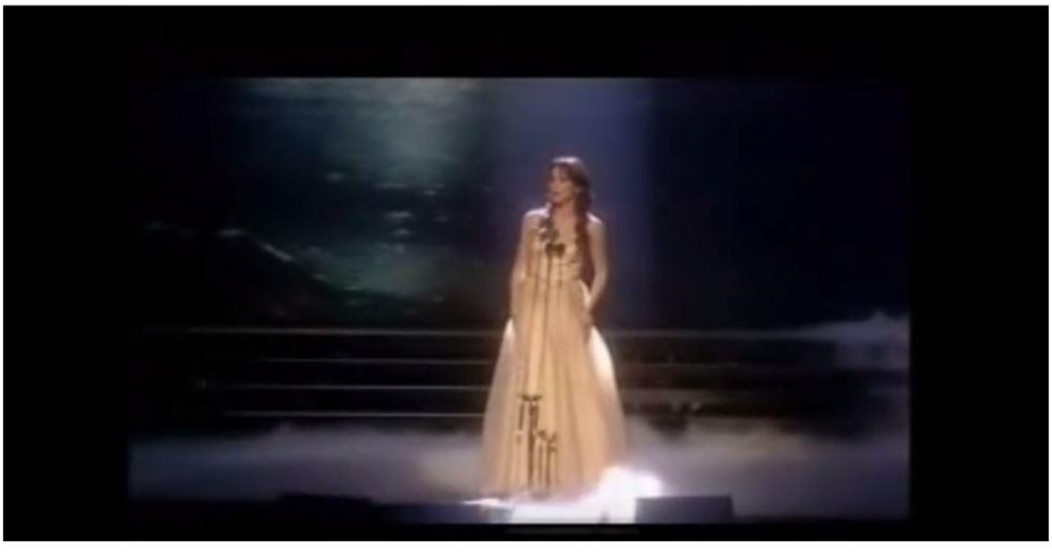
RusaLCA

What /Who is RusaLCA?

www.zag.si

- A RUSALKA is a water nymph a female spirit in Slavic mythology and folklore.

Ivan Kramskoi, *The Mermaids*, 1871



Antonin Dvorak: Rusalka

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RusaLCA

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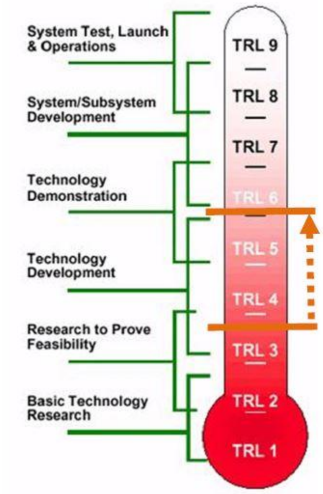

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- Capacity of 100 Population Equivalents
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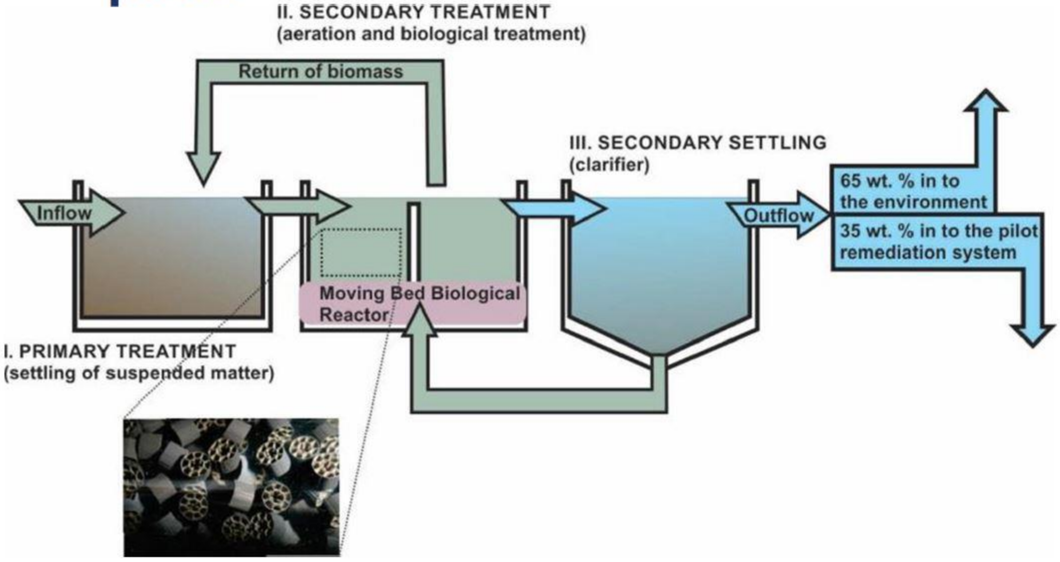
Small wastewater treatment plant



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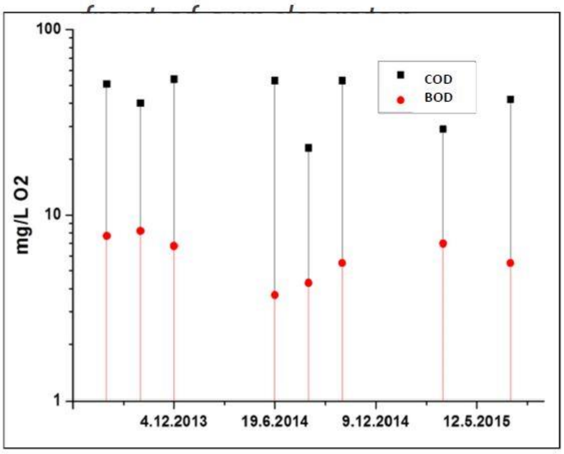

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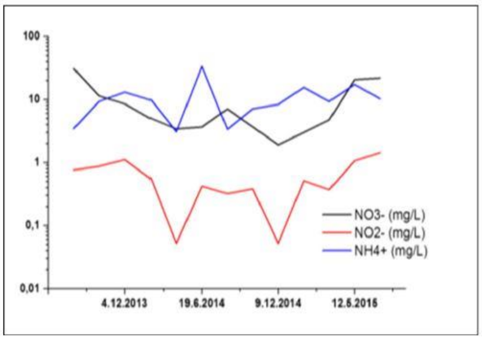

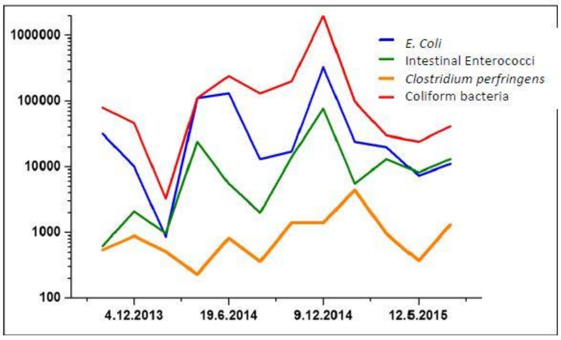

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- „green chemical“
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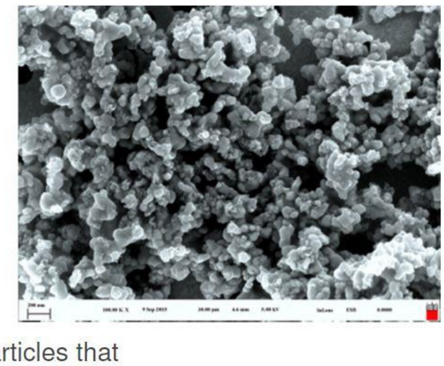

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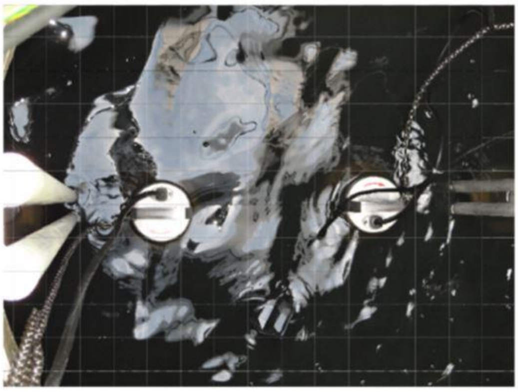

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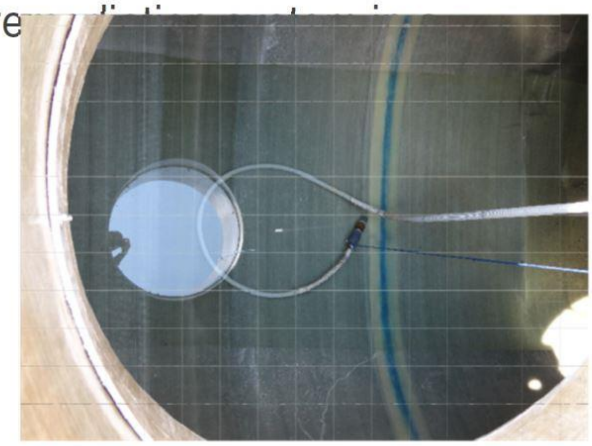

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167/7

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Lecture for students of Faculty of Nova Gorica: " Eco-innovative technologies in construction sector and quantification of their environmental impacts ", 05/05/2017, Faculty of Nova Gorica, Vipava, Slovenia

ZAG ZAVOD ZA GRADBENIŠTVO SLOVENIJE

SLOVENIAN NATIONAL BUILDING AND CIVIL ENGINEERING INSTITUTE

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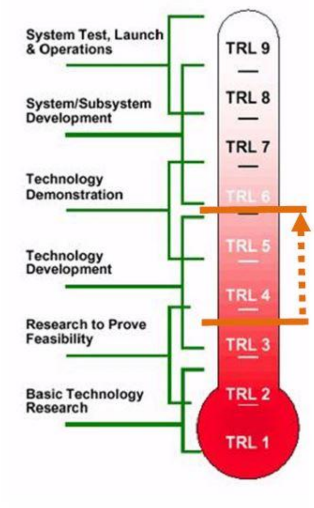

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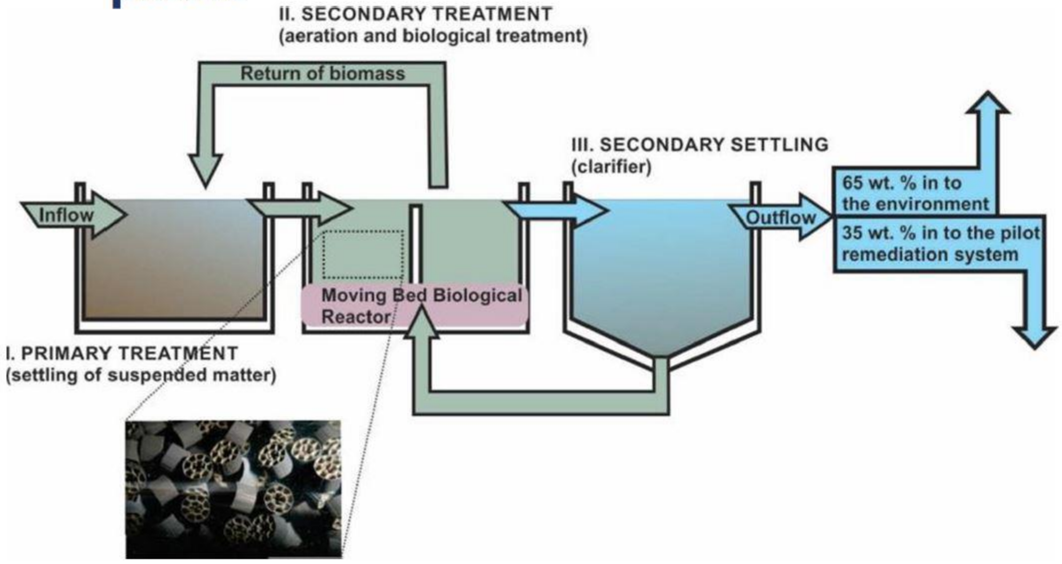

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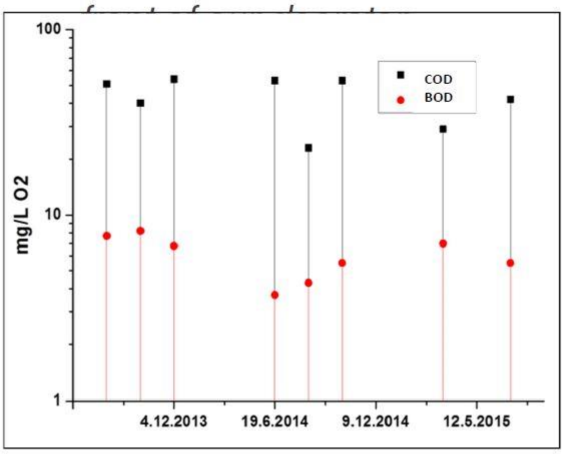

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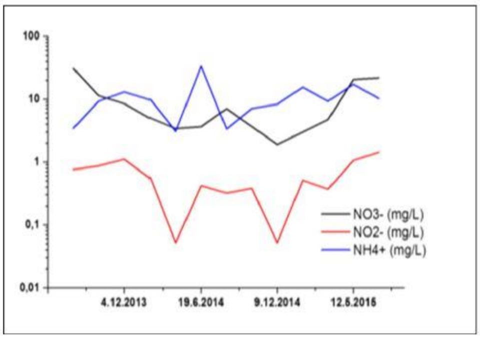

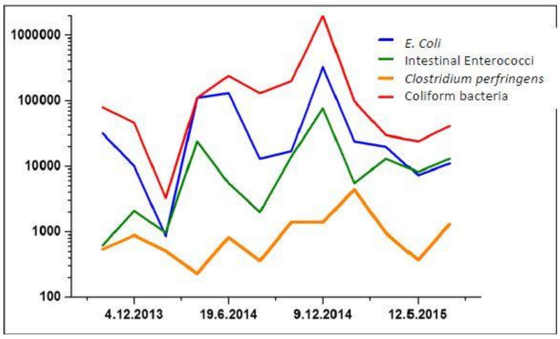

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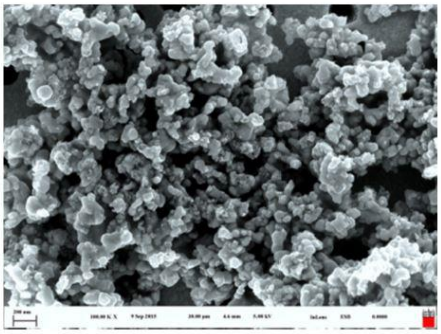

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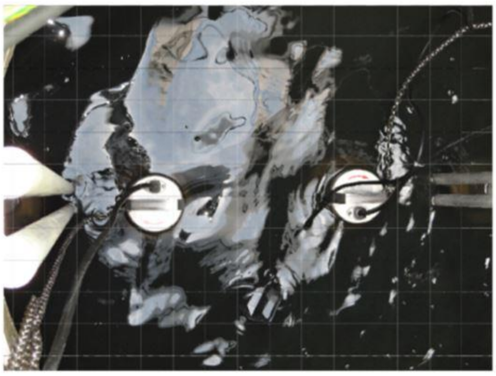

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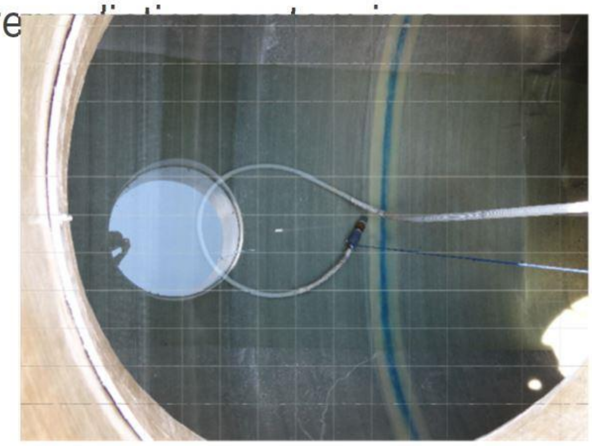

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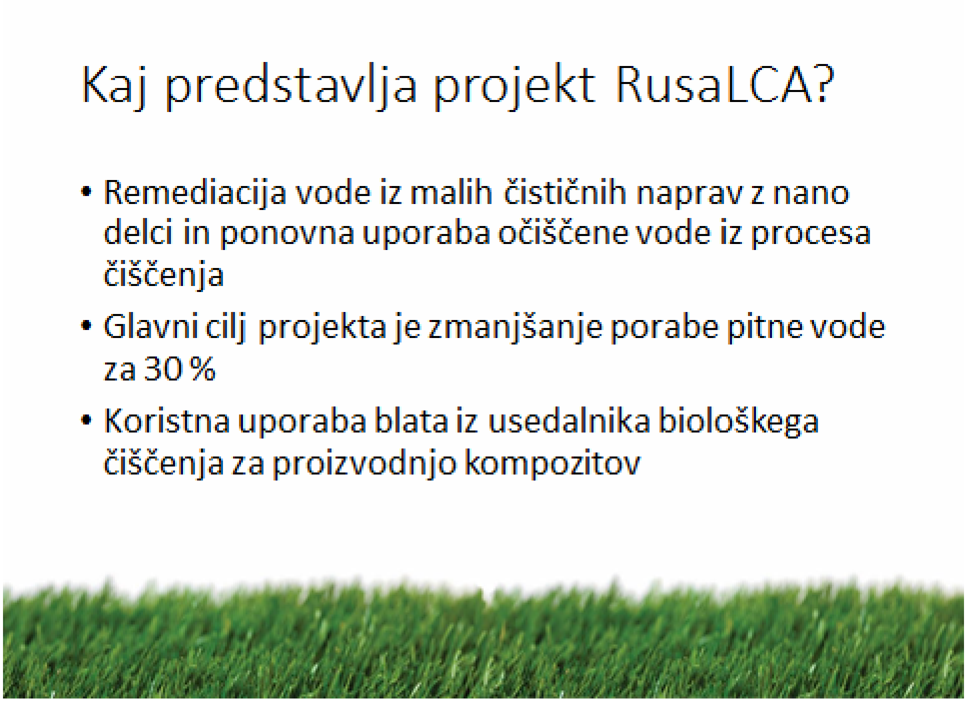
Presentation at elementary school in Šentrupert (16/10/2017)

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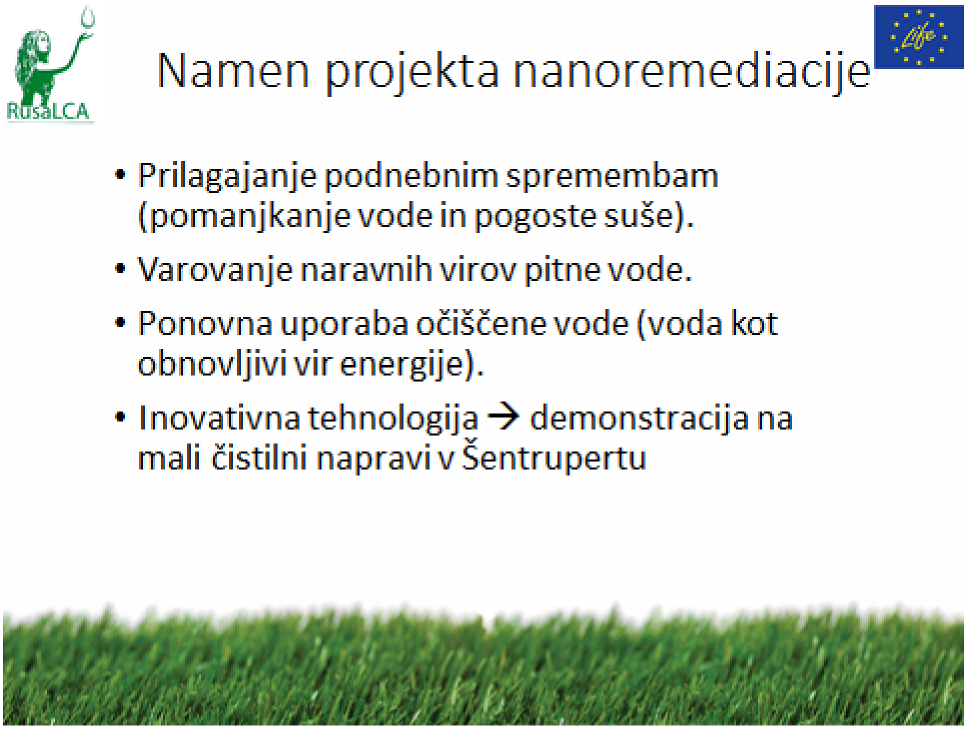
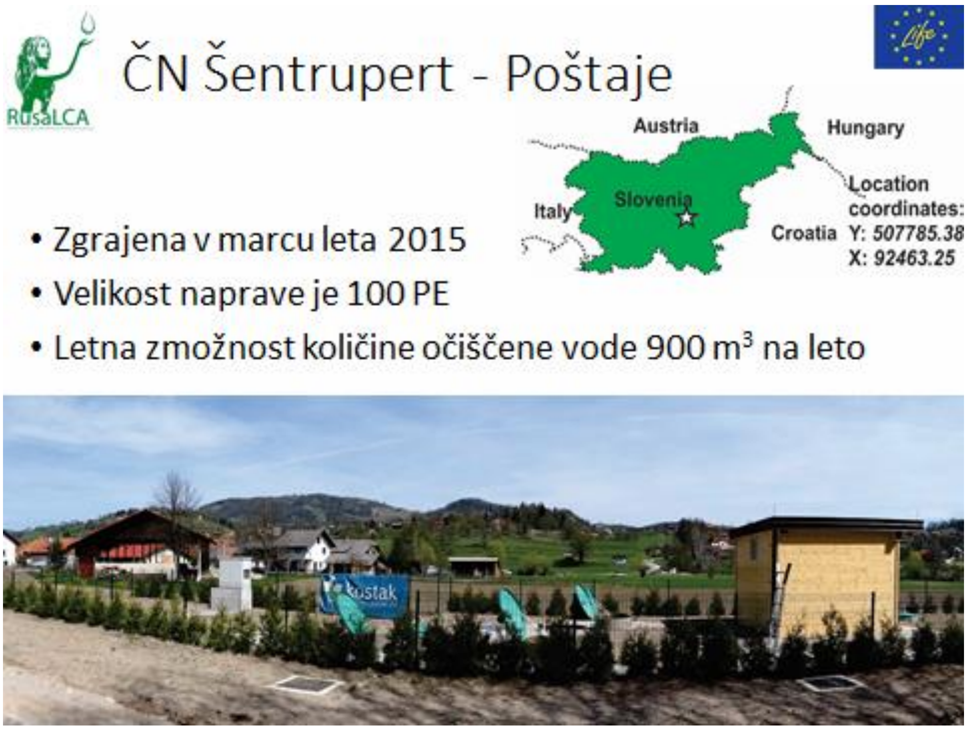
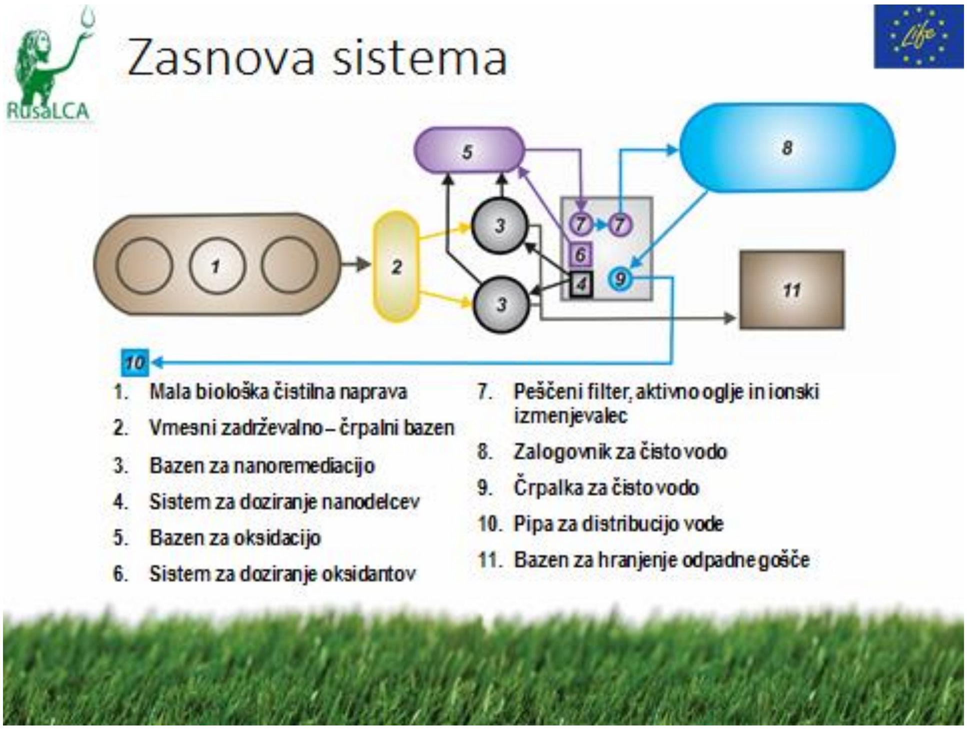

RusaLCA
Namen projekta nanoremediacije
• Prilagajanje podnebnim spremembam (pomanjkanje vode in pogoste suše).
• Varovanje naravnih virov pitne vode.
• Ponovna uporaba očiščene vode (voda kot obnovljivi vir energije).
• Inovativna tehnologija → demonstracija na mali čistilni napravi v Šentrupertu


Gradnja ČN Poštaje
RUSALCA


ČN Šentrupert - Poštaje
RUSALCA
Austria
Hungary
Italy
Slovenia
Croatia
Location coordinates:
Y: 507785.38
X: 92463.25
• Zgrajena v marcu leta 2015
• Velikost naprave je 100 PE
• Letna zmožnost količine očiščene vode 900 m³ na leto
kostak


Zasnova sistema
RUSALCA
1
2
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7
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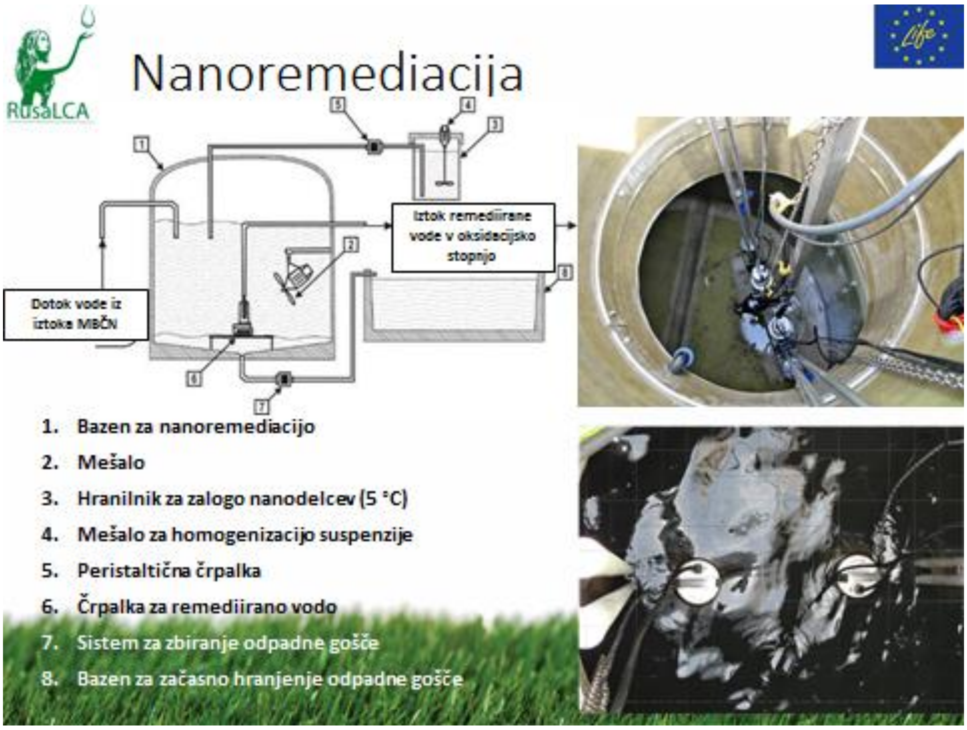
9
10
11
1. Mala biološka čistilna naprava
2. Vmesni zadrževalno – črpalni bazen
3. Bazen za nanoremediacijo
4. Sistem za doziranje nanodelcev
5. Bazen za oksidacijo
6. Sistem za doziranje oksidantov
7. Peščeni filter, aktivno oglje in ionski izmenjevalec
8. Zalogovnik za čisto vodo
9. Črpalka za čisto vodo
10. Pipa za distribucijo vode
11. Bazen za hranjenje odpadne gošče


RusaLCA
Razvoj projekta
• Na laboratorijskem nivoju optimiziran postopek čiščenja odpadne komunalne vode s kombinacijo nanodelcev ničvalentnega železa
• Postopek uspešno prenesen v prakso z izgradnjo pilotnega sistema

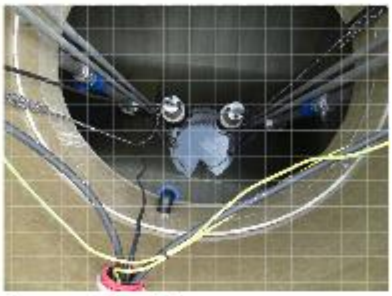

RusaLCA
Nanoremediacija
Iztok remediirane vode v oksidacijsko stopnjo
Dotok vode iz iztoka MBČN
1. Bazen za nanoremediacijo
2. Mešalo
3. Hranilnik za zalogo nanodelcev (5 °C)
4. Mešalo za homogenizacijo suspenzije
5. Peristaltična črpalka
6. Črpalka za remediirano vodo
7. Sistem za zbiranje odpadne gošče
8. Bazen za začasno hranjenje odpadne gošče

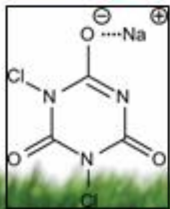
Pilotni sistem remediacije

- Robustna zasnova; večina objektov je pod zemljo
  - Reakcijski bazeni so iz armiranega poliestra
  - Črpalke in cevi so iz korozijsko odpornih materialov
  - Betonski podzemni bazen je namenjen začasnemu skladiščenju odpadne gošče
- Sistem je elektronsko krmiljen in delno avtonomen
  - Program omogoča prilagajanje parametrov
  - Ročni ali pol-avtomatski način
- Preprosta uporaba

Obdelava z oksidanti

- Dezinfekcija
- Oksidacija možnih še prisotnih nZVI
- Konvencionalna metoda za pripravo vode
- Uporabna sredstva:
  - Sodium dichloroisocyanurate (**IZOSAN G 30 mg/L**)
  - Hypochlorite (AREKINA)

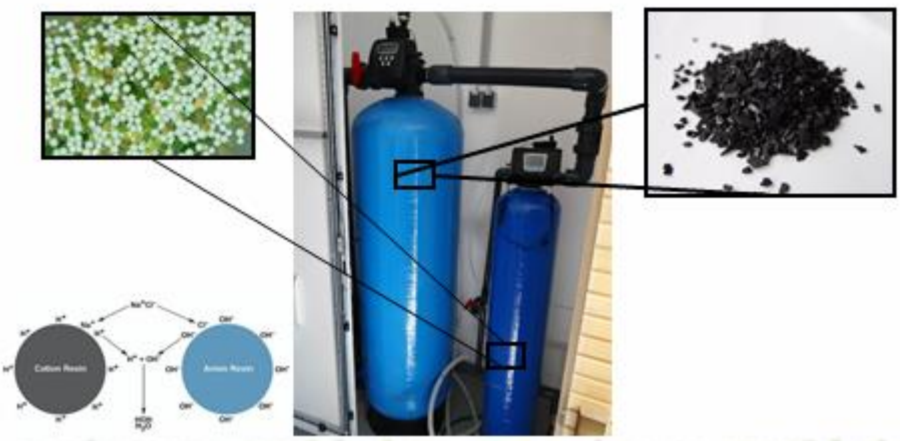




Aktivno oglje in ionska izmenjava

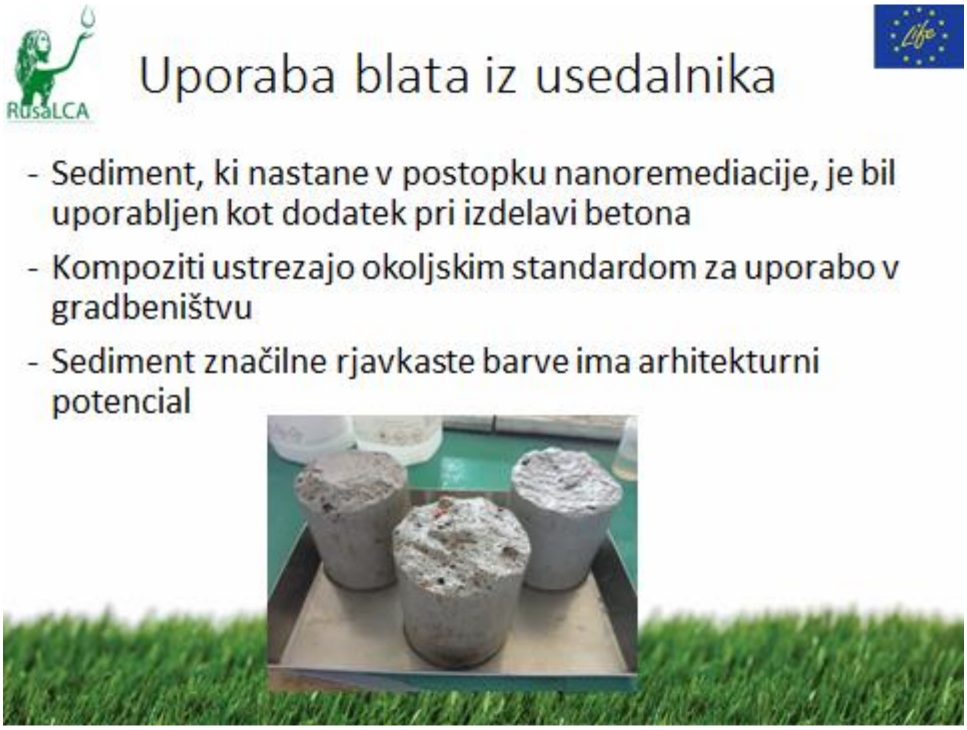
- Zadnja stopnja za doseganje ustrezne kvalitete vode.
- Uporabljene ionske izmenjevalne smole.
- Aktivno oglje v kombinaciji s peskom.
- Regeneracijski sistem

Aktivno oglje in ionska izmenjava




RusaLCA
Očiščena voda
• Primerna za: zalivanje okrasnih in zelenjavnih vrtov, za pranje cest in ter za potrebe gasilcev in lokalne industrije
• Voda se zbira v zalogovnikih (40 m3)
• Izvedenih preko 60 postopkov nanoremediacije
• Očiščeno skupaj 400 m3 vode


RusaLCA
Primer uporabe očiščene vode


RusaLCA
Uporaba blata iz usedalnika
- Sediment, ki nastane v postopku nanoremediacije, je bil uporabljen kot dodatek pri izdelavi betona
- Kompoziti ustrezajo okoljskim standardom za uporabo v gradbeništvu
- Sediment značilne rjavkaste barve ima arhitekturni potencial


RusaLCA
Hvala za pozornost
Life

An invited lecture at the concluding conference of LIFE PharmaDegrade project, 24-25/11/2016

Extended abstract:

Nanoremediacija vode iz male čistilne naprave za ponovno uporabo in izzivi z vidika mikroonesnaževal; projekt LIFE RusLCA

Nanoremediation of effluent water from a small wastewater treatment plant and its challenges from the point of view of the treatment of micro-pollutants; the RusaLCA project

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Abstract
Water scarcity is expected to become a globally occurring problem in the near future, even in those regions that are now considered to be water rich. The on-going LIFE project RusaLCA is based on an active approach towards a water efficient and water saving society, through the development of an advanced water remediation system which is based on nanotechnology. The aim of the multi-phase remediation of effluent water from a small biological wastewater treatment plant is to reduce the consumption of drinking water indirectly, by the re-use of purified wastewater. The nanoremediation process is based on the use of nanoscale zero-valent iron particles - nZVI, which were first tested for water remediation on a laboratory scale. In the project the research and development of technological solutions for a real case application of nZVI in a pilot remediation system was performed. The optimal amount of added nZVI was determined based on cost and remediation efficiency. The duration of the mixing and settling processes was also optimized. In order to achieve the desired level of water quality, several additional conventional purification processes were added: oxidation, ion exchange, and filtration by activated charcoal. The thus obtained cleaned water complies with the limit values for irrigation purposes, and it can also be used for secondary purposes by individuals and the economy as a whole.
Ključne besede: mala biološka čistilna naprava, nanodelci nič-valentnega železa, remediacija
Keywords: small biological wastewater treatment plant, nanoscale zero-valent iron particles, remediation

Uvod

Globalni klimatski in demografski trendi napovedujejo pomanjkanje vode v prihodnosti, tudi na območjih, ki danes veljajo za bogata s pitno vodo. Zato je v gospodarjenje z vodo potrebno vpeljati nove, energetsko in ekonomsko učinkovitejše sisteme čiščenja voda, ki so hkrati okoljsko manj obremenjujoči (Shanon et al., 2008). Iz tega razloga so nanodelci nič-valentnega železa (nZVI) predmet številnih raziskav. V znanstveni literaturi so opisani dokazi o učinkovitem odstranjevanju kovin, razgradnji organskih onesnažil in dezinfekciji (Lefevre et al., 2016, O'Carrol et al., 2013). Kljub temu, da so lastnosti nZVI za remediacijo vode poznane že več kot 20 let, je realnih primerov uporabe malo, predvsem kot posledica pomanjkanja raziskav o tehničnih omejitvah in okoljskih tveganjih.

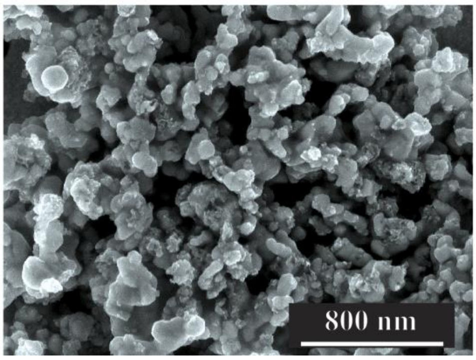
Projekt LIFE RusaLCA je razvil tehnologijo in znanje na področju realne uporabe nZVI s primerom izgradnje pilotnega sistema čiščenja komunalne odpadne vode za namen njene ponovne uporabe. Pilotni sistem je sklopljen z malo biološko čistilno napravo (MBČN). Delno očiščena voda iz MBČN vstopa v večstopenjski sekvenčni sistem remediacije, v katerem prvo stopnjo predstavlja nanoremediacija, sledijo pa obdelava z oksidanti, ionska izmenjava in filtracija z aktivnim ogljem. Pri tem se voda očisti do kakovosti, da je primerna za sekundarne potrebe ljudi (zalivanje, gasilska voda, pranje avtomobilov, lokalno gospodarstvo). Pilotna naprava je postavljena v naselju Poštaje v občini Šentrupert (Dolenjska – Osrednjeslovenska regija).

Mala biološka čistilna naprava

Komunalna odpadna voda se najprej delno očisti v MBČN tipa MBBR (Moving Bed Bioreactor Process) za 100 populacijskih ekvivalentov. Učinkovitost čiščenja se kaže z znižanjem vrednosti KPK do 50 in BPK do 15 mg O_2 L^{-1}. Procesi nitrifikacije znižajo vsebnost NH_4^+ na vrednosti do 30 mg L^{-1}, procesi denitrifikacije pa vsebnost NO_2^- na vrednosti do 1,2 mg L^- in NO_3^- na okoli 30 mg L^-. Voda na iztoku tako ustreza predpisom za izpuste v okolje (Ur. L. RS št. 98/15), ni pa primerna za ponovno uporabo. Presežene so predpisane omejitve vnosa nevarnih snovi v tla (Ur. L. RS, št. 99/13), še posebno glede vsebnost koliformnih bakterij (na primer *E. Coli*), ki so po merilih za namakanje presežene tudi do 1000 krat. Občasno so presežene tudi vrednosti kovin, nitratov in suspendiranih delcev (>100 mg/L). V vodi so še vedno prisotna mineralna olja in maščobe ter nekatera organska onesnaževala.

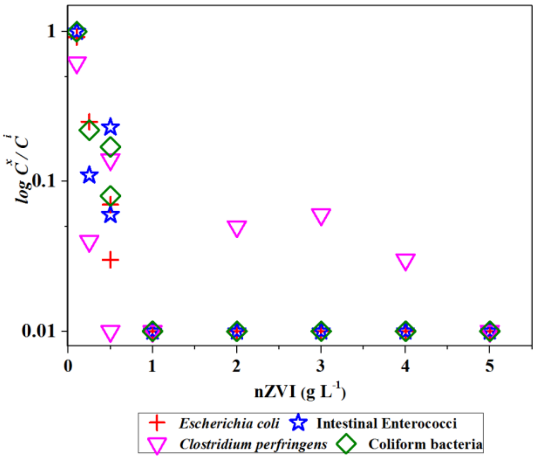
Nanoremediacija z nanodelci nič-valentnega železa

Nanoremediacija predstavlja najpomembnejšo stopnjo sistema. Uporabljen material je suspenzija na vodni osnovi, ki vsebuje 20 mas. % nZVI (Slika 1). Nanodelci vsebujejo 85 mas. % Fe^0 v kristalni obliki. Jedro iz Fe^0 obdajajo ovoji Fe-oksidov. Velikost delcev je med 20 in 80 nm, specifična površina pa je 44 m^2 g^{-1}. V vodi se nanodelci hitro aglomerirajo v mikrometerske delce, hkrati pa se tudi oksidirajo.



Slika 1: Nanodelci nič-valentnega železa.

Ključni parametri za nanoremediacijo so koncentracija dodanih nZVI (do 0,5 g L^{-1}), trajanje mešanja v vodni suspenziji (do 6 ur) in trajanje usedanja izrabljenih delcev (do 10 ur). Koncentracija dodanih nZVI vpliva na učinkovitost odstranjevanja kovin in dezinfekcije, ki narašča s količino dodanih delcev (Slika 2). Pri tem je pomemben faktor ekonomska učinkovitost, kar pomeni, da je ciljana koncentracija tista, kjer je ob ustrezni učinkovitosti poraba nZVI najnižja.



Slika 2: Učinkovitost dezinfekcije v odvisnosti od koncentracije dodanih nZVI.

Nanoremediacija odstrani do 98 % različnih bakterij (*E. coli*, *Clostridium perfringens*, intestinalni enterokoki, koliformne bakterije) s procesi motenja bakterijskih membran, uničenja genetskega materiala in škodljivega vključevanje delcev v bakterijsko celico (Lefevre et al., 2016). Odstranjevanje kovin je vezano na korozijske procese Fe^0, ki ustvarjajo redukcijske pogoje (redukcijski potencial -0,44 V). Pri tem se Fe^0 oksidira in raztaplja v Fe(II), ta pa se obarja in kristali kot Fe(III) oksidi in hidroksidi. Večina kovin se adsorbira na veliko specifično površino nanodelcev, nekatere pa se reducirajo in soobarjajo z novonastalimi Fe – hidroksidi (O'Carrol et al., 2013).

Nanoremediacija vode ne očisti do ustrezne kvalitete. Nanodelci uspešno razgrajujejo in nase vežejo del organskih onesnažil, ki se s koagulacijo in usedanjem odstranijo iz vode. Del obstojnih organskih onesnažil pa je še mogoče zaznati v vodi. Problem predstavljajo tudi dušikove spojine, saj nZVI, zaradi redukcijske moči, pretvorijo NO_2^- in NO_3^- nazaj v NH_4^+. V vodi ostaja del raztopljenega železa (približno 1 mg L^{-1}), Cl^-, Na in nekateri sledni elementi (na primer Mn). Prav tako delci ne uničijo vseh škodljivih mikroorganizmov.

Obdelava z oksidanti, ionska izmenjava in filtracija z aktivnim ogljem

Dodatne stopnje remediacije odstranijo onesnažila, ki še prisotna v previsokih koncentracijah. Nanoremediaciji tako sledi obdelava z oksidanti, ki omogoča odstranjevanje preostalih patogenih mikroorganizmov, razgradnjo organskih onesnažil in oksidacijo nZVI, ki bi lahko ostali v vodi. Kationi (NH_4^+, Fe, Ca, Na, ...) in anioni onesnažil (NO_2^- in NO_3^-, SO_4^{2-}, PO_4^{3-}, Cl^-) so v naslednji stopnji odstranjeni z ionsko izmenjavo. Končna filtracija z aktivnim ogljem pa omogoča učinkovito odstranjevanje organskih onesnažil.

Zaključki

Opisane metode remediacije sestavljajo več stopenjski pilotni sistem za pridobivanje očiščene vode za sekundarne potrebe ljudi, iz komunalne odpadne vode. Pilotni sistem je bil razvit v okviru projekta LIFE RusaLCA do te mere, da je bil dan v operativno rabo lokalnim prebivalcem občine Šentrupert na Dolenjskem. Kapaciteta sistema je 100 populacijskih ekvivalentov, pri čemer omogoča pridobivanje 900.000 L očiščene vode na leto. Voda po čiščenju ustreza najstrožjim kriterijem za namakanje rastlin, primerna pa je tudi za lokalno gospodarstvo saj je vsebnost kovin in NO_2^-/NO_3^- pod mejnimi vrednostmi za pitno vodo. Na ta način je posredno zmanjšana poraba pitne vode iz naravnih virov za do 30 %.

Literatura

Lefevre, E., Bossa, N., Wiesner, M.R., Gunsch, C.K., A review of the environmental implications of in situ remediation by nanoscale zero valent iron (nZVI): Behavior, transport and impacts on microbial communities. Sci. Tot. Environ. 889 – 901(2016)55.

O'Carrol D., Sleep, B., Krol, M., Boparai, H., Kocur, C., Nanoscale zero valent iron and bimetallic particles for contaminated site remediation. Adv. Water Resour.104–122(2013)51.

Shanon, M.A., Bohn, P.W., Elimelech, M., Georgiadis, J.G., Mariñas, B.J., Mayes, A.M., Science and technology for water purification in the coming decades. Nature. 301 – 310(2008)425.

Uredba o emisiji snovi pri odvajanju odpadne vode iz malih komunalnih čistilnih naprav (Uradni list RS, št. 98/07, 30/10 in 98/15).

Uredba o mejnih vrednostih vnosa nevarnih snovi in gnojil v tla (Uradni list RS, št. 84/05, 62/08, 62/08, 113/09 in 99/13).

List of technical papers

No.	Date	Title	Authors	Event / Publication	Place	Type	Reach
1	2016	The fate of zero valent iron nanoparticles after their use in wastewater remediation by single particle ICP-MS.	VIDMAR, Janja, OPRČKAL, Primož, MLADENOVIČ, Ana, MILAČIČ, Radmila, ŠČANČAR, Janez.	PAVLIN, Majda (ed.), et al. Zbornik : 1. del = Proceedings : part 1. Ljubljana: Mednarodna podiplomska šola Jožefa Stefana/ Jožef Stefan International Postgraduate School, 2016	Ljubljana, Slovenia	Published scientific conference contribution	National
2	2015	Napreden sistem nano-remediacije odpadnih voda za trajnostno gospodarjenje z vodnimi viri.	MLADENOVIČ, Ana, MILAČIČ, Radmila, ŠČANČAR, Janez, MAUKO PRANJIĆ, Alenka, NADRAH, Peter, SEVER ŠKAPIN, Andrijana, VIDMAR, Janja, OPRČKAL, Primož	ROŽIČ, Boštjan (ed.). Razprave, poročila = Treatises, reports, 22. posvetovanje slovenskih geologov = 22nd Meeting of Slovenian Geologists, Ljubljana, November 2015	Ljubljana, Slovenia	Published scientific conference contribution	National

3	2016	Nanoremediacija vode iz male čistilne naprave za ponovno uporabo in izzivi z vidika mikroonesnaževal; projekt LIFE RusaLCA = Nanoremediation of effluent water from a small wastewater treatment plant and its challenges from the point of view of the treatment of micro-pollutants; the RusaLCA project.	MLADENOVIČ, Ana, OPRČKAL, Primož, MILAČIČ, Radmila, ŠČANČAR, Janez, VIDMAR, Janja, SEVER ŠKAPIN, Andrijana, NADRAH, Peter, MAUKO PRANJIĆ, Alenka	ZUPANČIČ JUSTIN, Maja (ed.). Farmakološko aktivne snovi v odpadnih vodah : optimizacija analitskih metod in procesov odstranjevanja : zbornik konference = Pharmacologically active substances in wastewater : optimisation of analytical methods and removal processes : proceedings of the conference, Zaključna konferenca projekta LIFE PharmDegrade, 24.-25. November 2016	Ljubljana, Slovenia	Published scientific conference contribution abstract	National
4	2016	LIFE+ RusaLCA - an advanced water purification method with utilization of zero - valent iron nanoparticles.	MLADENOVIČ, Ana, OPRČKAL, Primož, NADRAH, Peter, SEVER ŠKAPIN, Andrijana, ŠČANČAR, Janez, MILAČIČ, Radmila, VIDMAR, Janja, MAUKO PRANJIĆ, Alenka	GODEC, Matjaž (ed.), et al. Program in knjiga povzetkov = Program and book of abstracts, 23. mednarodna konferenca o materialih in tehnologijah, 28.-30. september 2016, Portorož	Portorož, Slovenia	Published scientific conference contribution abstract	National

5	2014	LIFE+ RusaLCA - Sustainable approach towards water-efficient society.	OPRČKAL, Primož, MLADENOVIČ, Ana, MILAČIČ, Radmila, ŠČANČAR, Janez, SEVER ŠKAPIN, Andrijana, NADRAH, Peter	ROŽIČ, Boštjan (ur.), VERBOVŠEK, Timotej (ur.), VRABEC, Mirijam (ur.). Povzetki in ekskurzije = Abstracts and field trips, 4. slovenski geološki kongres, Ankaran, 8.-10. oktober 2014.	Ljubljana, Slovenia	Published scientific conference contribution abstract	National
6	2014	Projekt RusaLCA - nanotehnologija v službi okolja.	MLADENOVIČ, Ana, OPRČKAL, Primož, MILAČIČ, Radmila, ŠČANČAR, Janez, SEVER ŠKAPIN, Andrijana, NADRAH, Peter	Ekolist, ISSN 1854-3758, December 2014	Ljubljana, Slovenia	Professional article	National
7	2014	Trajnostno ravnanje z vodo - projekt RusaLCA	MLADENOVIČ Ana	Mineral 2013, No. 6	Ljubljana, Slovenia	Professional article	National
8	2014	Karakteristike pepelov kot potencialnih veziv za gradbene kompozite	MLADENOVIČ Ana	Mineral 2014, No. 3	Ljubljana, Slovenia	Professional article	National
9	2017	The behaviour of zero-valent iron nanoparticles and their interactions with Cd2+ in wastewaters	VIDMAR, Janja, OPRČKAL, Primož, MILAČIČ, Radmila, MLADENOVIČ, Ana,	Metallomics 2017, The 6th International Simposium on Metallomics, August 14th to 17th, 2017	Vienna, Austria	Professional article	International

		investigated by single particle ICP-MS	ŠČANČAR, Janez				

Contributions to non-technical journals and the media

No.	Date	Media	Media type	Title	Type	Reach
1	13. 7. 2013	Dnevnik	National daily	Evropska sredstva za razvoj treh novih tehnologij	Print article	National
2	17. 12. 2013	Dolenjski-list.si	Regional web portal	Vodo bodo čistili do te mere, da bi jo lahko pili	Web article	Regional
3	17. 12 .2013	ePosavje	Regional web portal	Podpis pogodbe za izvedbo projekta RusaLCA	Web article	Regional
4	17. 12. 2013	Nadlani.si	National web portal	Inovativna mala čistilna naprava v Šentrupertu	Web article	National
5	17. 12. 2013	Radio Krka	Regional radio	Mala čistilna naprava za manjšo porabo pitne vode	Web article	Regional
6	10. 12. 2013	Šentrupert	Local municipal quarterly	Inovativna mala čistilna naprava v Šentrupertu	Print article	Local
7	2. 1. 2014	Dolenjski list	Regional weekly	Vodo iz čistilne bi lahko celo pili	Print article	Regional
8	15. 1. 2014	Na dlani	Regional quarterly	Šentrupert: Snujejo dva velika projekta	Print article	Regional
9	14. 4. 2014	Moja Občina	National web portal	Pridobljeno gradbeno dovoljenje za inovativno malo	Web	National

				čistilno napravo projekta Rusalca	article	
10	1. 12. 2014	Ekolist	Expert magazine	Projekt RusaLCA - nanotehnologija v službi okolja	Print article	Expert
11	17. 12. 2014	Dolenjski list	Regional web portal	Podpisali pogodbo za gradnjo inovativne male čistilne naprave	Web article	Regional
12	18. 12. 2014	Moja Občina	National web portal	Podpisali pogodbo za gradnjo inovativne male čistilne naprave Rusalca	Web article	National
13	24. 12. 2014	Dolenjski list	Regional weekly	Še inovativna čistilna naprava	Print article	Regional
14	9. 1. 2015	TV Vaš kanal	Regional tv station	V Šentrupertu spet inovativni	TV feature	Regional
15	21. 1. 2015	Radio Slovenija 1	National radio	Inovativna mala čistilna naprava v Šentrupertu	Radio feature	National
16	10. 4. 2015	Primorske novice	National web portal	Z lesom kurijo, svetijo in vabijo turiste	Web article	National
17	5. 6. 2015	Šentrupert	Local municipal quarterly	Mala čistilna naprava RusaLCA pričela s poskusnim obratovanjem	Print article	Local
18	1. 10. 2015	Dolenjski list	Regional weekly	Mala čistilna naprava obratuje	Print article	Regional
19	10. 11. 2015	Levstikova pot	Regional interest magazine	LIFE RusaLCA - Razvoj inovativne tehnologije čiščenja voda	Print article	Regional

20	25. 5. 2015	Gradbenik	Expert magazine	Remediacija vode iz malih čistilnih naprav - Projekt RusaLCA	Print article	National
21	16. 6. 2016	Dolenjski list	Regional weekly	Prihranili bodo lahko pitno vodo	Print article	Regional
22	20. 6. 2016	Moja Občina	National web portal	V Šentrupertu predstavili projekt RusaLCA in inovativno čiščenje komunalnih voda	Web article	National
23	5.8. 2014	Občina Šentrupert	Web portal of the Municipality of Šentrupert	Projekt RusaLCA - Remediacija vode iz male čisitlne naprave z nano delci in ponovna uporaba očiščene vode ter blata iz procesa čiščenja	Web article	Local
24	11. 11. 2017	Akademija Finance	National web portal	V Šentrupertu zalivajo vrtove s posebno očiščeno komunalno odpadno vodo	Web article	Regional
25	22. 1. 2014	Na dlani	Regional quarterly	V Šentrupertu snujejo dva velika projekta	Web article	Regional
26	23. 9. 2016	Gospodarska zbornica Slovenije	Web portal of Chamber of Commerce and Industry of Slovenia	LIFE RusaLCA – vabilo na mednarodno konferenco, 3. in 4. 10. 2016	Web article	National
27	15. 9. 2017	Bio.si	Web portal	Razstava: RusaLCA v odsevu. Galerija Mitnica	Web article	Regional
28	10. 5. 2017	Občina Šentrupert	Web portal of the Municipality of Šentrupert	Priprave na distribucijo vode iz čistilne naprave RusaLCA	Web article	Local
29	12. 6. 2016	Občina Šentrupert	Web portal of the Municipality of	Predstavitev projekta RusaLCA v Šentrupertu	Web article	Local

			Šentrupert			
30	2017	Občina Šentrupert	Web portal of the Municipality of Šentrupert	Mala čistilna naprava RusaLCA pričela s poskusnim obratovanjem	Web article	Local

List of scientific articles

No.	Date	Title	Authors	Publication	Type	Reach
1	2017	Critical evaluation of the use of different nanoscale zero-valent iron particles for the treatment of effluent water from a small biological wastewater treatment plant	Primož Oprčkal, Ana Mladenovič, Janja Vidmar, Alenka Mauko Pranjić, Radmila Milačič, Janez Ščančar	The Chemical Engineering Journal 321.	Scientific paper	International

List of dissemination events

No.	Date	Event	Reach	Participation	Type
1	12. 3. 2014	Local community project presentation	Local	50	General
2	9. 6. 2016	Regional dissemination and project presentation for SE Slovenia	Regional	30	General / Professional
3	3. 10. 2016	International Conference RusaLCA – Innovative Technology for Cleaning Communal Water from Small Water Treatment Plants	European	50	Professional
4	4. 10. 2016	International Conference RusaLCA – Innovative Technology for Cleaning Communal Water from Small Water Treatment Plants (Field tour with practical demostration of nanoremediation of effluent water at the pilot system in Šentrupert)	Regional and European	50	General / Professional

Dissemination at conferences, workshops and lectures

No.	Date	Title	Event / Publication	Place	Type	Reach
1	30. 11. 2015	LIFE RusaLCA - An advanced system for nanoremediation of waste waters for sustainable water management	22nd conference of Slovenian geologists	Ljubljana, Slovenia	Conference presentation	National
2	28. 9. 2015	LIFE+ RusaLCA – An innovative Prototype System for the remediation of Municipal Waste Water	23rd International Conference on Materials and Technology	Ljubljana, Slovenia	Conference presentation	National
3	10. 12. 2015	Research in the field of innovative technologies for water remediation	Faculty of Natural Sciences and Engineering	Ljubljana, Slovenia	Lecture	National
4	14. 1. 2016	RusaLCA – Nanoremediation of water from waste water treatment plants	Faculty of Civil and Geodetic Engineering	Ljubljana, Slovenia	Lecture	National
5	24. and 25. 5. 2016	Nanoremediation of water from small waste water treatment plants and reuse of water and solids for local needs	LIFE Water Platform meeting	Manchester, UK	Poster	International
6	24. and 25. 5. 2016	Pilot water remediation plant	LIFE Water Platform meeting	Manchester, UK	Poster	International
7	30. 9. 2016	An advanced water purification method with the utilization of zero-valent iron nanoparticles	International conference on materials and technology	Portorož, Slovenia	Conference presentation	National
8	24. and 25. 11. 2016	Nanoremediation of effluent water from a small wastewater treatment	Concluding conference of the LIFE PharmDegrade	Ljubljana, Slovenia	Lecture	National

		plant and its challenges from the point of view of the treatment of micro-pollutants; the RusaLCA project	project			
9	26. 1. 2017	Nanoremediacija vode iz male čistilne naprave in uporaba vode in blata za lokalne potrebe : predstavitev na dogodku LIFE informativni dan	LIFE informative day	Postojna, Slovenia	Workshop presentation	National
10	14. 4. 2016	Life Cycle Assessment – Methodology and examples from practice	Lecture for students at the University of Nova Gorica	Nova Gorica, Slovenia	Lecture	National
11	20. 10. 2016	Closing the loops and use of secondary resources in construction sector	aRAWness workshop, Geological Survey of Slovenia	Ljubljana, Slovenia	International workshop	International
12	27. 10. 2016	Krožno gospodarstvo in vrednotenje okoljskih odtisov [Circular economy and assessment of environment impacts]	CEL.Cycle workshop, ZAG	Ljubljana, Slovenia	Smart Specialisation Program Workshop	National
13	5. 5. 2017	Eco-innovative technologies in construction sector and quantification of their environmental impacts	Lecture for students at the University of Nova Gorica	Nova Gorica, Slovenia	Lecture	National
14	12. 1. 2017	Closing the loops in construction sector LIFE ReBirth and RusaLCA projects	European Circular Construction Alliance workshop	Ljubljana, Slovenia	Conference presentation	International
15	18. 2. 2017	Recycling of ferrous slags for construction purposes	Lecture for students	Polytechnic University of Madrid	Lecture	International

16	16. 10. 2017	Projekt LIFE RusaLCA – Čistilna naprava Šentrupert - Poštaje	Lecture for pupils	Elementary school in Šentrupert	Lecture	Local