BMBF/ZECURA

*Z*ero *E*mission *C*oncepts for *U*rban *R*esilience in selected *A*frican cities

Federal Ministry of Education and Research

IfaS Institut für angewandtes Stoffstrommanagement

Umwelt-Campus Birkenfeld | Hochschule Trier

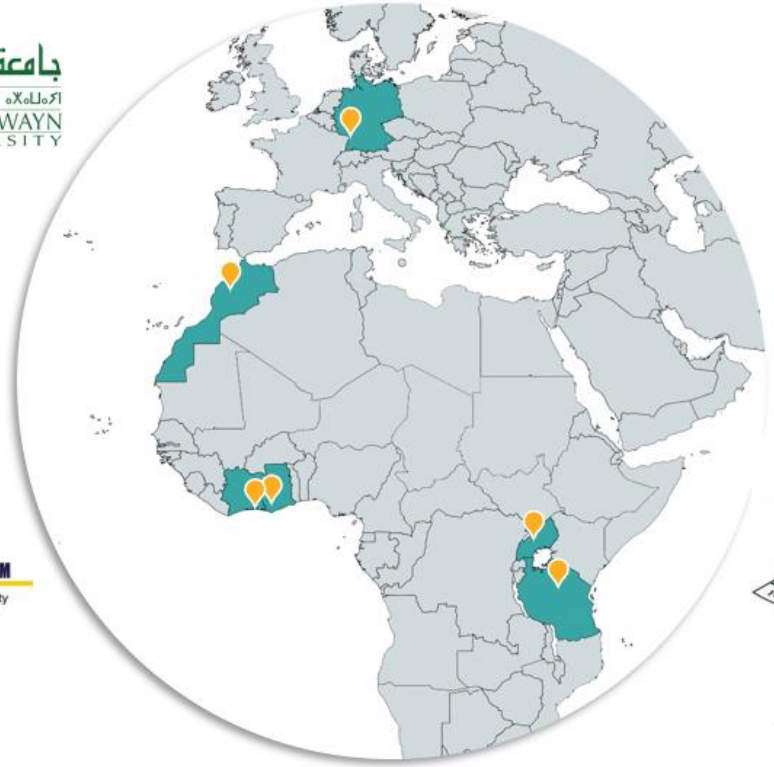
ZECURA

The Consortium

Umwelt-Campus Birkenfeld

HOCHSCHULE TRIER

جامعة الأخوين
ⵜⴰⵙⴷⴰⵡⵉⵜ ⵏ ⵉⵅⴰⵡⴰⵢⵏ
AL AKHAWAYN UNIVERSITY



UNIVERSITY OF ENERGY AND NATURAL RESOURCES

INTERNATIONAL UNIVERSITY OF GRAND-BASSAM
Excellence • Accountability • Opportunity

GULU UNIVERSITY
FOR COMMUNITY TRANSFORMATION

The Nelson Mandela African Institution of Science and Technology
Arusha
Kilimanjaro
2009
Academia for Society and Industry

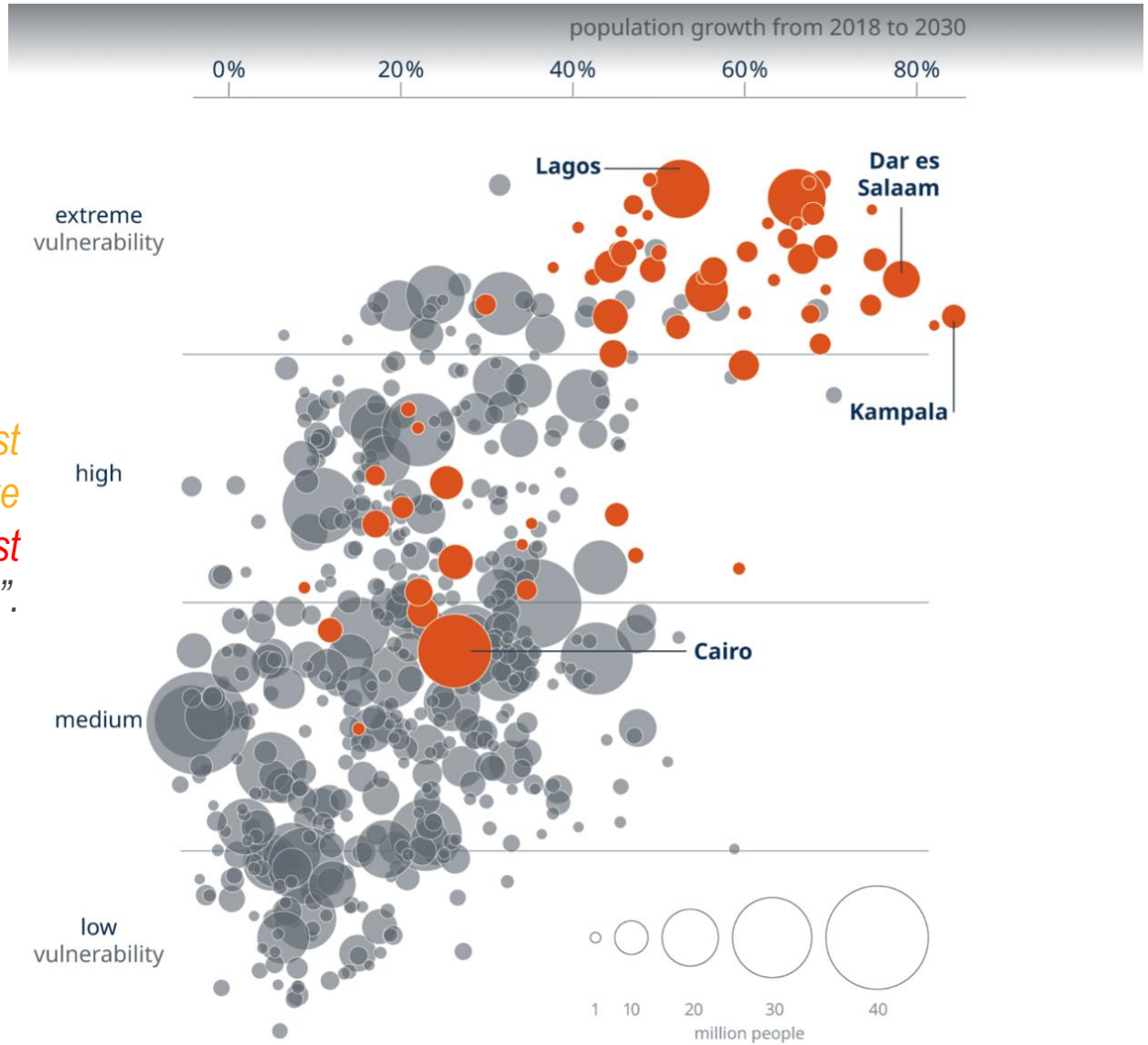
Resource panel

Partner	*Name/Designation*	*Role in the project*
IfaS/HT, DE	**Professor Dr. Peter Heck**	**Project Leader**
	Dr.-Ing. Ranahansa Dasanayake	**General Manager**
	Mr. Marco Angilella	**Finance Advisor**
	Mr. Navoda Senanayake	**Technical Manager**
GU, UG	Professor Dr. Peter John Opio	Project Coordinator
	Dr. Jimmy Byakatonda	Researcher
NM-AIST, TZ	Professor Dr. Askwar Hilonga	Project Coordinator & Researcher
UENR, GH	Prof. Dr. Nana Sarfo Agyeman Derkyi	Project Coordinator
	Ing. Lewis Ofori Amankona	Project Manager
IUGB, CI	Prof. Dr. Sinde Seydou	Project Coordinator & Researcher
AUI, MA	**Professor Dr. Abdelghani El Asli**	**Project Coordinator**
	Mr. Sami Ezzabri	**Project Manager**

The rationale…

The Rationale

"African cities are most vulnerable to climate change but least responsible for it".



SOURCE: https://visualstories.dw.com/african-megacities-environment-adaptation/ | Accessed 25.04.21

In summary…

- Rapid population growth
- High rate of urbanization
- Increasing climate vulnerability
- …

…impact the resource base, economy, and the society

The Rationale

How does that manifest in cities?

… let's take some popular examples

Naples, Italy

Hyderabad, India

Location unknown, but?

SOURCE: google.com/images, (2021.); accessed 22.AUG.2021

Hidden flow of wealth…

Show me the money?

1 tonnes of waste;

SOURCE: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Recycling_–_secondary_material_price_indicator#Price_and_trade_volumes | https://www.cargopedia.net/europe-fuel-prices (Accessed 15.SEP.2022)

The million dollar question is…

How ready are we to tap into these potentials while becoming more sustainable?

Building resilient cities…

What is a resilient city?

"… resilient cities are cities that have the ability to absorb, recover and prepare for future shocks (economic, environmental, social & institutional). Resilient cities promote sustainable development, well-being and inclusive growth"

SOURCE: Resilient Cities - OECD. (n.d.). Retrieved July 21, 2021, from https://www.oecd.org/cfe/regionaldevelopment/resilient-cities.htm

Why do we care?

In a nutshell:

- It's about safety and security
- It's about *creating wealth* and wellbeing
- It's about political stability
- It's about sustainability
- It's about the *future we want*
- …

ZECURA: towards resilience!

ZECURA: what is this about?

An initiative for *resilient cities*…

"[...] collaborative development and transfer of knowledge to support the transition towards resilient water, energy, food and waste management services in selected African cities enabling communities to achieve a sustainable, low-carbon future while improving the service quality"

Objective of ZECURA

In a nutshell:

- Develop innovative and practical solutions to *enhance the resilience* of target regions
- Strengthen research capacities and competencies
- *North-south-south networking and exchange*
- …

Objective of ZECURA

African-German transdisciplinary cooperation in

- *Resilience of megacities* (overarching goal)
- Climate protection (and climate finance)
- Resource management (water and waste)
- Energy supply and renewable energies
- Education for sustainability

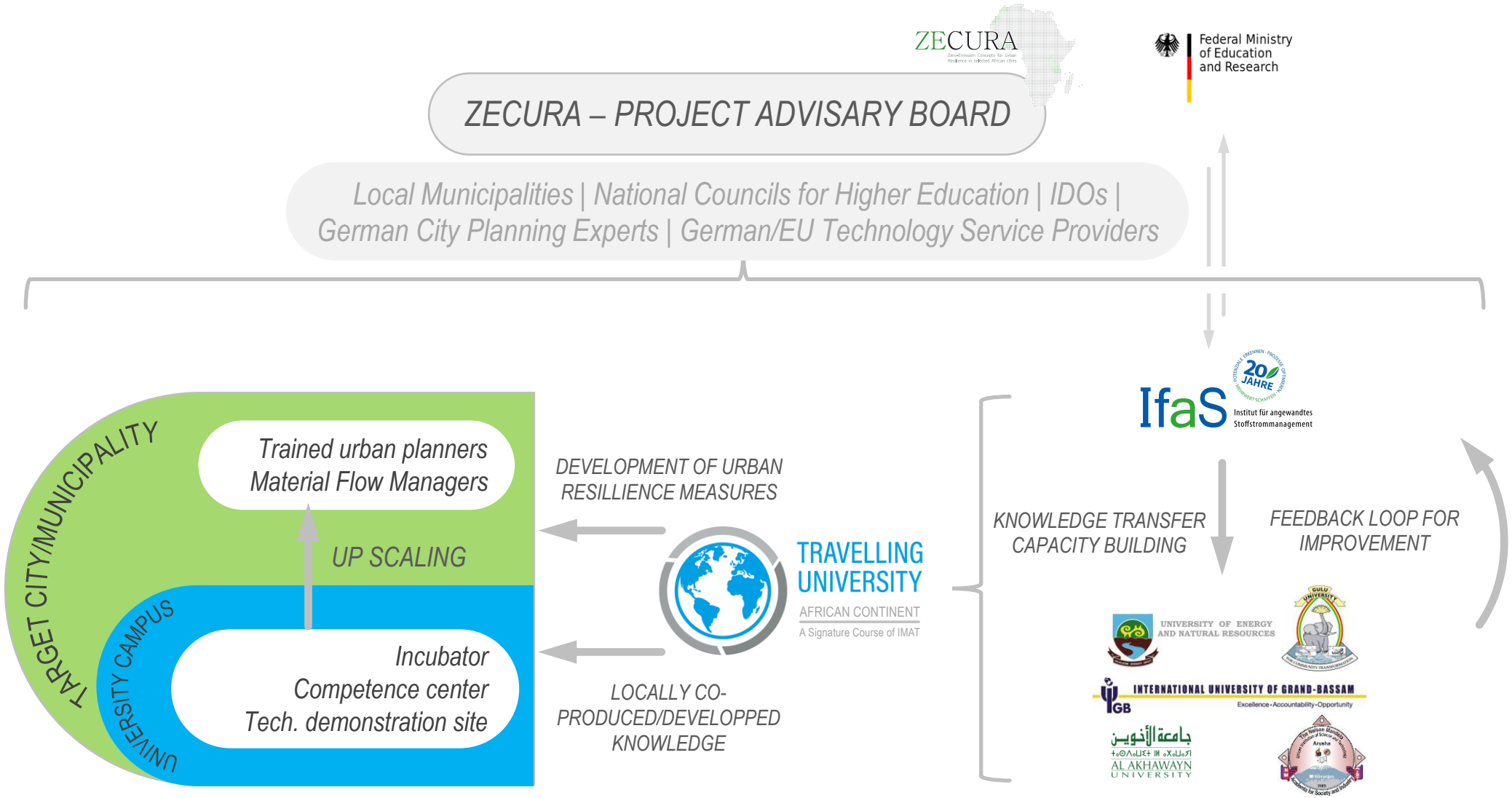
Additional topics **not directly** covered are health, transport and mobility, food security, administration, education and good governance

The role of partner HEIs

To provide

“both theoretical and practical examples of resilience strategies based on Zero-emission Campus models those that are scalable, adaptable, and replicable in municipalities and cities”.

Linking ZE-C to resilient cities



What is in for our partners?

Status quo system(s) of partner cities

European Commission

- Increase the probability of pegging *EU funded projects* (partnerships)

What does that mean?

The transformation we aim for…

Thank You!

ZECURA Grand Finale

Traveling University as a catalyst for resilient city development

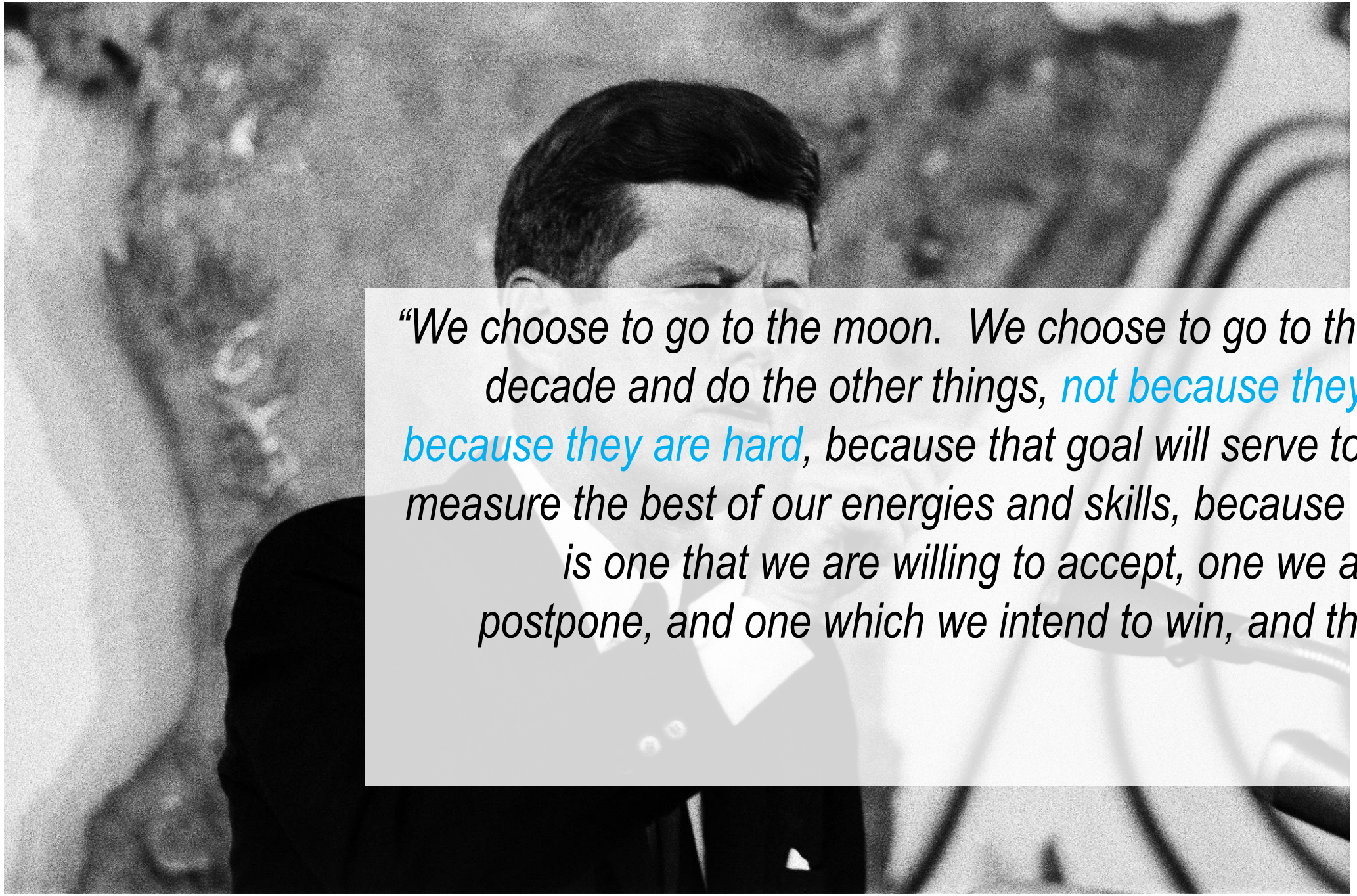
26.SEPTEMBER.2023 | Dr.-Ing. RANAHANSA **DASANAYAKE** | IFRAN, MOROCCO

Federal Ministry of Education and Research

IfaS Institut für angewandtes Stoffstrommanagement

Umwelt-Campus Birkenfeld | HOCHSCHULE TRIER

ZECURA



"We choose to go to the moon. We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win, and the others, too."

JFK,
RICE UNIVERSITY,
SEP. 1962

ZECURA

The Endeavor

TRAVELLING UNIVERSITY

AFRICAN CONTINENT

A Signature Course of IMAT

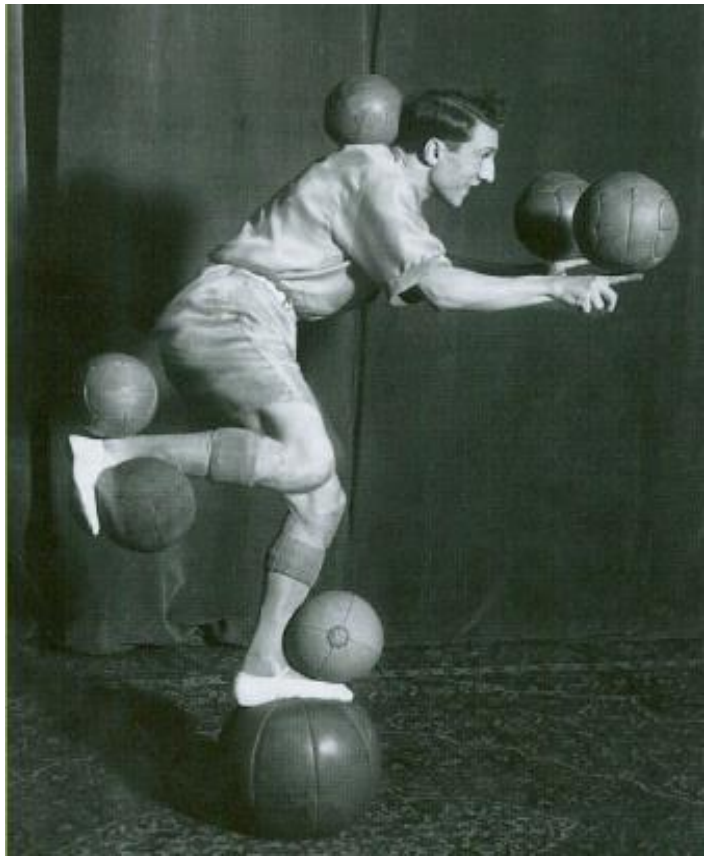
ZECURA

TU Challenges: get to know…

- Understanding *clients' needs*
- Understanding the *system*
- Get to know the *stakeholder*

IMAGE SOURCE: Google Imagery, (2019)

TU Challenges: work-work-balance



- Time, tasks, teams
- Contingency planning
- *Concentrate on results* not on being busy

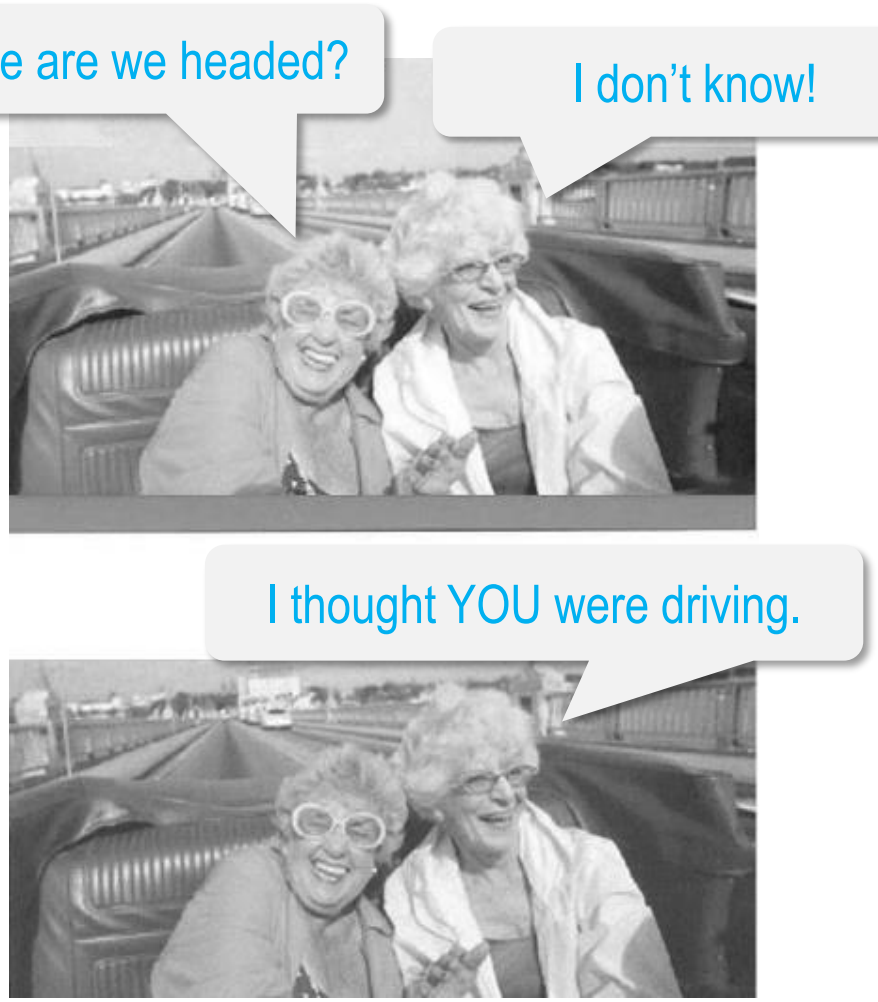
IMAGE SOURCE: Google Imagery, (2019)

TU Challenges: importance of partnership

- Get together as a team
- *Faith and trust*
- Maintain the team spirit

IMAGE SOURCE: Google Imagery, (2019)

TU Challenges: get your bearing



- Navigation is the key
- *No map, no chance*
- What is the red line?

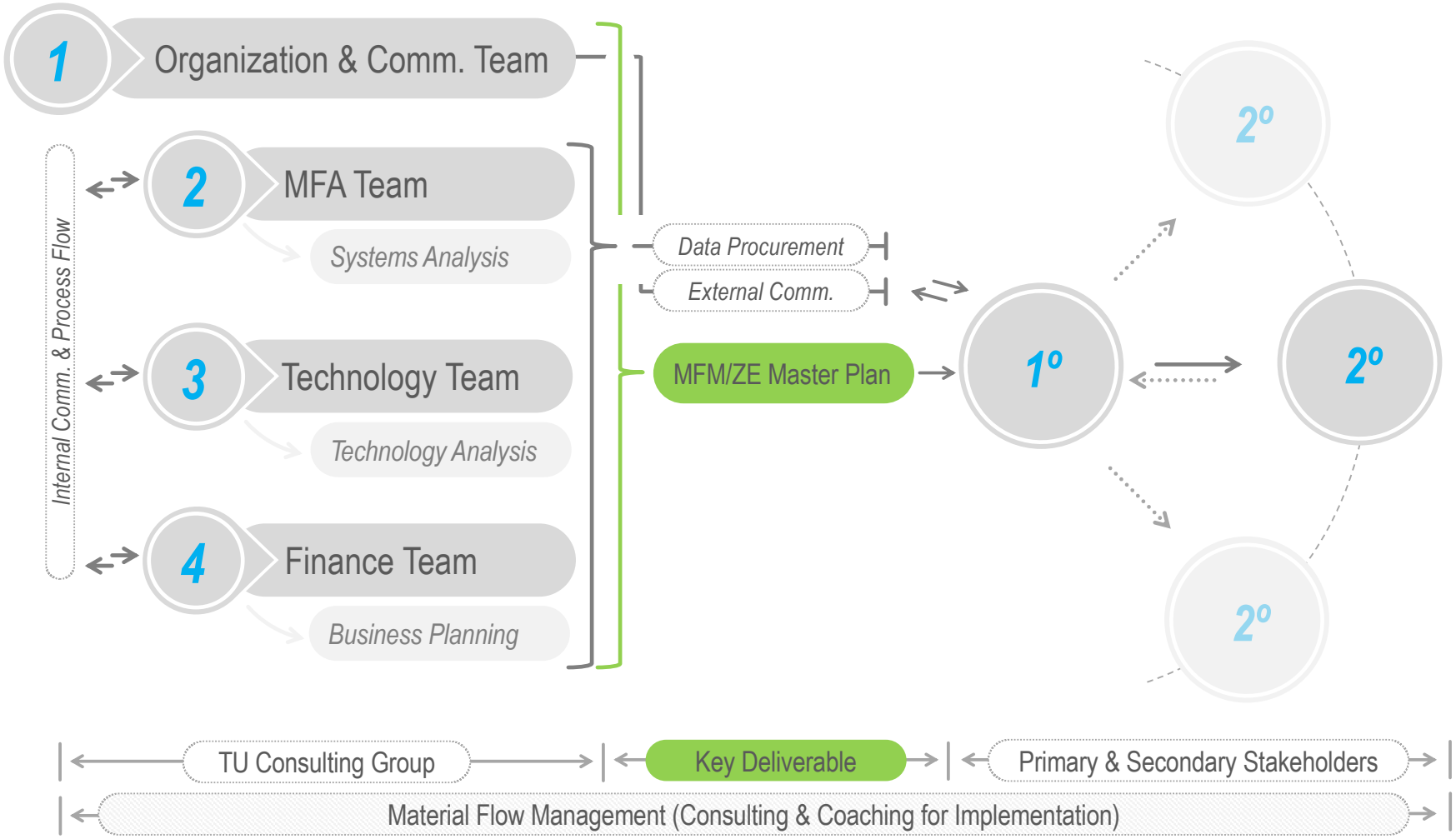
IMAGE SOURCE: Google Imagery, (2019)

TU Challenges: take a deeper look

- Curiosity
- Practicality
- *Hands-on*

IMAGE SOURCE: Google Imagery, (2019)

Travelling University: mechanism of delivery



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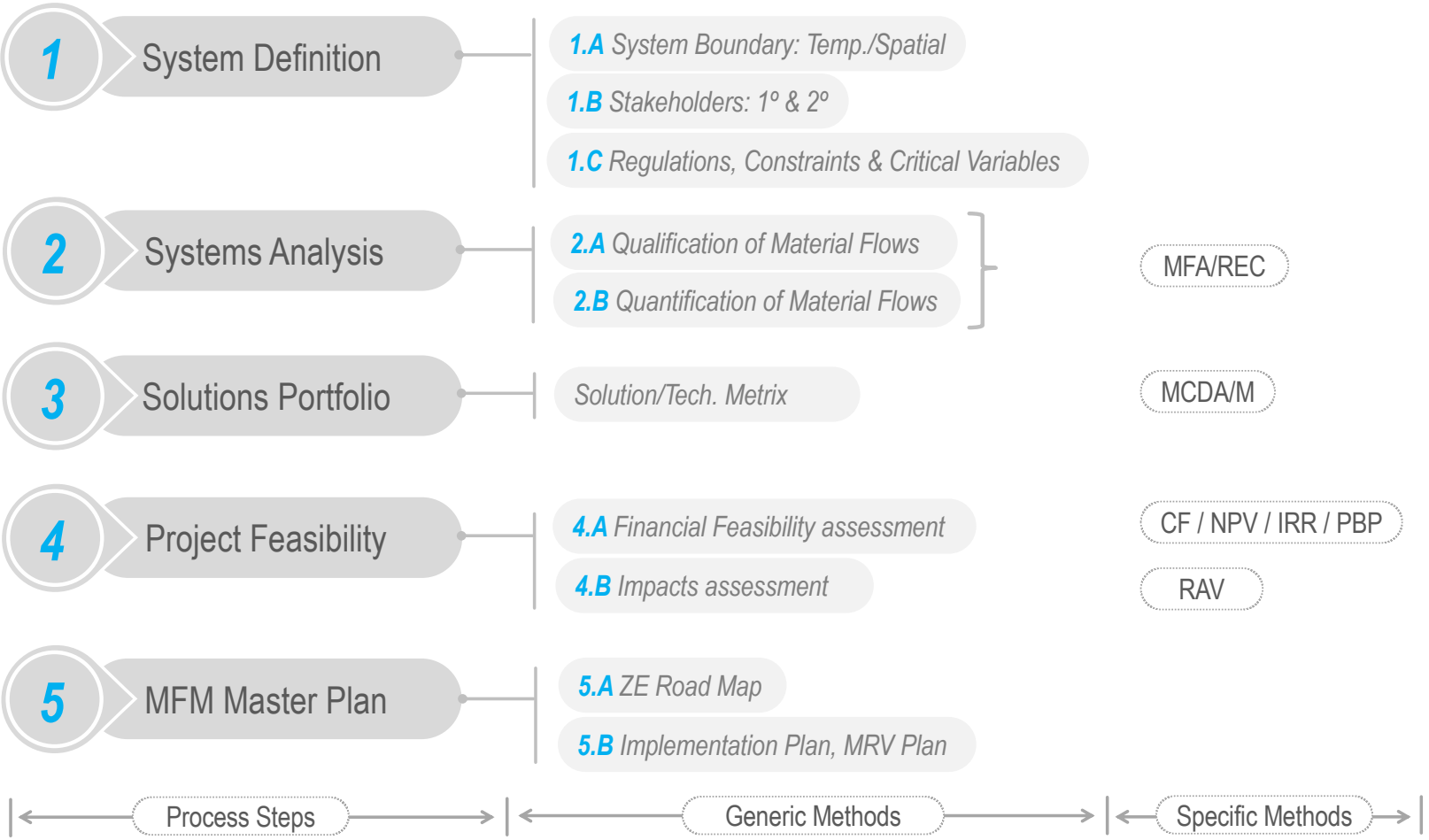
Travelling University: mechanism of delivery



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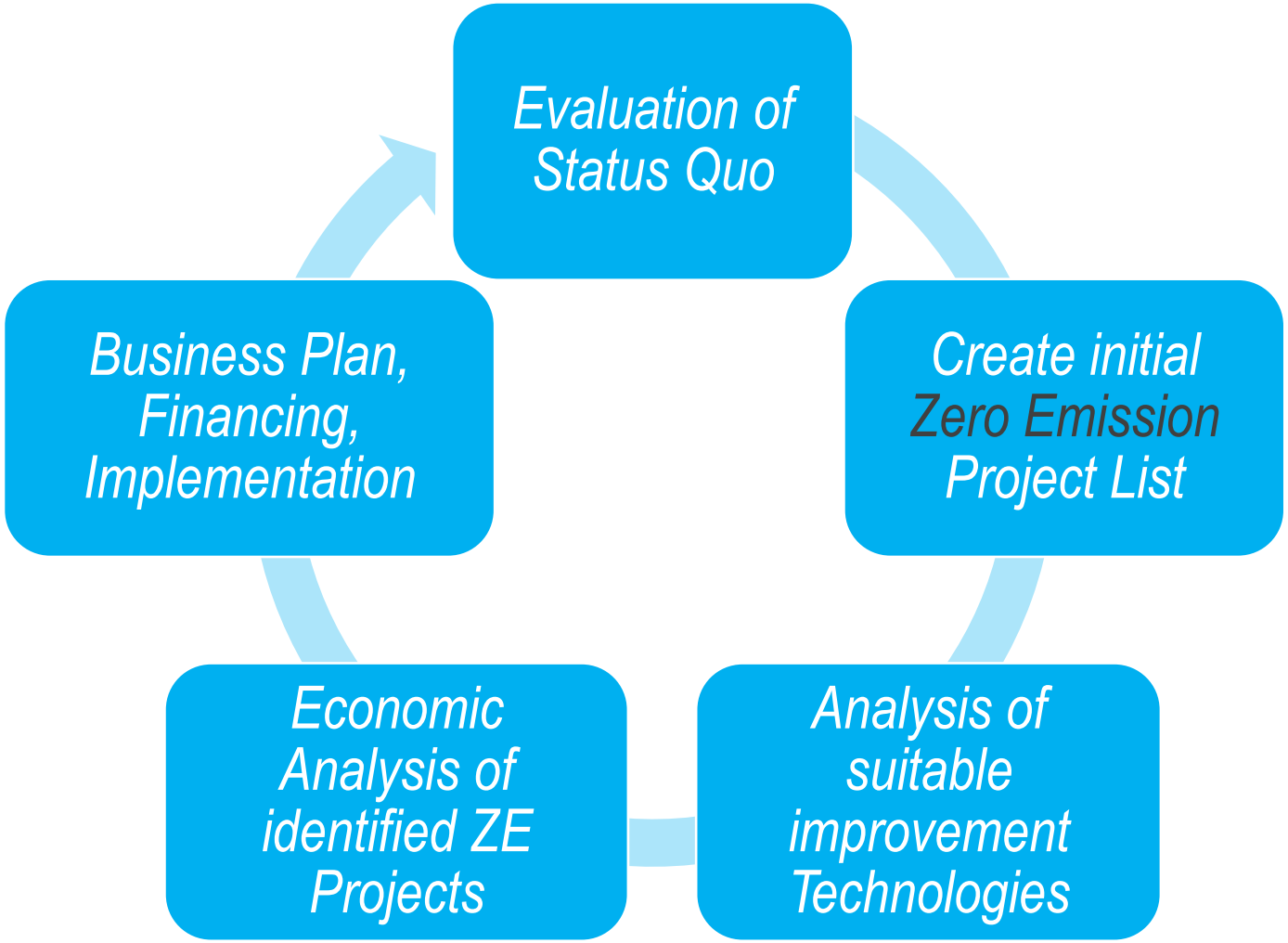
MFA: systemic method



We've been around the world

Transition to climate neutrality

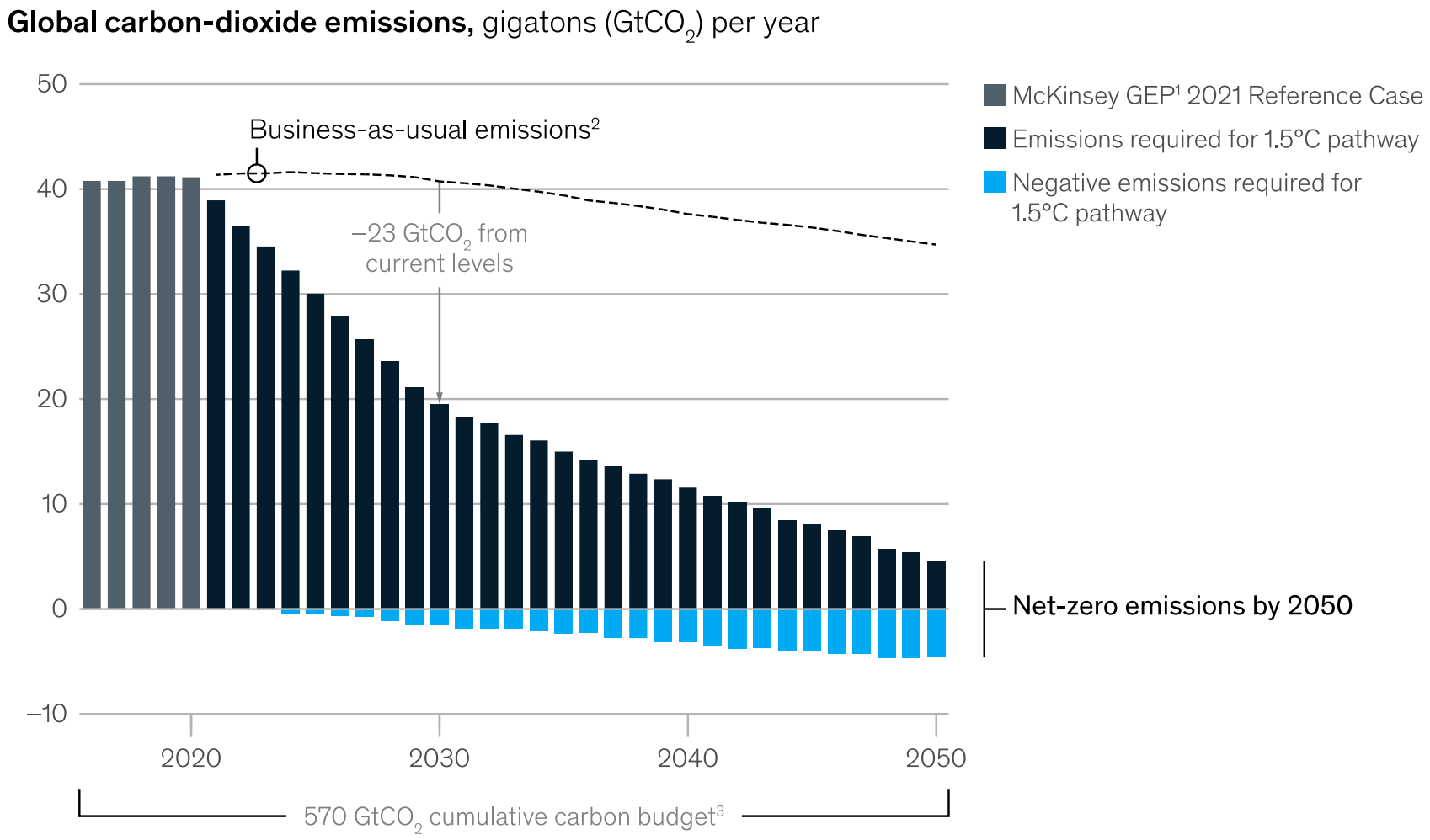


IMAGE SOURCE:
https://www.mckinsey.com/capabilities/sustainability/our-insights/a-blueprint-for-scaling-voluntary-carbon-markets-to-meet-the-climate-challenge, (2022)

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Transition to climate neutrality

In Scenario 1.5ºC *strict emission reductions and carbon removals* are required!

Need for *100% renewable* (electricity, heat, mobility)

Massive *investments* in RE and Circular Economy and new business concepts necessary

Africa is a prime spot to *leapfrog green development*

ZECURA

#1 Greenest university campus

ECB is a living laboratory

100% renewable heat supply based on waste wood, biogas (co-generation) and solar thermal

ECB is a living laboratory

100% renewable electricity supply based on cogeneration (heat and electricity) & photovoltaic

ECB is a living laboratory

100% renewable cooling system based on geothermal, biomass and solar adsorption chilling

ECB is a living laboratory

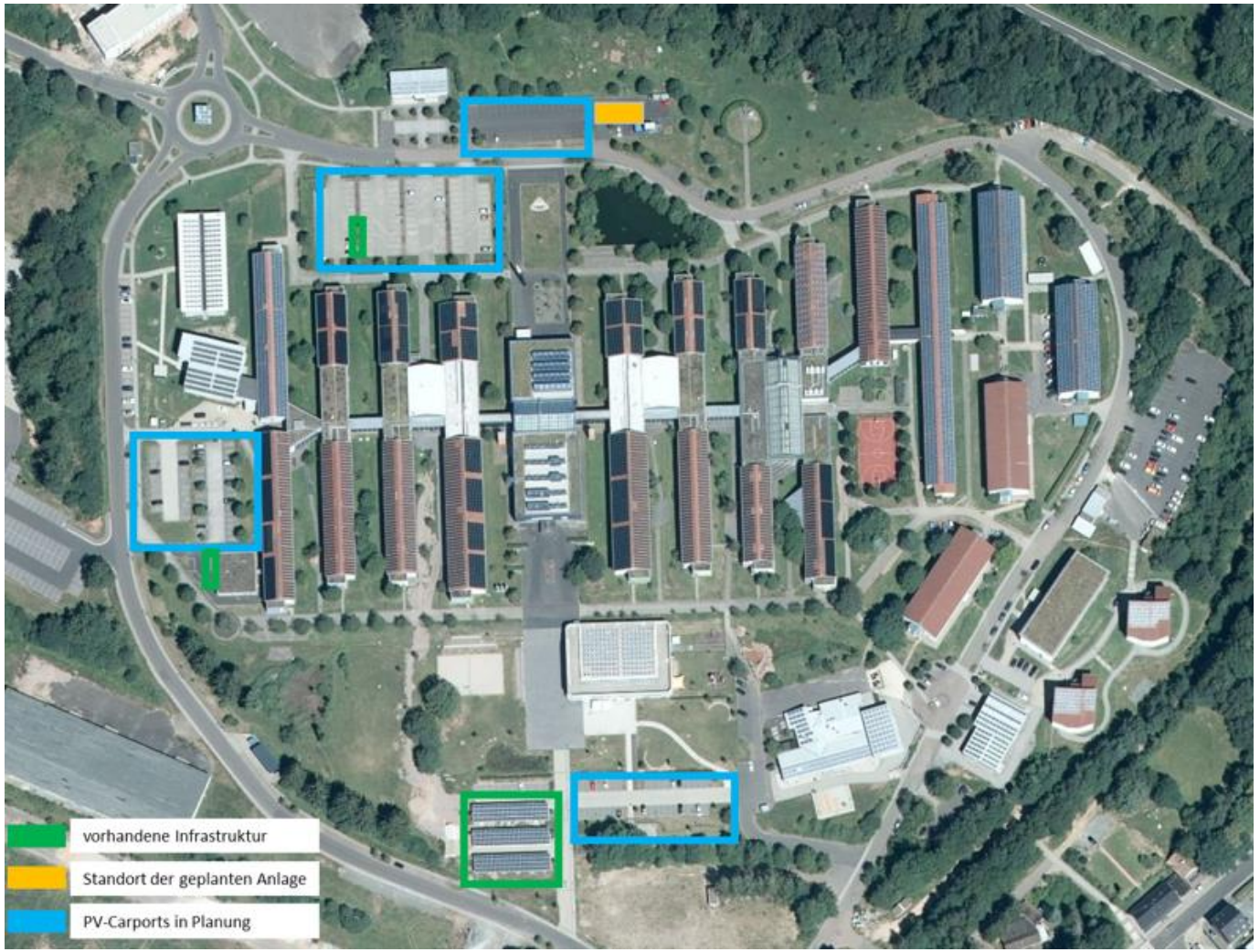
EE/RE

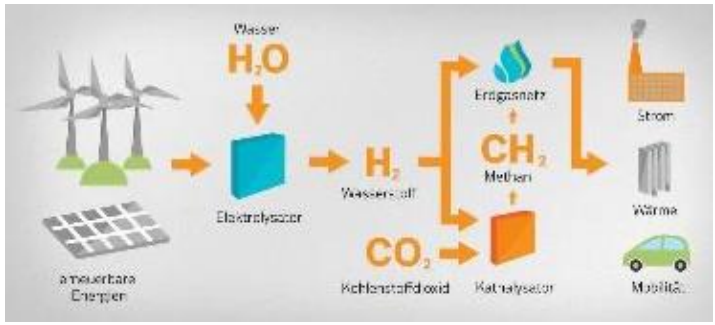
State-of-the art energy and resource efficiency technologies and strategies in place

Zero Emission Building

Powered by the sun

Green hydrogen





An institute for change…

ZECURA

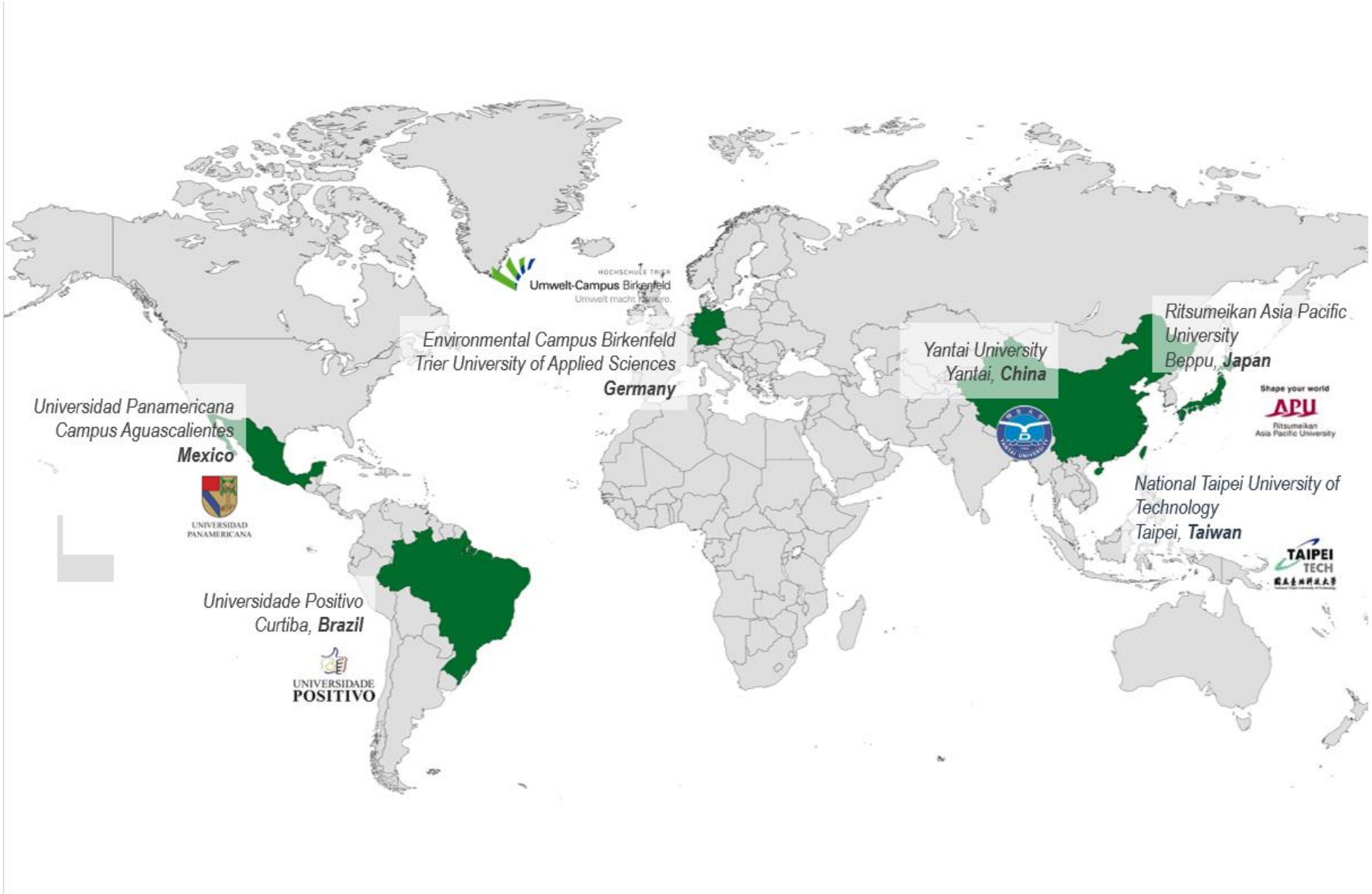
IMAT masters

IMAT
INTERNATIONAL
MATERIAL FLOW MANAGEMENT

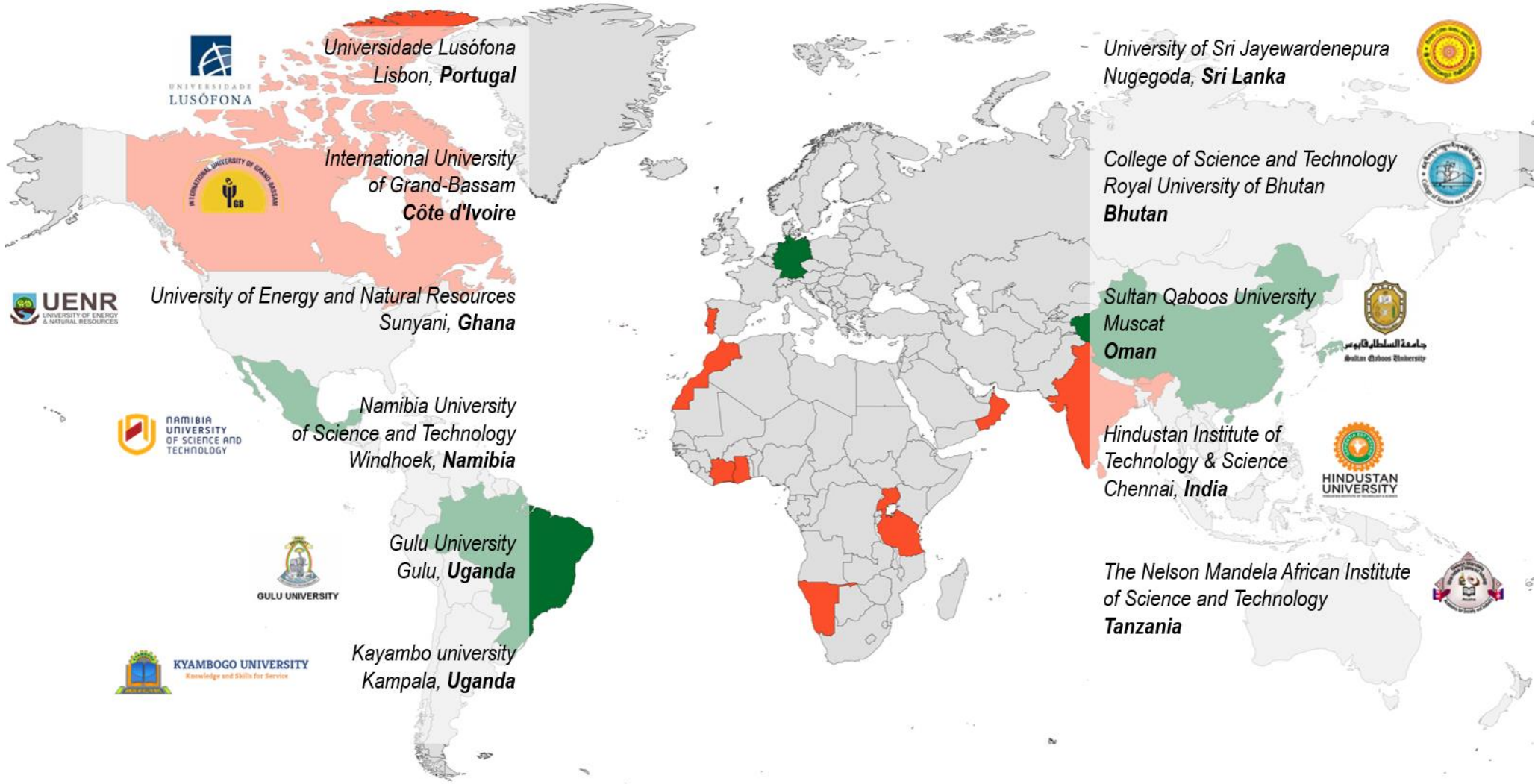
Joint education, research & technology transfer for Circular Economy

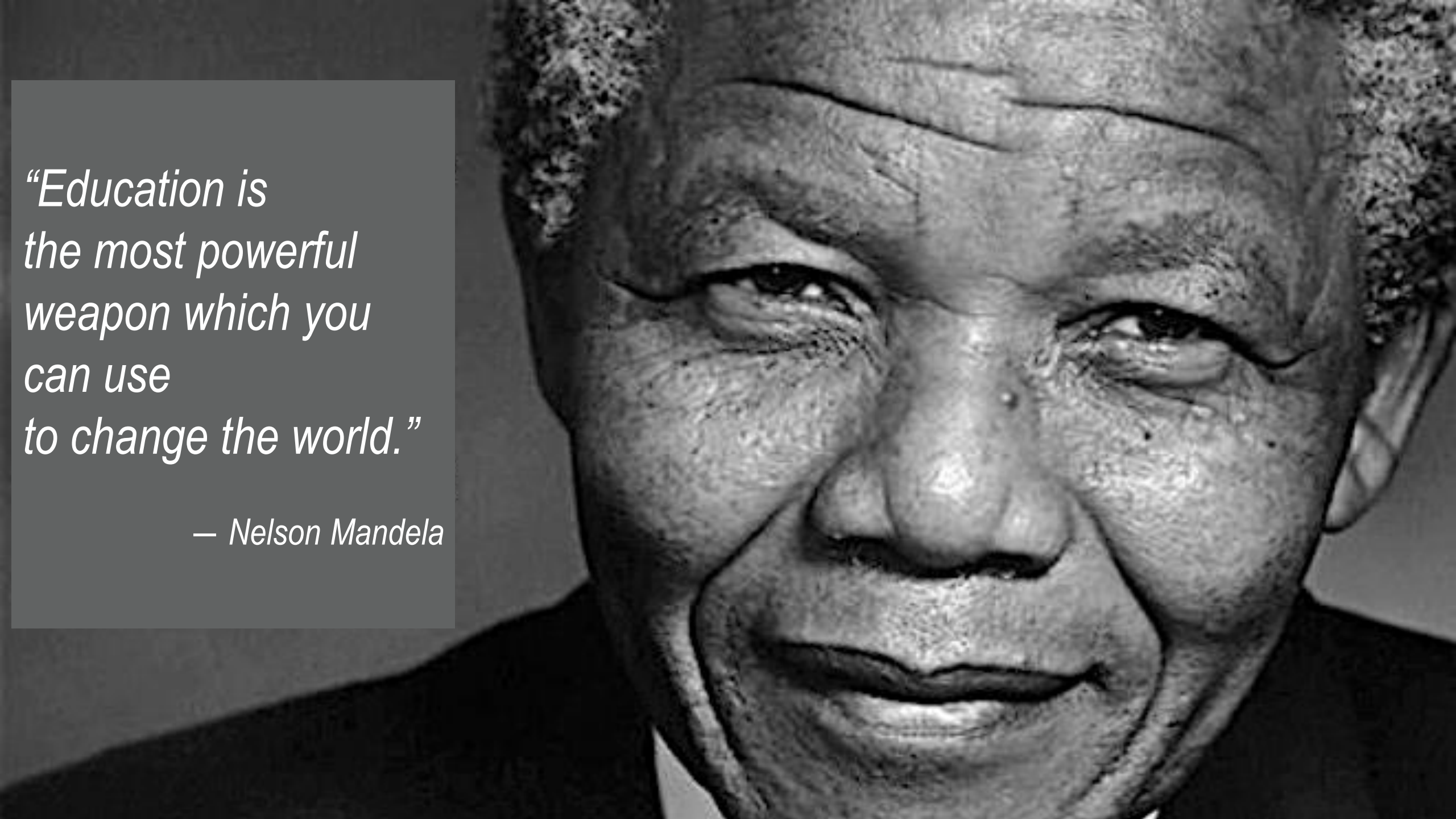
ZECURA

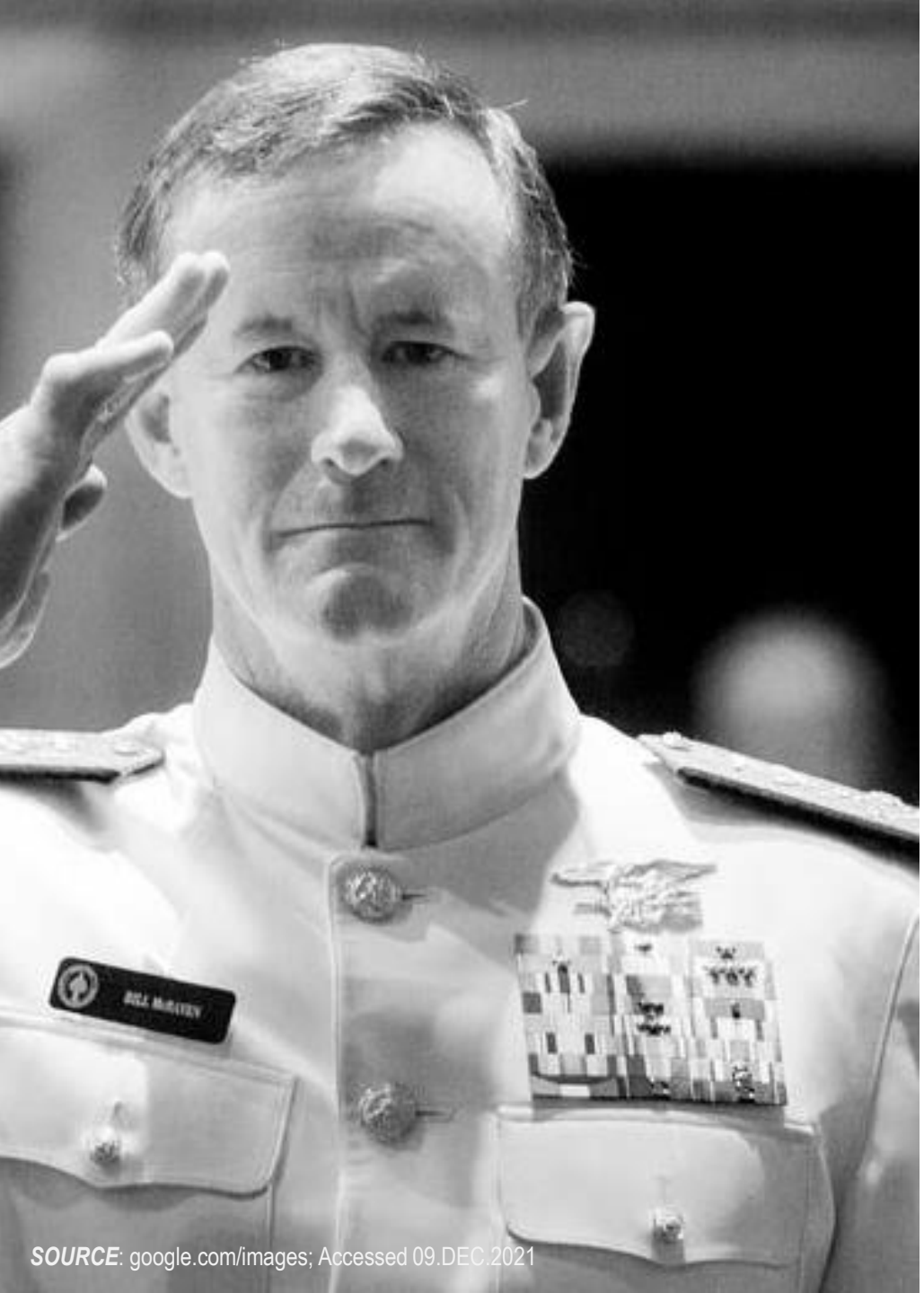
IMAT-Network
University (IMAT-NU)



IMAT-NU: a growing network




“Education is
the most powerful
weapon which you
can use
to change the world.”
— Nelson Mandela



SOURCE: google.com/images; Accessed 09.DEC.2021

"If you want to change the world, start off by making your bed."

— William H. McRaven

ZECURA

Zero-Emission Concepts for Urban Resilience in selected African cities

Grand Finale
Travelling University AUI

DIAGNOSTIC SUMMARY: ZERO-EMISSION CAMPUS MASTER PLAN

جامعة الأخوين
ⵜⴰⵙⴷⴰⵡⵉⵜ ⵏ ⵓⵅⴰⵡⴰⵢⵏ
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— Vision —

“Our vision is to create innovative resilience strategies for fast growing cities to successfully overcome current and future sustainability challenges”.

— Mission—

"Our mission is to make Azrou a resilient city; a city that withstands socio-political and environmental stressors and demographic change whilst accelerating its economic growth. Al Akhawayn University will be the sustainability, technology and transport hub of Morocco through a secure, independent and sustainable economy, whilst sharing its knowledge with surrounding communities".

Research team

Visiting team

Host team

Contents

Critical parameters

Market rates

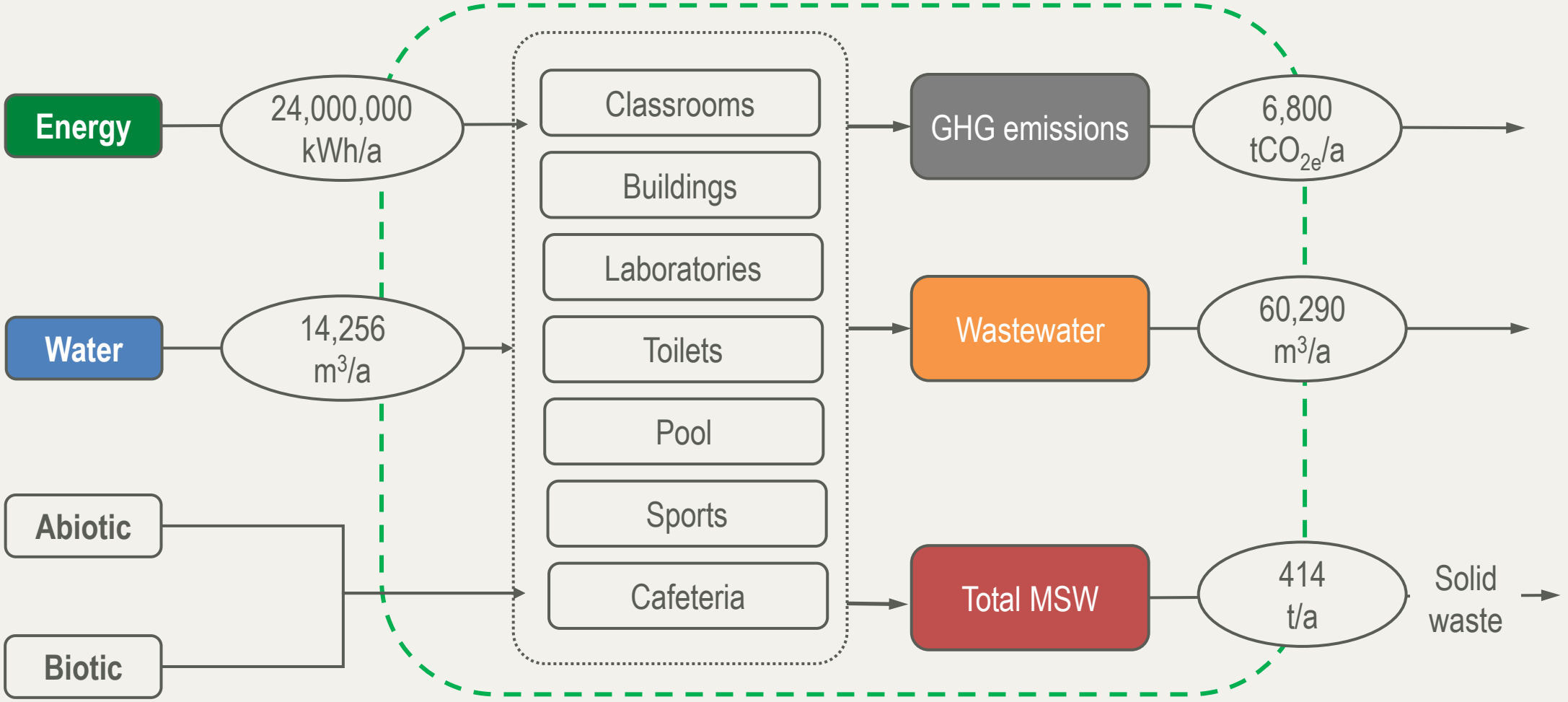
Item	Unit	Value	Source
Electricity	MAD/kWh	1.02	AUI, 2023
Conversion rate	MAD/EUR	10.9	Google Finances, 2023
Water	MAD/m^3	2.54	AUI weighted average
Petrol	MAD/L	15.5	Global Petrol Prices, 2023
LPG	MAD/kg	3.3	AUI, 2023
Diesel	MAD/L	13.6	Global Petrol Prices, 2023

Emission factors

Energy sources	Unit	Value	Source
Petrol	$kgCO_{2e}/kWh$	0.27	IPCC AR6, 2023
Diesel	$kgCO_{2e}/kWh$	0.25	IPCC AR6, 2023
LPG	$kgCO_{2e}/kWh$	0.20	IPCC AR6, 2023
Grid	$kgCO_{2e}/kWh$	0.73	IFI, 2021

System

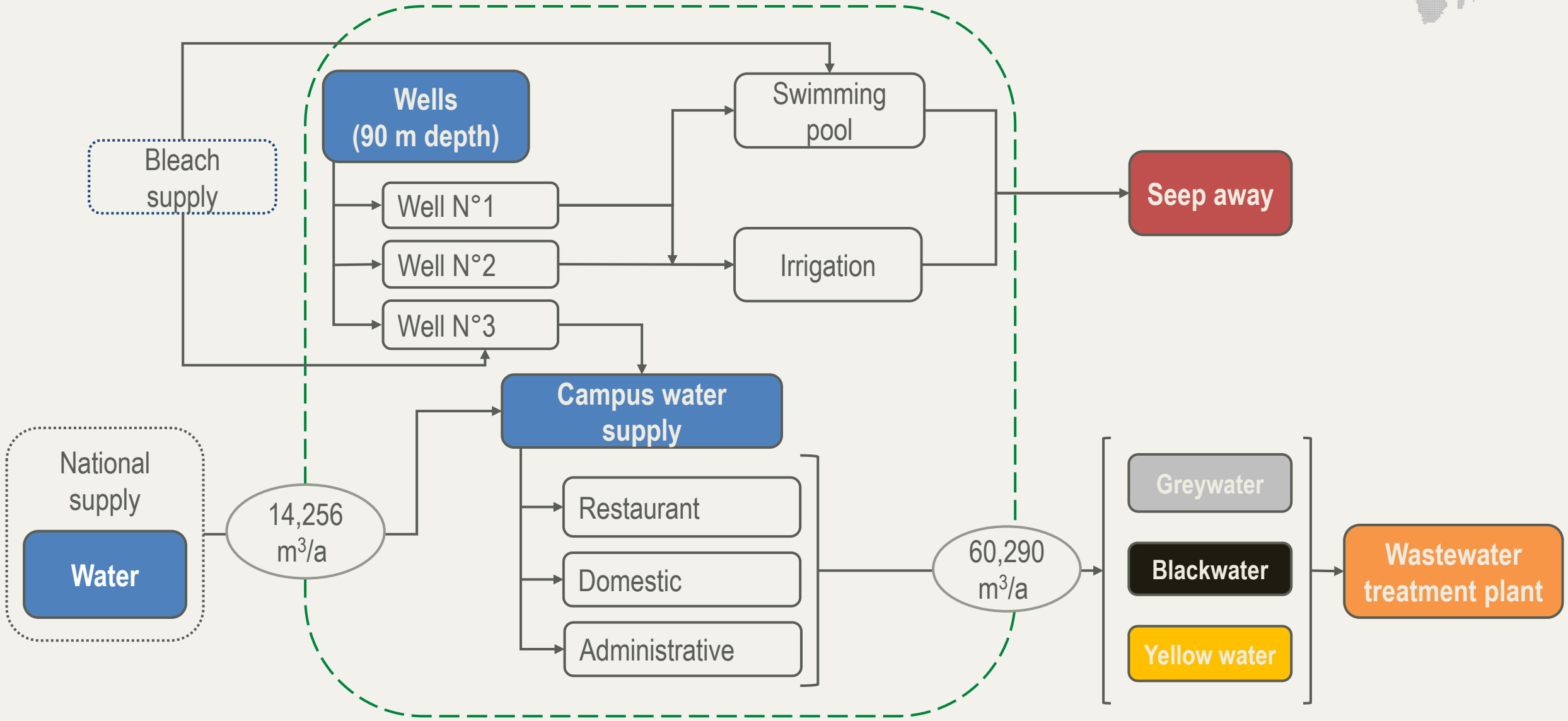
Status quo: material flow (AUI, 2023)



System boundary: AUI, 2023

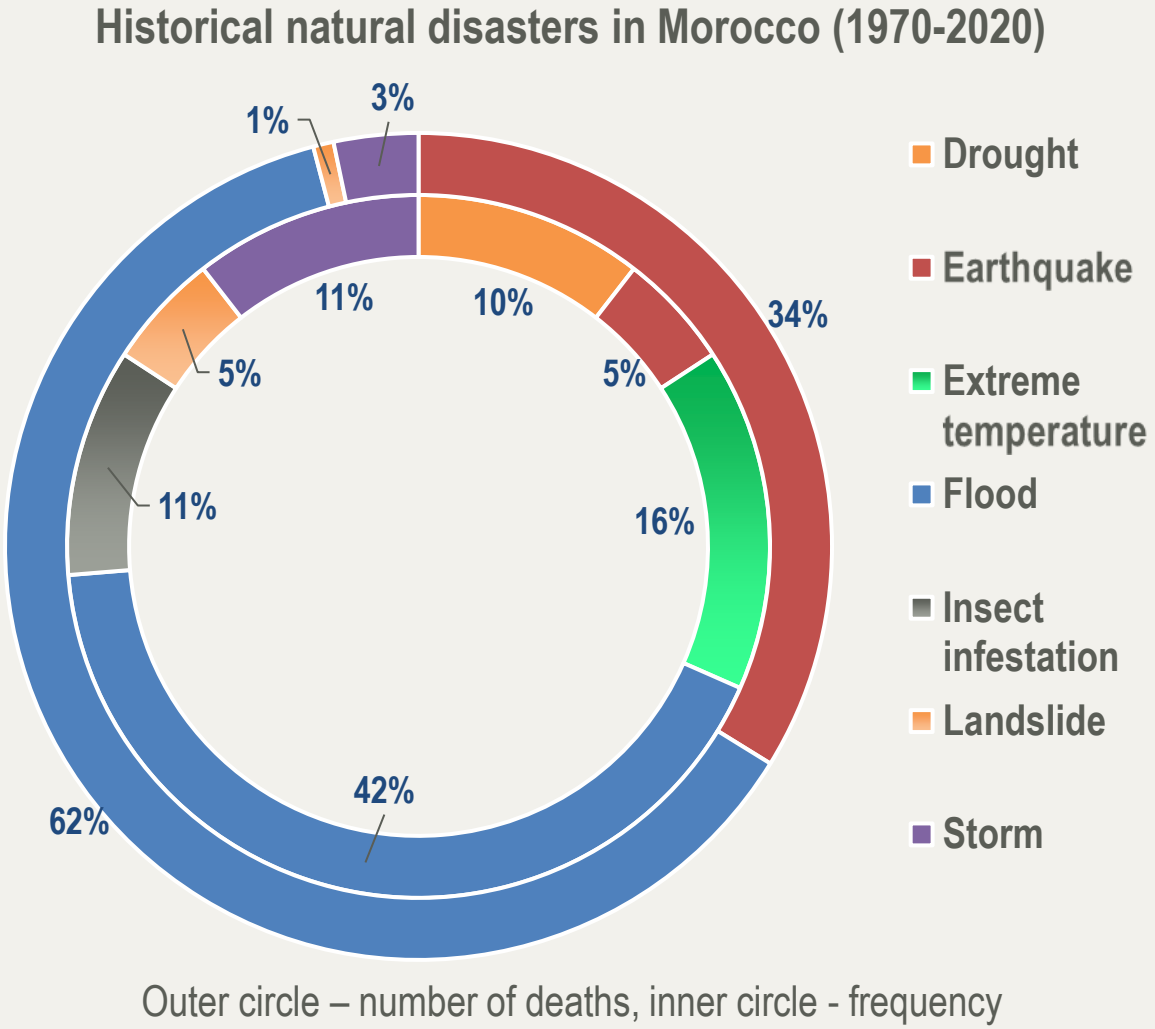
Water

Status quo: water (AUI, 2023)



System boundary: AUI, 2023

Status quo (Azrou, 2023)



Outer circle – number of deaths, inner circle - frequency

High flood risk sites

Sites with protective measures

SOURCE: Loudyl et al. (2022); OCDE (2017)

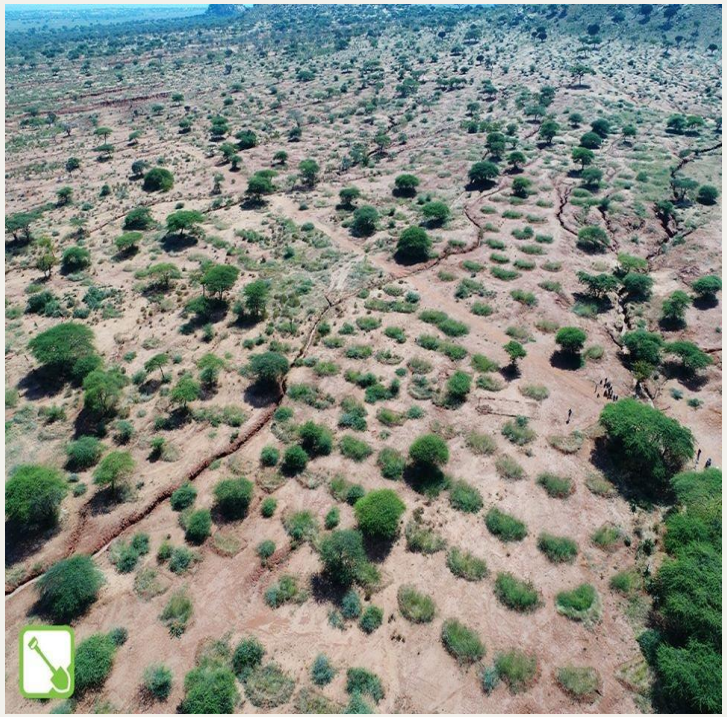
Structural measures (Azrou, 2023)

Before canalization

After canalization

SOURCE: OCDE (2017)

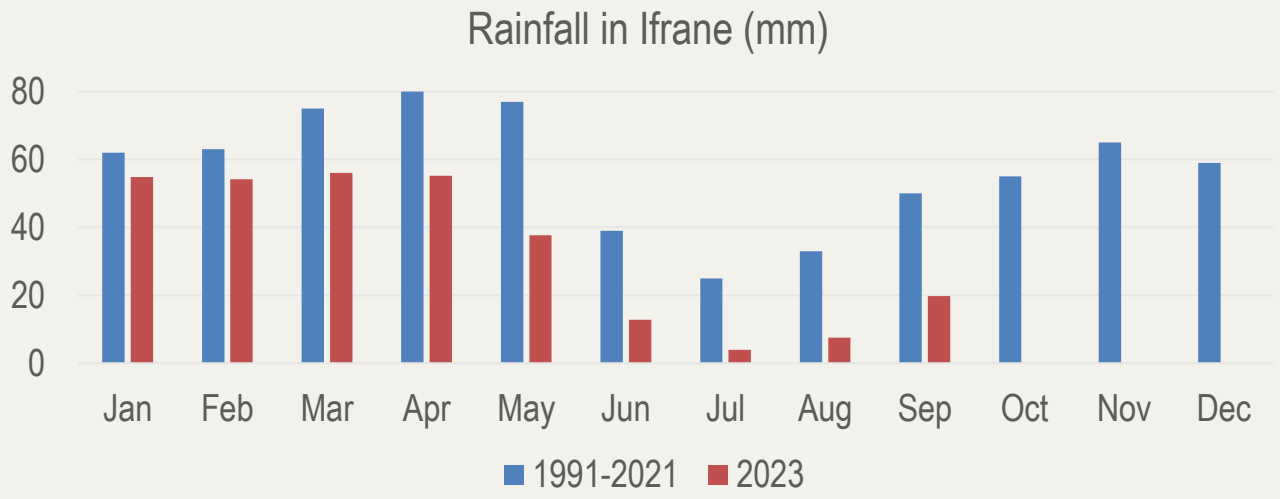
Non-structural measure (Azrou, 202X)



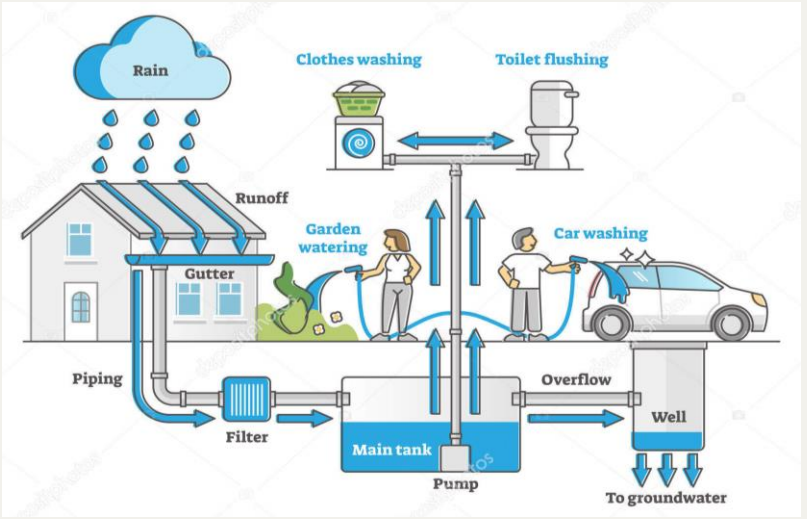
Earth smiles (Bunds)

SOURCE: Justdiggit, (2023)

Rainwater harvesting (AUI, 202X)



Parameter	Unit	Amount
Roof area	m^2	51,000
Irrigated area	m^2	83,000
Potential harvest	m^3/a	24,000
Estimated irrigation (150 days)	m^3	1,278

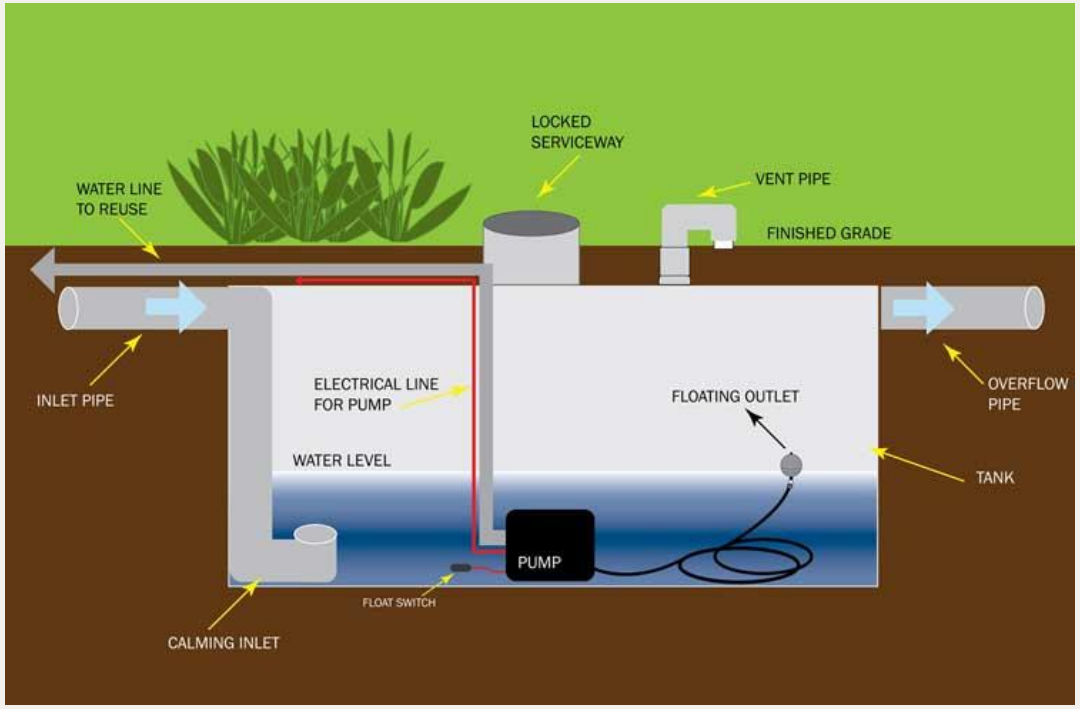


SOURCE: https://en.climate-data.org/africa/morocco/ifrane, https://fr.weatherspark.com; https://raiwa24.de/produkt/polynet-laubstopp/, TU Ghana 2023

Rainwater harvesting (AUI, 202X)

Reservoir for 2,350 m^3 of rainwater

For a dry period of five months and backup



Parameter	Unit	Amount
Total construction cost	MAD	768,570
Operating cost	MAD/a	7,685
Monetary saving	MAD/a	59,000
LCoS	MAD/m^3	4.04

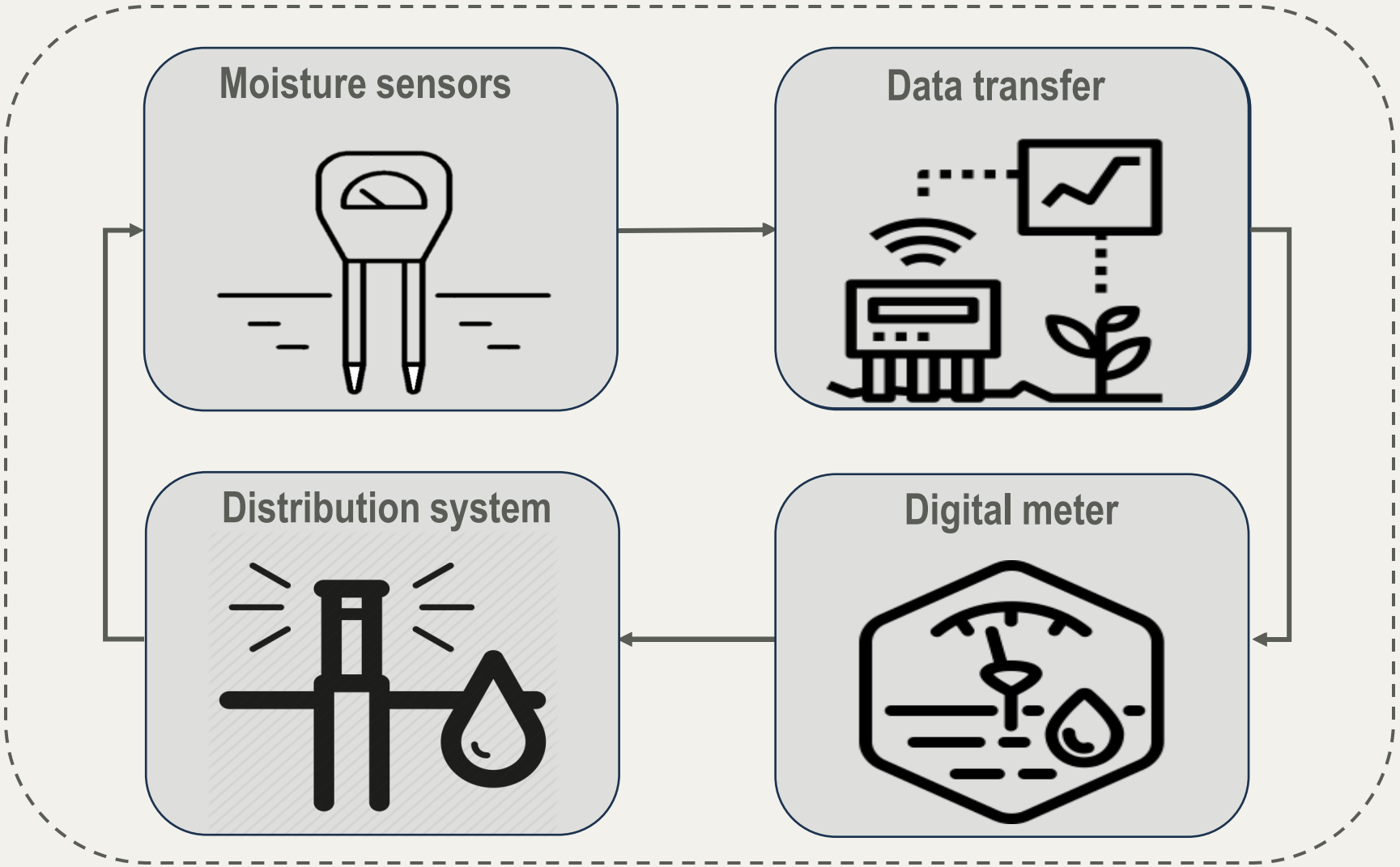
NOTE: LCoS = Levelised cost of service

SOURCE: https://www.conteches.com

Status quo: irrigation system (AUI, 2023)

SOURCE: ZECURA 2023

Smart irrigation system (AUI, 202X)

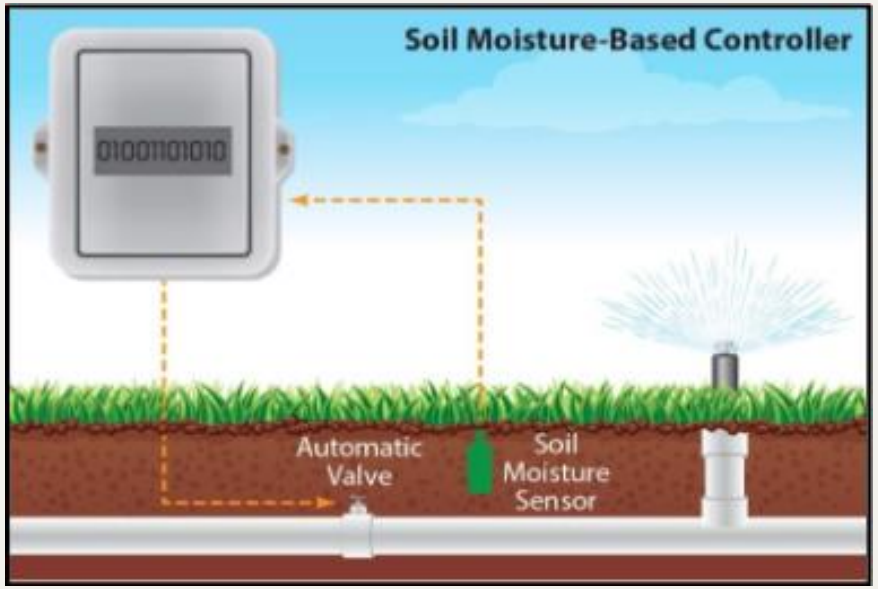


System boundary: AUI, 202X

SOURCE: Bing images, (2023); Google Images (2023)

Smart irrigation system (AUI, 202X)

Parameter	Unit	Amount
Total irrigated area	m^2	83,000
Sensors needed	n	413
Price per sensor	MAD	368
CapEx	MAD	154,220
Water savings	m^3/a	23,100



Water savings
→ 20%

Static payback
→ 8 years

SOURCE: GSA.gov (2023)

Ideas & strategies: water use efficiency (AUI, 202X)

Separation toilets

Water saving faucets

Water-efficient shower

Water savings (compared to conventional)

→ 50%

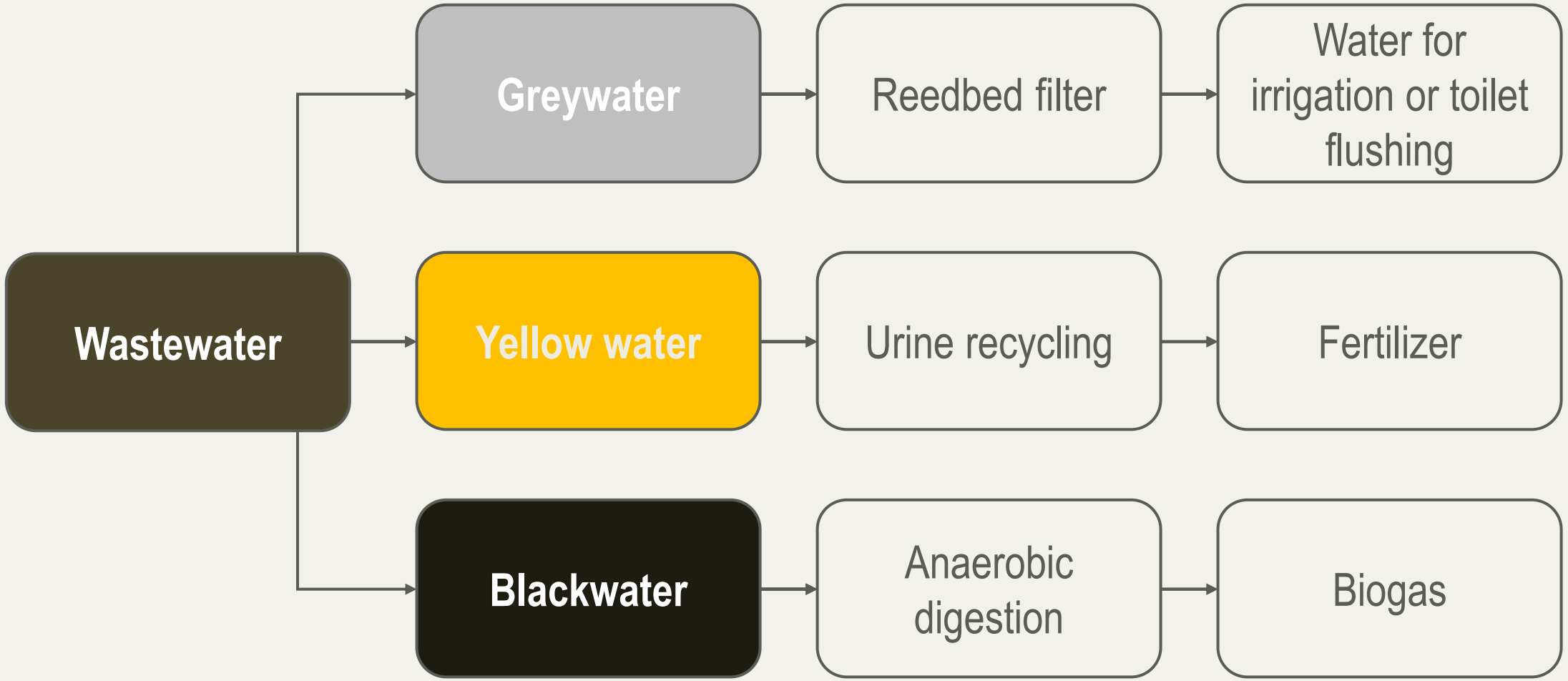
→ 68%

→ 58%

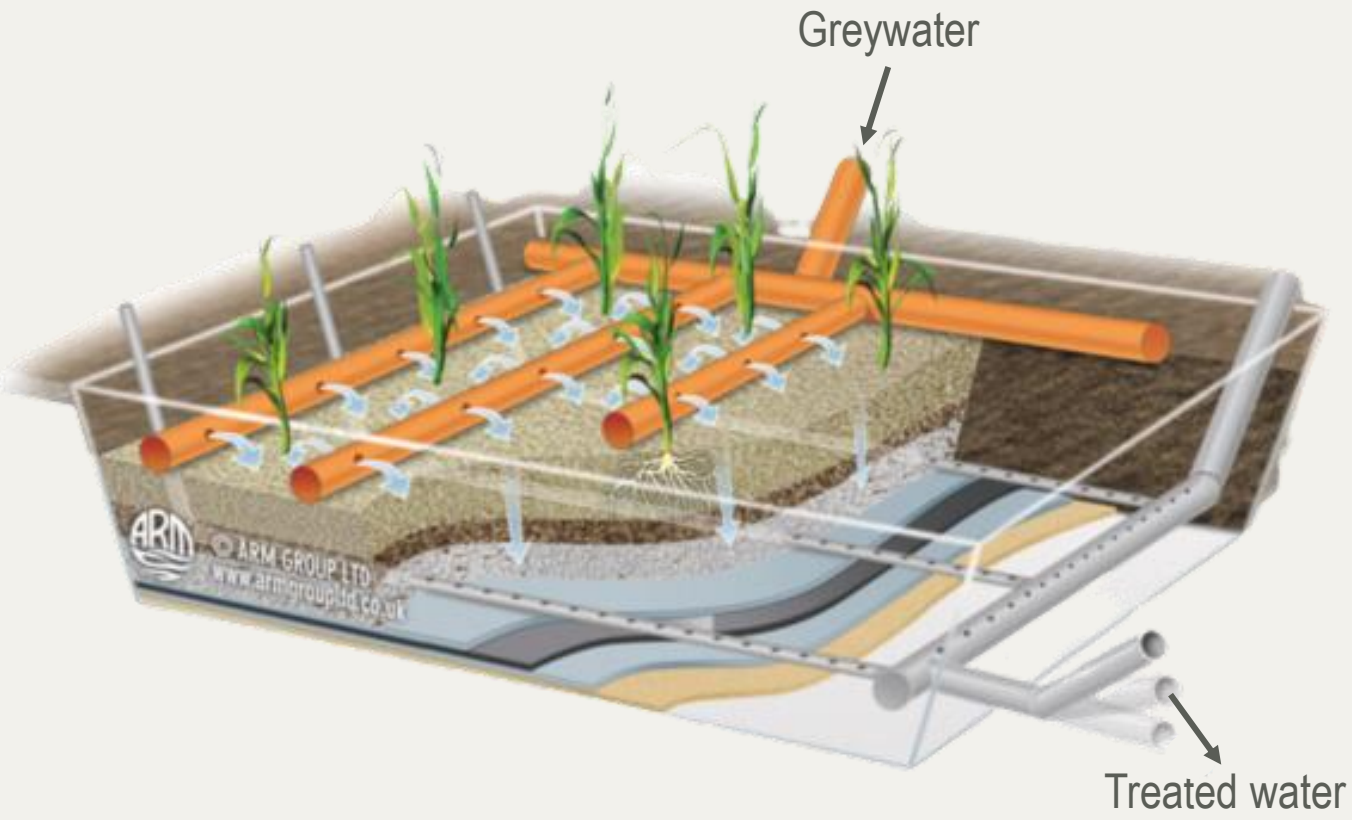
SOURCE: https://m.media-amazon.com/images/I/318zI+8c9ML._AC_.jpg, www.de.laufensave.com, https://s3.img-b.com

Proposed wastewater treatment methods

(AUI, 202X)



Reed bed filter (RBF) system (AUI, 202X)



SOURCE: https://www.reedbeds.co.uk, https://armreedbeds.co.uk/projects/vertical-flow/

Reed bed filter system (AUI, 202X)

Parameter	Unit	Value
Wastewater	m^3/a	82,965
Greywater	m^3/a	62,224
Inflow	$L/m^2/d$	60
Area demand	m^2	3,758
LCoS	MAD/m^3	1.28

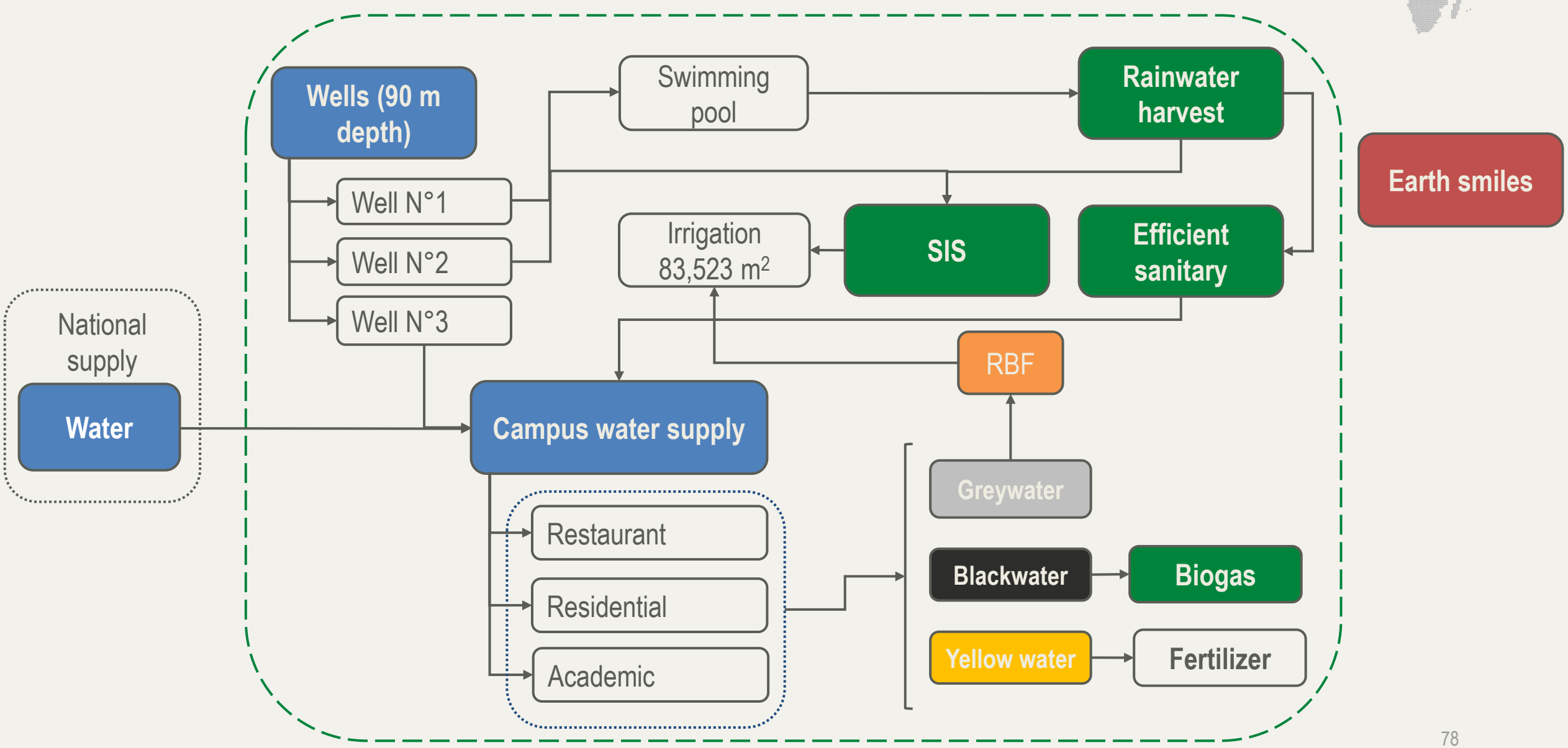
Investment costs:
1,687,500 MAD

Emission savings:
13 tCO_{2e}/a

NOTE: LCoS = Levelised cost of service

SOURCE: IfaS- technical division (2023)

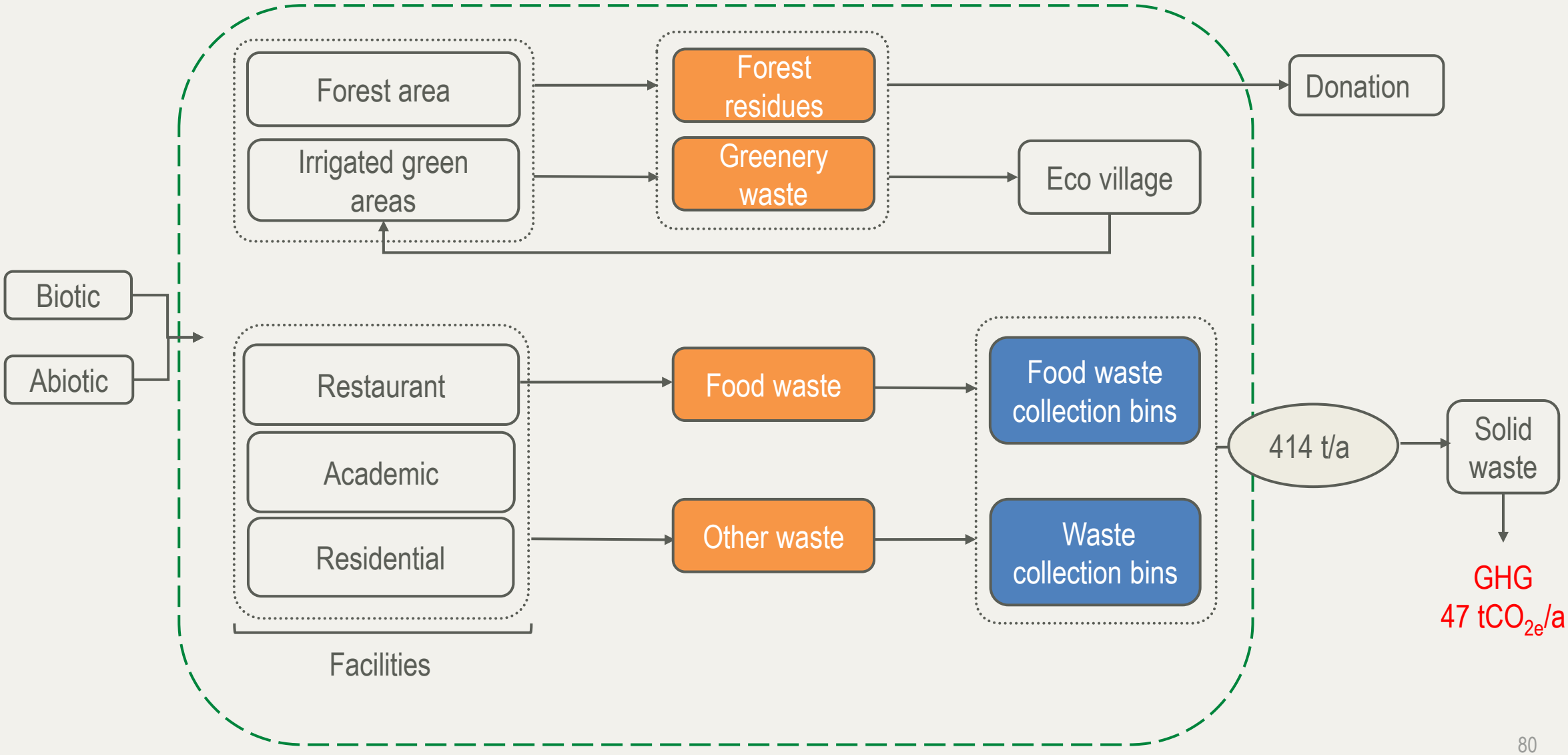
Proposed water management (AUI, 202X)



System boundary: AUI 202X

Waste

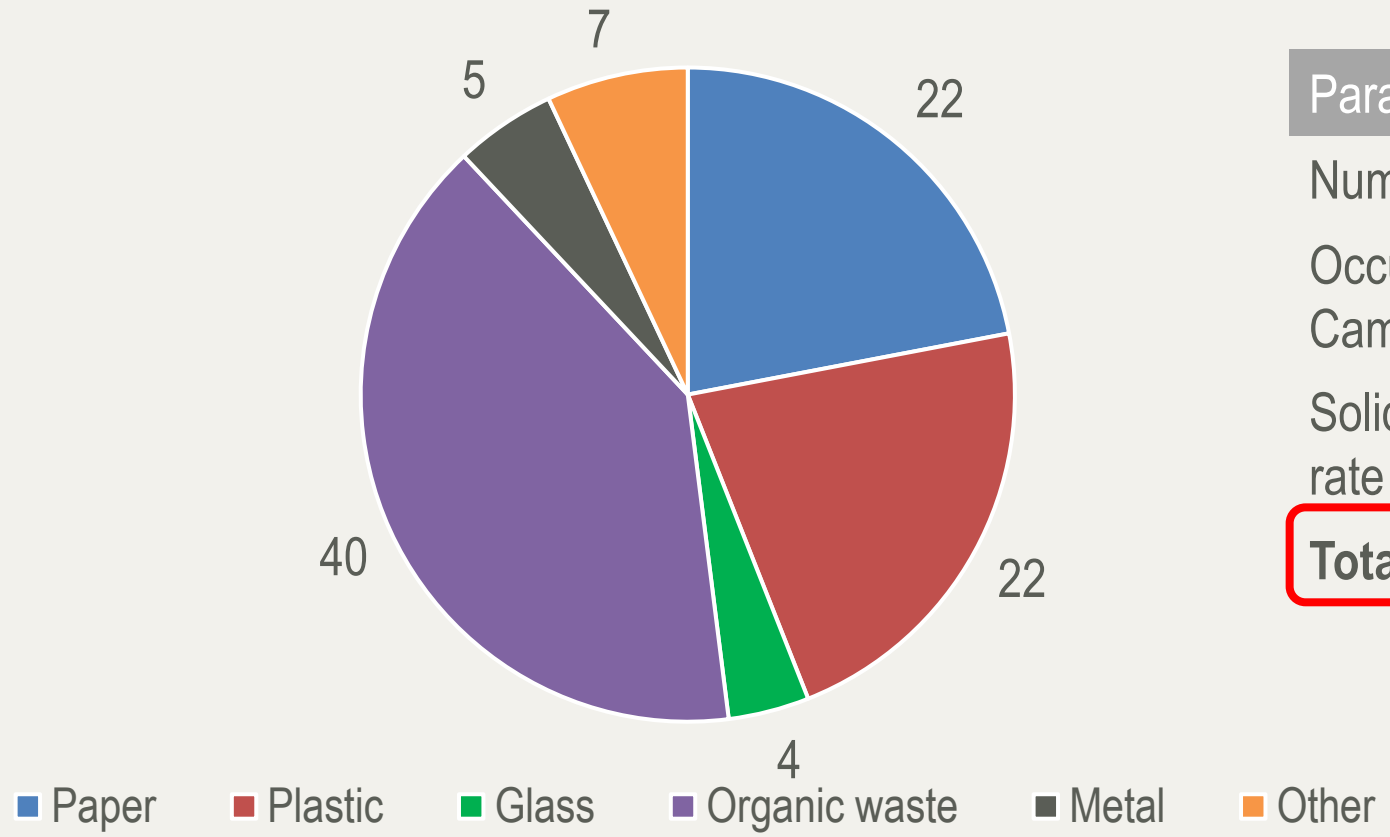
Status quo: solid waste (AUI, 2023)



System boundary: AUI, 2023

Solid waste composition (AUI, 2022)

Estimated solid waste composition of AUI [%]



Parameter	Unit	Amount
Number of students	x	3,382
Occupancy of AUI Campus	day	276
Solid waste generation rate	kg/ca/day	0.44
Total amount generated	t/a	414

Status quo: solid waste (Azrou, 2023)

SOURCE: ZECURA, (2023)

Waste management: awareness (AUI, 202X)

SOURCE: Google Images, https://www.bangor.ac.uk/environment/wastecampaigns.php.en

Waste management: sorting (AUI, 202X)

Parameter	Amount [t/a]	Value [MAD/a]
Plastic waste	92	294,400
Paper waste	91	91,000
Metal waste	21	203,700

Potential market value
589,100 MAD/a

SOURCE: Google Images,https://www.bangor.ac.uk/environment/wastecampaigns.php.en

Status quo: disposable cutlery (AUI, 202X)

Disposable cutlery:
11,000 units per day

=

Cost:
2,420 MAD per day

667,000 MAD every year

SOURCE: *GoogleImages(2022), https://www.google.com/search =plastic+cutlery&tbm=isch&source=lnms&sa=X&ved=2ahUKEwi_vrON2cGBAxXMU0EAHT24OjYQ0pQJegQIDBAB&biw*

Alternatives: stainless steel cutlery or biodegradable cutlery? (AUI, 202X)

Stainless steel cutlery

Biodegradable cutlery

***SOURCE*:** Amazon.com, (2023)

Valorization potential: PET plastic (AUI, 202X)

1,400 MAD/t

2,600 MAD/t

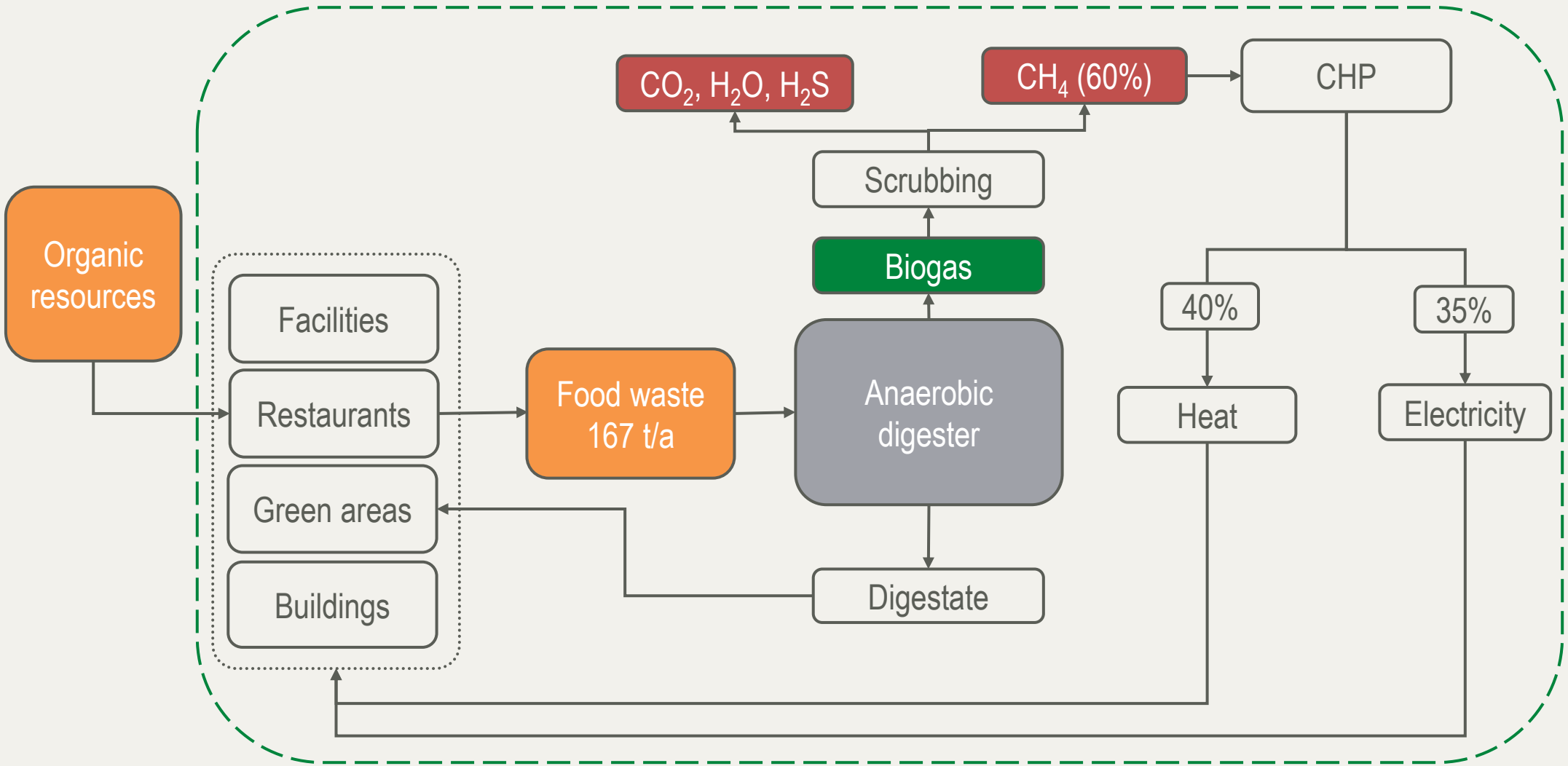
SOURCE: Google image, https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.recycling-magazine.com%2F2020%2F06%2F08%2Fpet-recycling-towards-a-circular-economy

PET recycling industry potential (Azrou, 202X)

PET flakes	PET pellets	Synthetic wood composite
		
2,600 MAD/t	7,500 MAD/t	39,500 MAD/t

SOURCE: https://www.google.com/search?sca_esv=567971749&rlz=1C1GCEB_enMX1019MX1019&sxsrf=AM9HkKkgC6lrwgO2lVmYbriHL92Xxw5-kQ:1695548682145&q=pet+pellets&tbm=isch&source=lnms&sa=X&ved=2ahUKEwij6peH-8KBAxUCT6QEHT0TBhwQ0pQJegQIDRAB&biw=1624&bih=815&dpr=1.13

Biogas from organic waste (AUI, 202X)



System boundary: AUI, 202X

Biogas potential (AUI, 202X)

Parameter	Unit	Amount
Food waste	t/a	167
Total biogas production	m^3/a	18,443
Electricity production	kWh/a	38,731
Heat production	kWh/a	44,264

Parameter	Percentage
Electricity contribution to AUI	0.8%
Heat contribution to AUI	1.2%

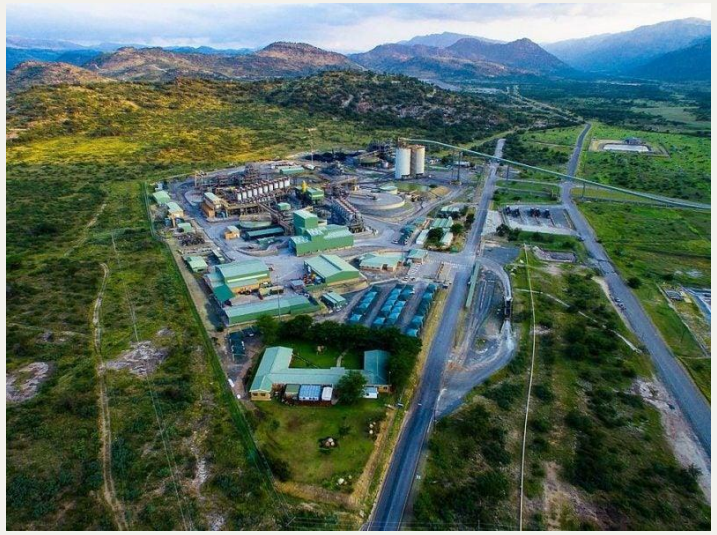
Parameter	Unit	Amount
Electricity savings	MAD/a	40,676
Heat savings	MAD/a	619,819
Total savings	MAD/a	660,495
Estimated CapEx	MAD	424,533
IRR		15%
Payback	Years	7.1

Biogas potential (AUI, 202X)

Parameter	Unit	Amount
LCoE: Electricity	MAD/kWh	0.71
LCoE: Heat	MAD/kWh	0.78
Avoided emissions (Heat)	tCO_{2e}/a	11
Avoided emissions (Electricity)	tCO_{2e}/a	28

NOTE: LCoE = Levelised cost of energy

Ideas & strategies: WRS (Azrou, 202X)



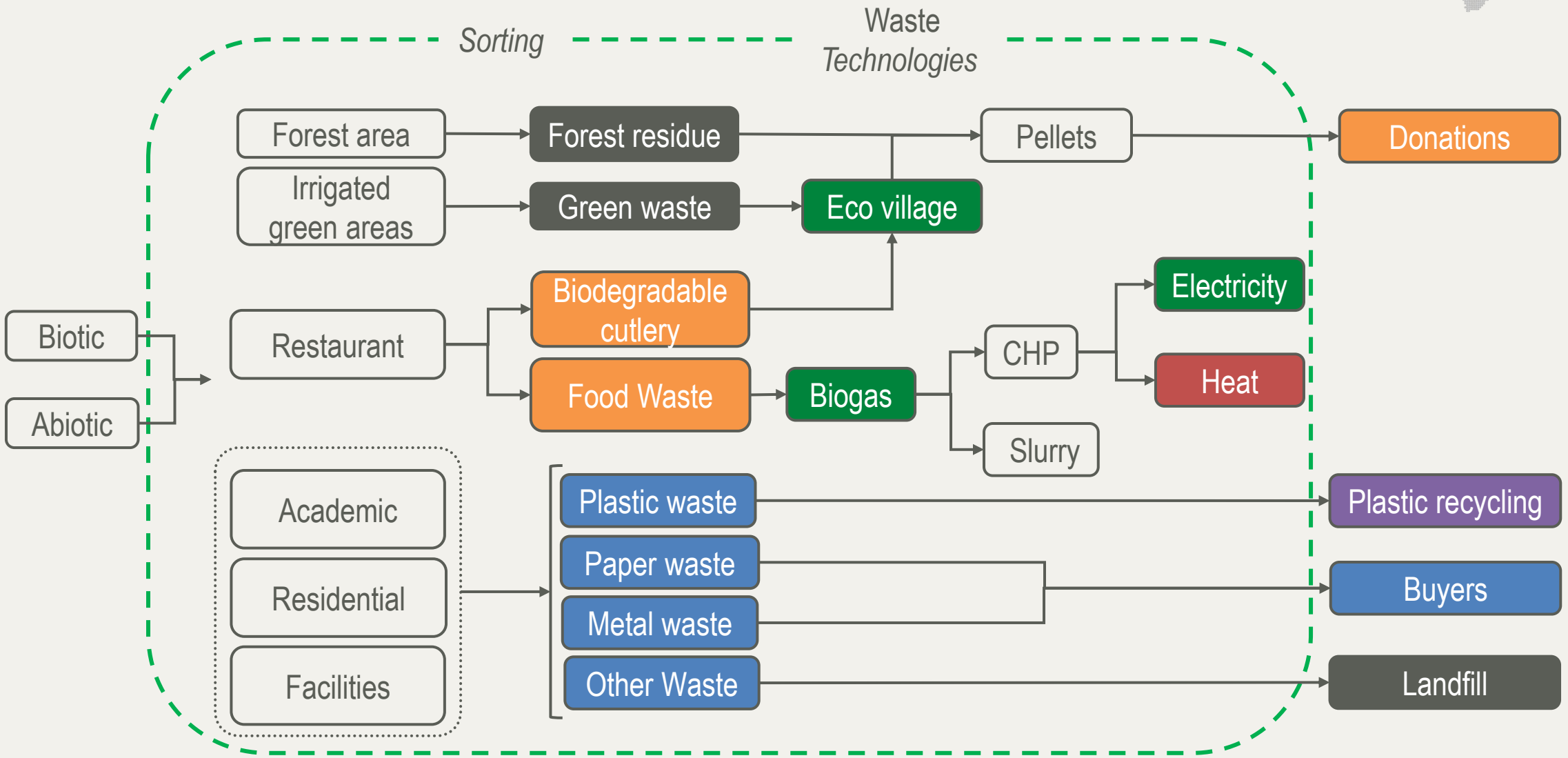
SOURCE: https://wasteconcern.org/waste-concerns-integrated-resource-recovery-center-irrc-being-replicated-by-dhaka-city-corporations-north-and-south/

Biogas potential (Azrou, 202X)

Parameter	Unit	Amount
Total	t/day	165
Organic waste	t/a	39,146
Total biogas production	m^3/a	4,306,000
Electricity production	kWh/a	10,334,600
Heat production	kWh/a	11,626,400

SOURCE: https://www.cri-man.com/biogas/biogas-plants

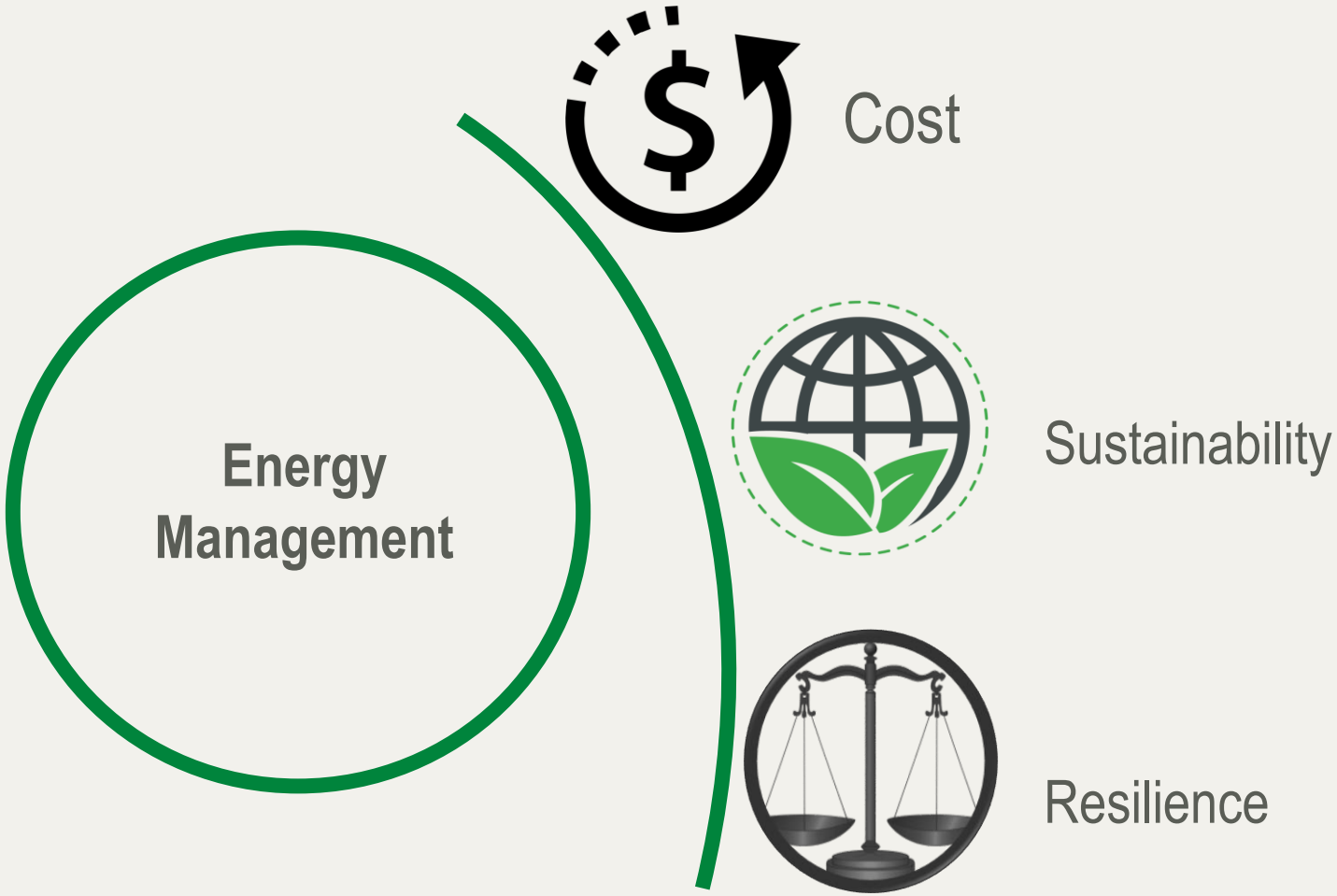
Technology: solid waste (AUI, 202X)



System boundary: AUI, 202X

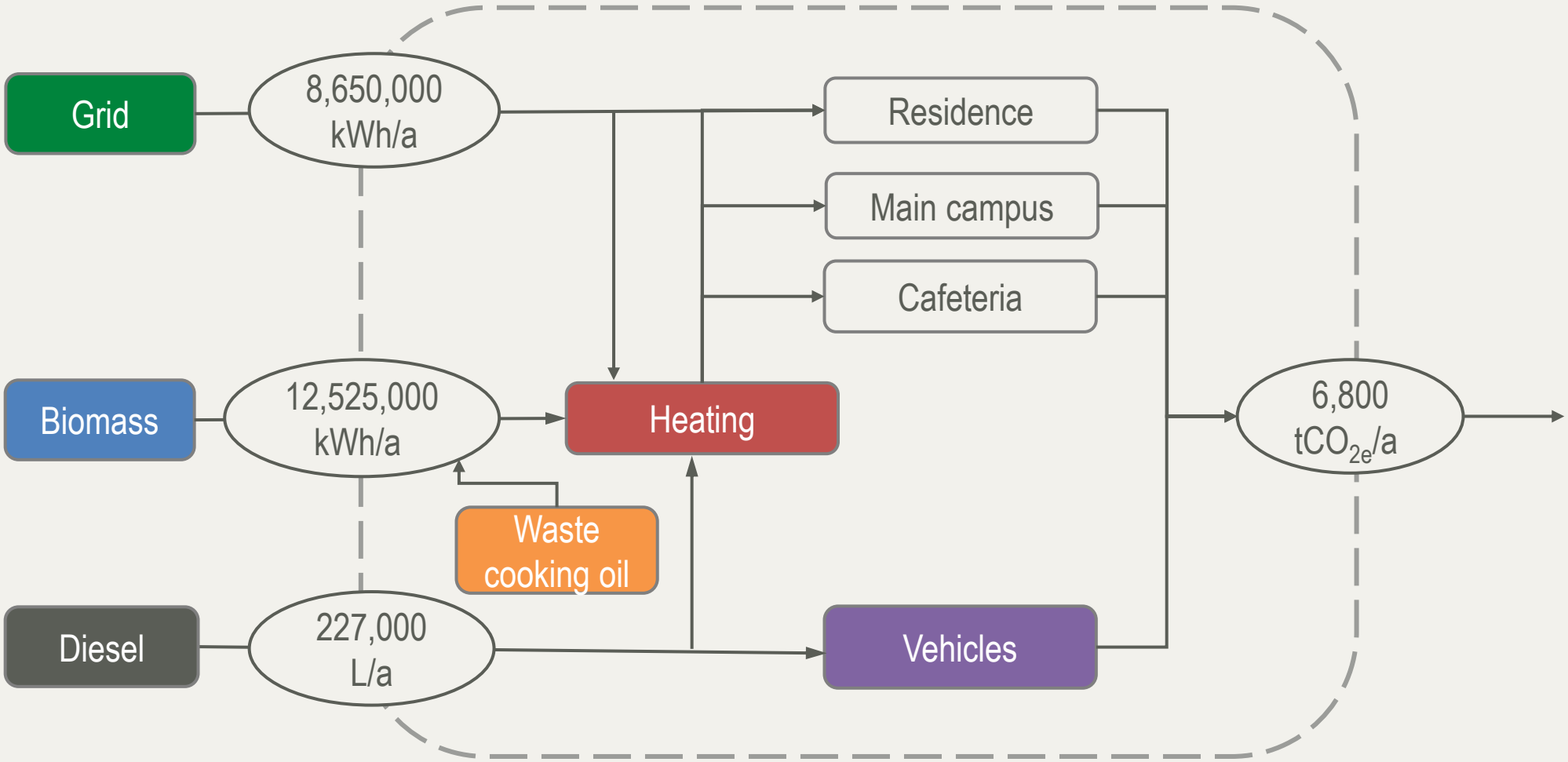
Energy

Energy management (AUI & Azrou, 202X)



SOURCE: https://as2.ftcdn.net, https://www.arenasolutions.com/, https://e7.pngegg.com/pngimages

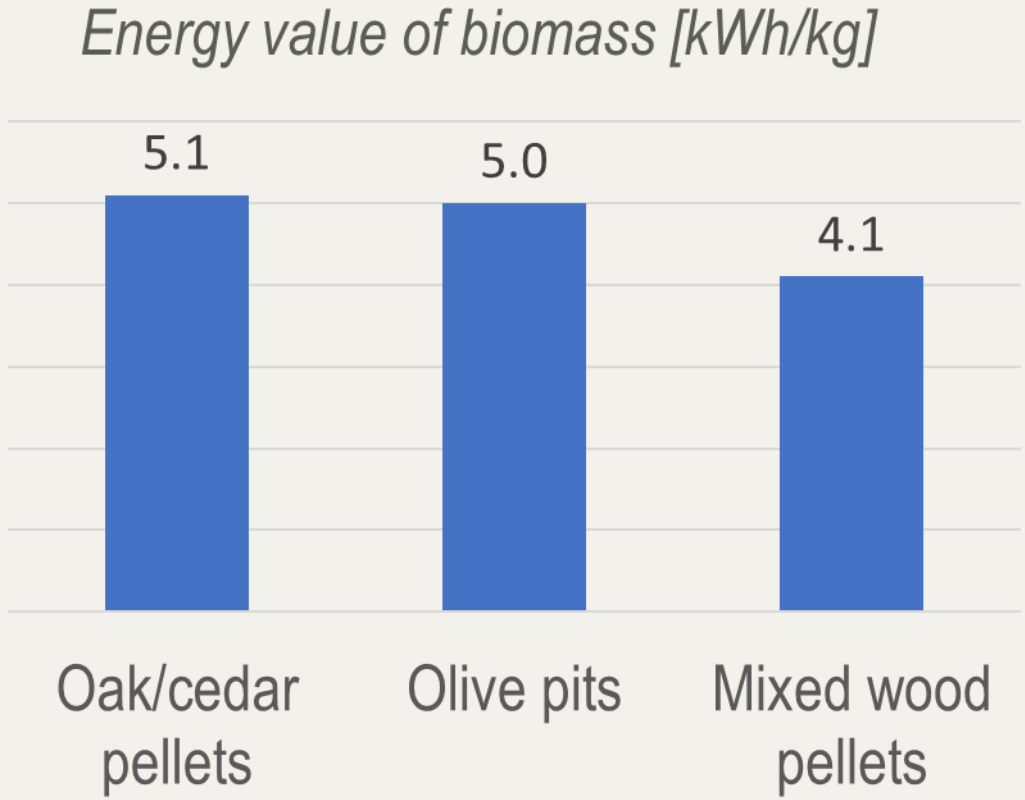
Status quo: energy (AUI, 2023)



System boundary: AUI, 2023

Biomass energy: pelletizing wood (AUI, 202X)

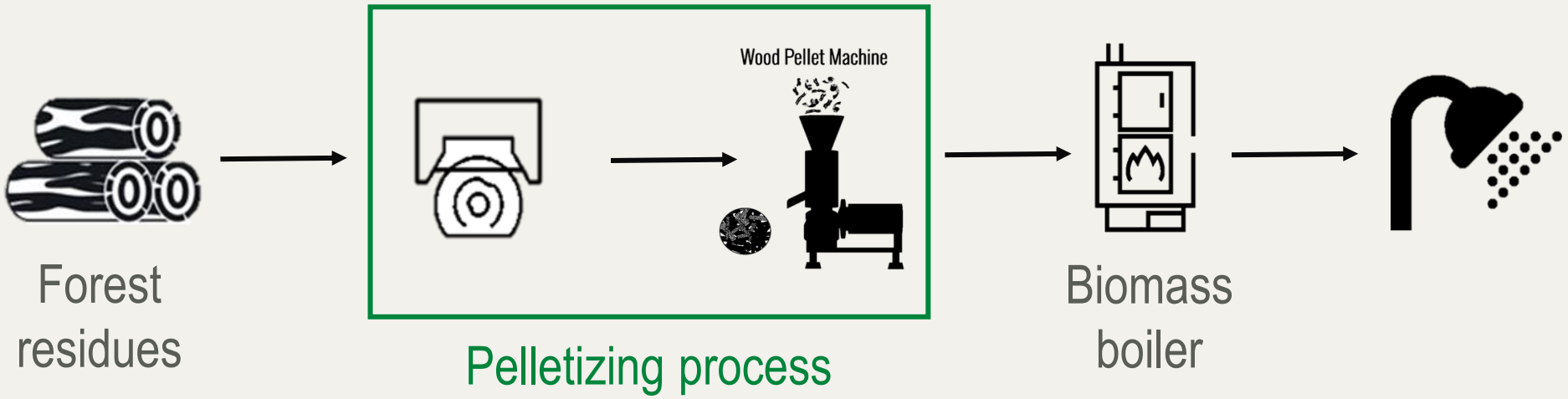
Forest area of AUI = 530,000 m^2



SOURCE: Google maps

Biomass energy: pelletizing process

(AUI, 202X)



SOURCE: https://www.cn-pellet.com/pellet-plant/wood-pellet-machine/

Biomass energy: pellets (AUI, 202X)

Parameter	Unit	Amount
Annual wood residues	t/a	6.9
Ratio wood/pellets	%	50
Total amount of pellets produced	t/a	3.5
Total energy produced by pellets	kWh	36,000

- Social outreach
- Add to the biomass energy production of AUI

- Reforestation to increase biomass

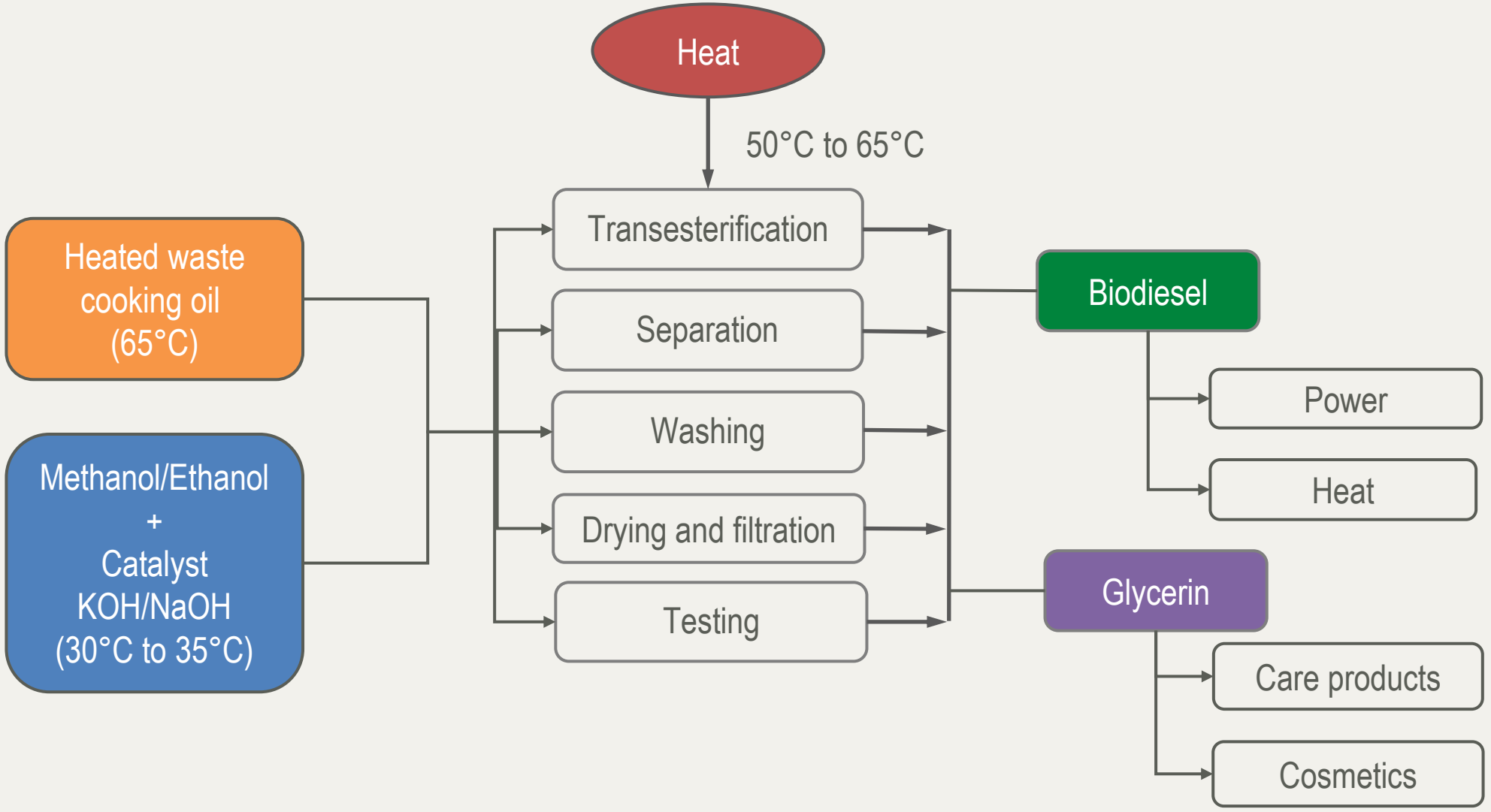
Investment
30,800 MAD

Coverage of total energy demand 2024
0.14%

Potential GHG avoidance
9 tCO_{2e}/a

Biodiesel production and application

(AUI, 2023)



Biodiesel production (AUI, 2022)

Parameter	Unit	Value
Waste cooking oil	L/a	7,680
Methanol	L/a	1,530
Catalyst	kg/a	65,200
Biodiesel	L/a	6,720
Energy produced	kWh/a	67,900
Glycerin	L/a	960

SOURCE: ZECURA, (2023)

Technoeconomics of biodiesel (Azrou, 202X)

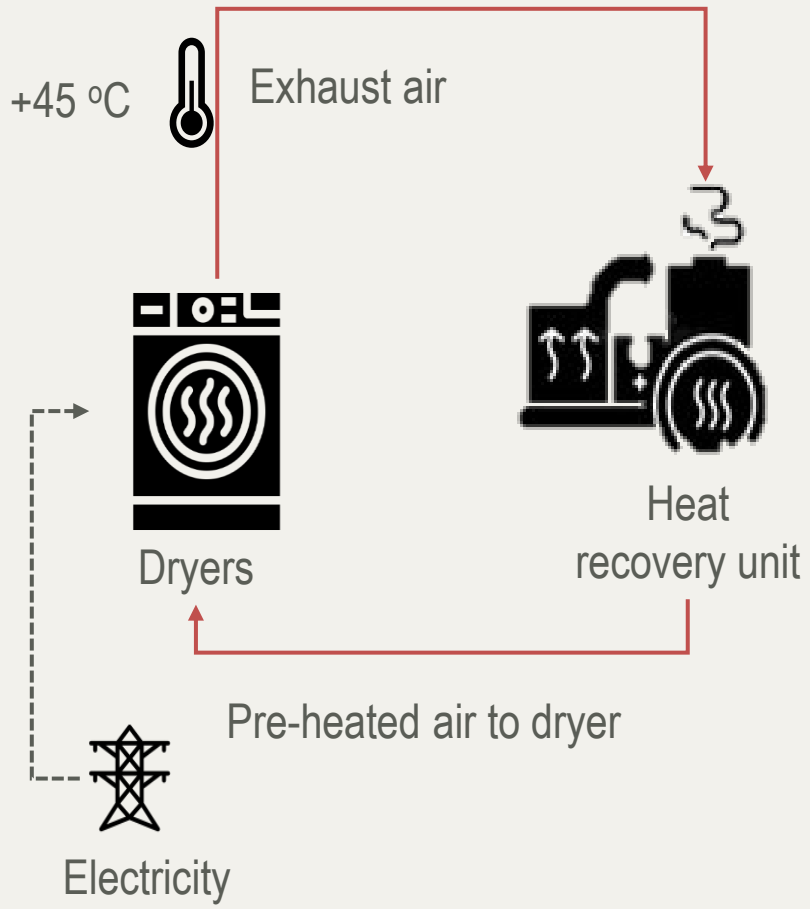
Parameter	Unit	Amount
Total biodiesel production	L/a	87,700
LPG equivalent	kg/a	68,700
Cost equivalent	MAD/a	119,500
LCoE service output	MAD/L	1.27
LCoE of biodiesel energy	MAD/kWh	0.12

LCoE of LPG: 0.25 MAD/kWh

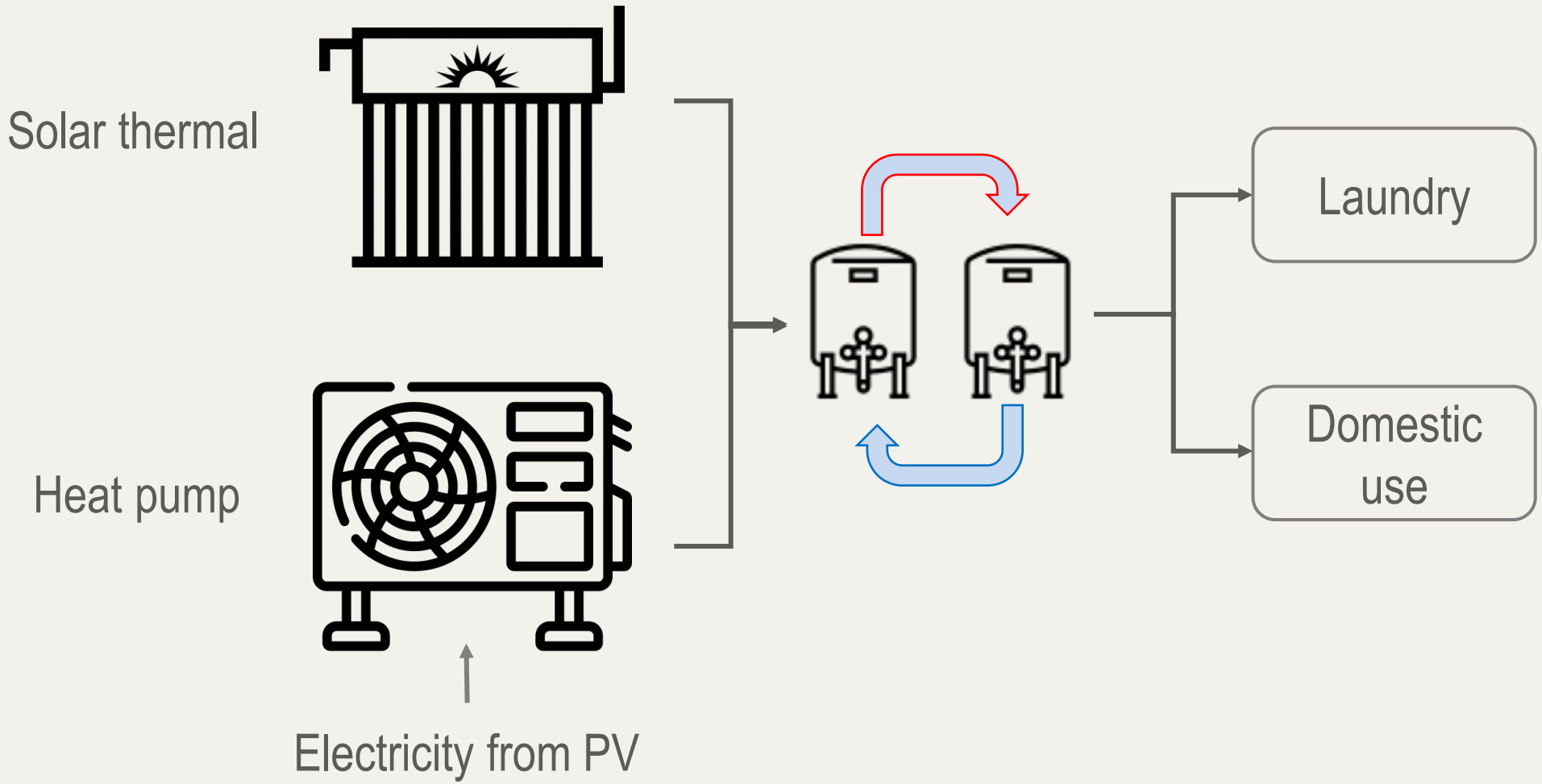
NOTE: LCoE = Levelised cost of energy
SOURCE: https://4.imimg.com/data4/XE/HB/MY-1198324/biodiesel-plant-500x500.jpg

Heat recovery from dryers (AUI, 202X)

Parameter	Unit	W/o heat recovery	With heat recovery
Total installed capacity	kW	86.4	86.4
Annual energy consumption	kWh/a	190,800	143,000
Energy price	MAD/kWh	1.24	1.24
Annual energy cost	MAD/a	236,800	177,600
Energy savings	kWh/a		47,700
Monetary savings	MAD/a		59,195
Estimated investment	MAD		400,000
GHG reduction potential	tCO_{2e}/a		37
Simple payback	a		6.8

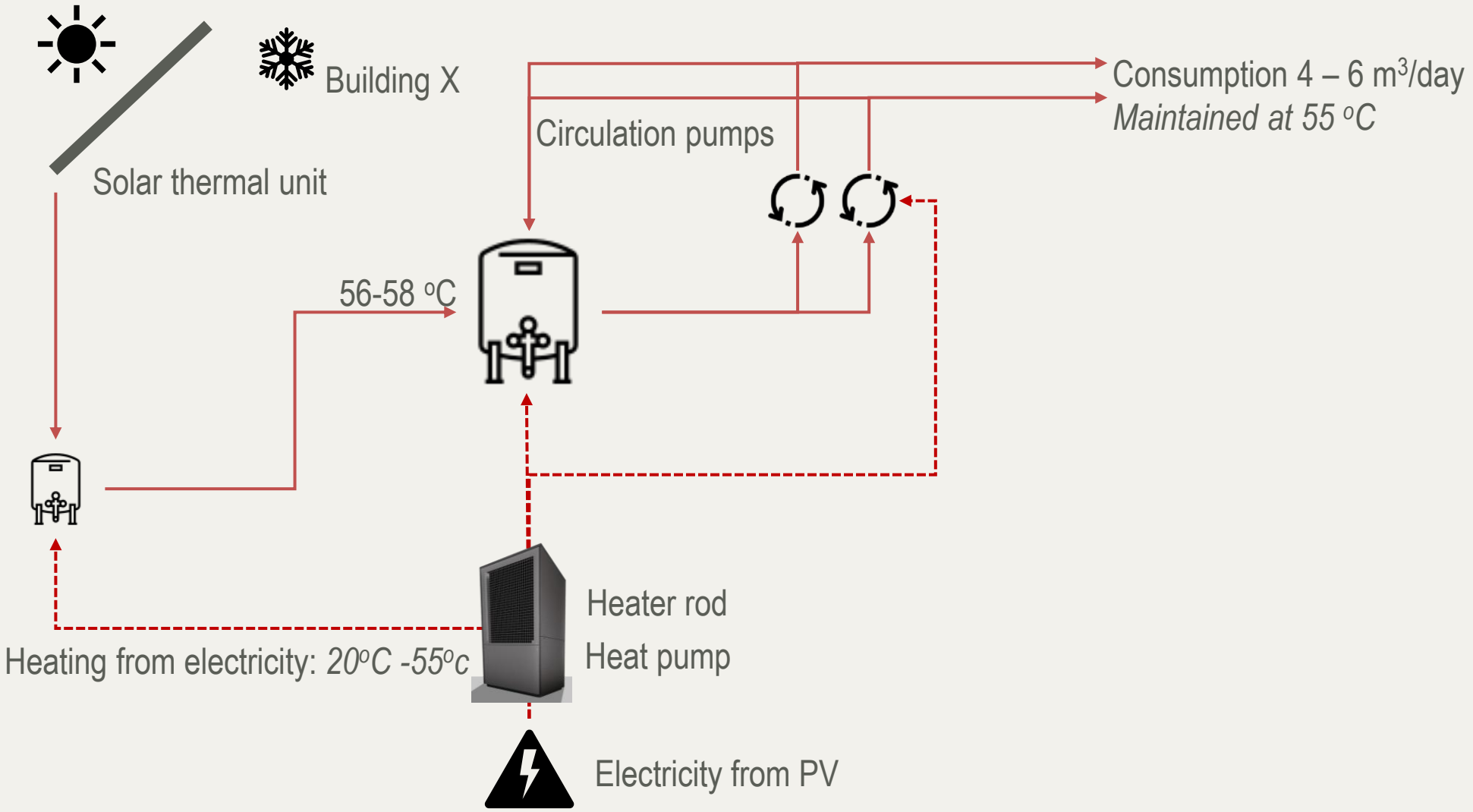


Pre-heating/heating (AUI, 202X)



SOURCE: https://www.flaticon.com, https://www.iconfinder.com

Hot water supply to dormitories (AUI, 202X)

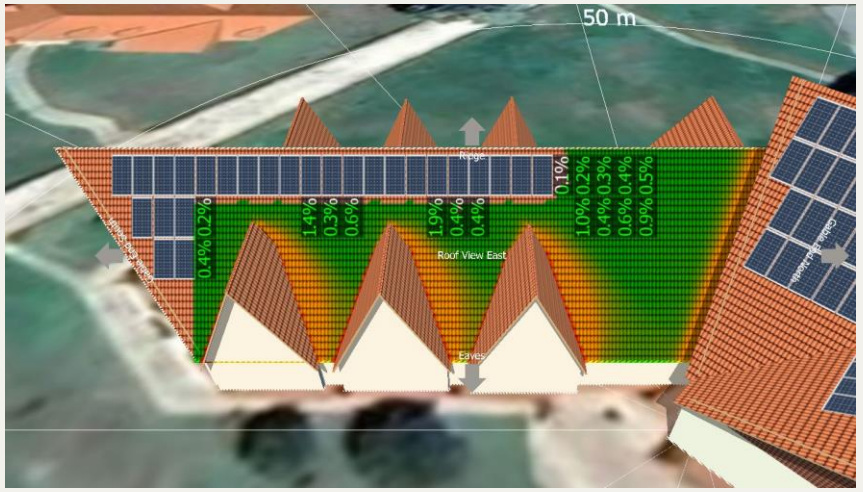


Heat pump for hot water (AUI, 202X)

Parameter	Unit	Status quo	Heat pump
Total thermal energy demand	$kWh_{Thermal}/a$	208,100	135,000
Supplied by solar thermal	$kWh_{Thermal}/a$	-	73,000
Electricity consumption for heating	$kWh_{Electrical}/a$	231,200	15,900
Electricity savings	$kWh_{Electrical}/a$		215,000
Monetary savings	MAD/a		220,000
Estimated investment for the new heat pump	MAD		225,000
Estimated investment for the solar thermal	MAD		357,300
Heat pump operating expenditure *(O&M 0.5% CapEx)*	MAD/a		1,125
GHG savings	tCO_{2e}/a		157
Simple payback	a		2.7

Photovoltaic potential (building 15) (AUI, 202X)

Parameter	Unit	Value
Available rooftop area	m^2	1,800
Useable rooftop area	m^2	876
PV power generation	kWh/a	280,000
LCoE (4.73% loan for 8 years)	MAD/kWh	0.68
Payback period	a	11.7



Specific annual yield 1,525 kWh/kWp

Simulated installed capacity 183 kWp

Photovoltaic potential (AUI, 202X)

Parameter	Unit	Value
Available rooftop area	m^2	47,000
Useable rooftop area	m^2	16,000
Simulated installed capacity	kW_p	3,341
PV power generation	kWh/a	5,099,000
Direct own consumption	kWh/a	3,263,000
PV power surplus	kWh/a	1,835,000
CO_2 emissions savings	tCO_{2e}/a	3,717
Payback period	a	16.2
LCoE	MAD/kWh	0.55

Grid electricity 1.02 MAD/kWh > LCoE PV 0.55 MAD/kWh

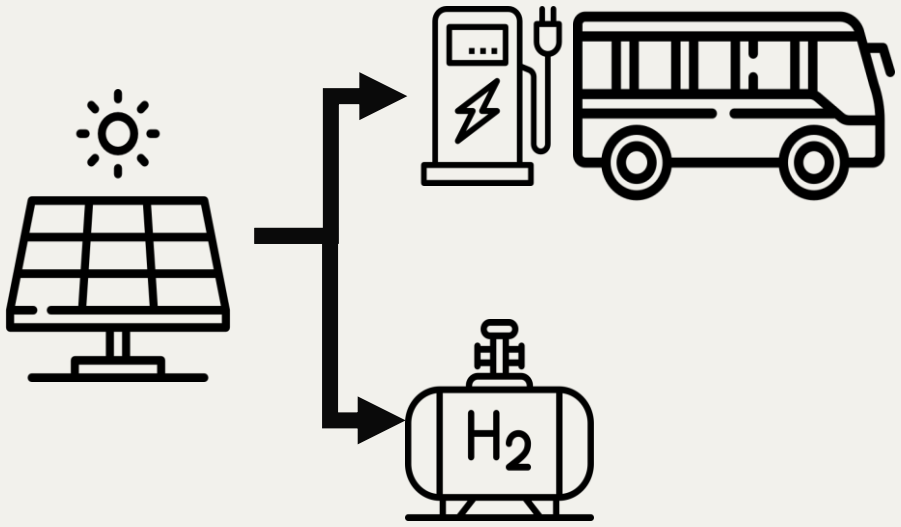
PV surplus (36%)
1,835,000 kWh

Electric vehicles (AUI, 202X)

Parameter	Unit	Citroen jumper	Citroen e-jumper
Purchase price (2023)	MAD	468,700	750,800
Fuel consumption	L/km or kWh/km	0.10	0.30
Annual travels	km/a	30,000	30,000
Annual fuel demand	L/a or kWh/a	3,000	9,000
Annual fuel costs	MAD/a	42,000	5,091
Maintenance	MAD/a	23,400	22,500
GHG emissions	tCO_{2e}/a	8.93	-
Lifetime cost (10 years)	MAD	1,123,000	1,026,000

SOURCE: https://www.pngegg.com/fr/png-swqdv, ZECURA TU 2023

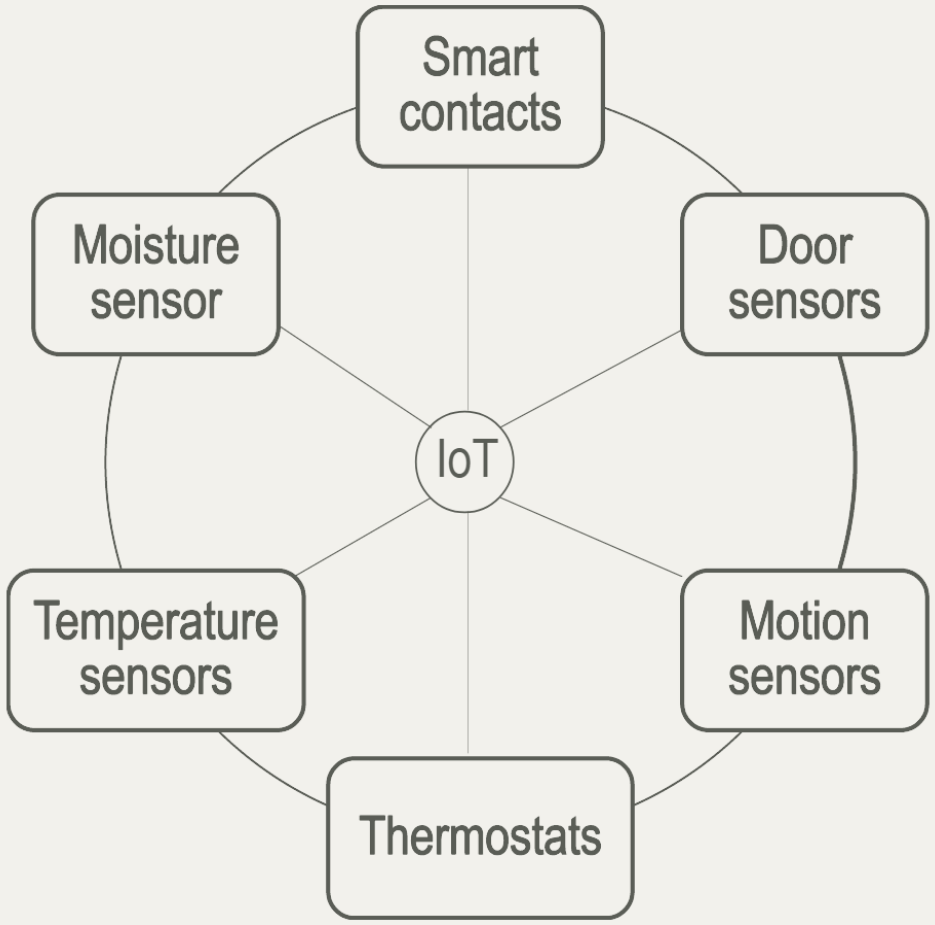
Potential uses for energy from PV (AUI, 202X)

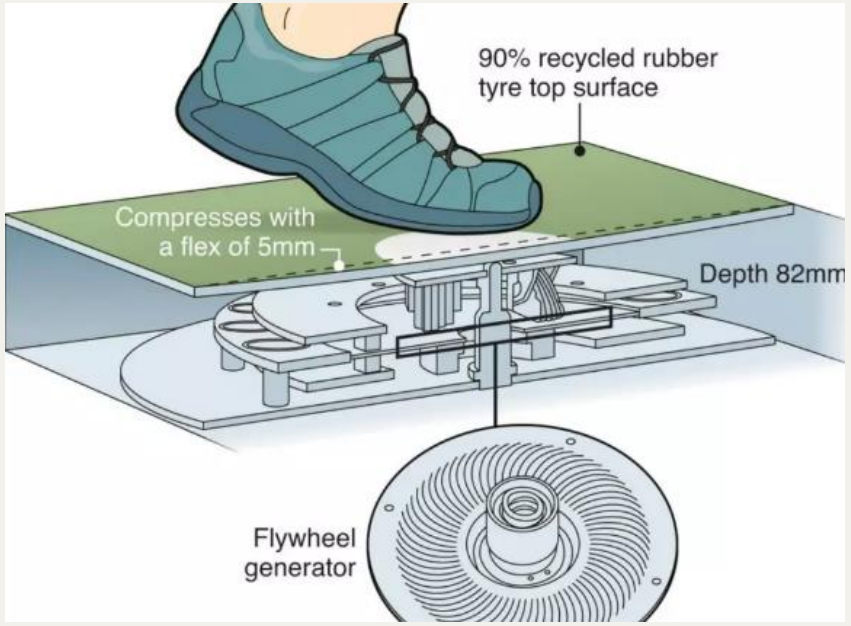


H_2 potential: 41,100 kg/a

- km equivalent: 4,400,000 km
- Diesel equivalent: 440,000 L
- GHG savings: 110 tCO_{2e}/a
- Monetary savings: 6,160,000 MAD/a

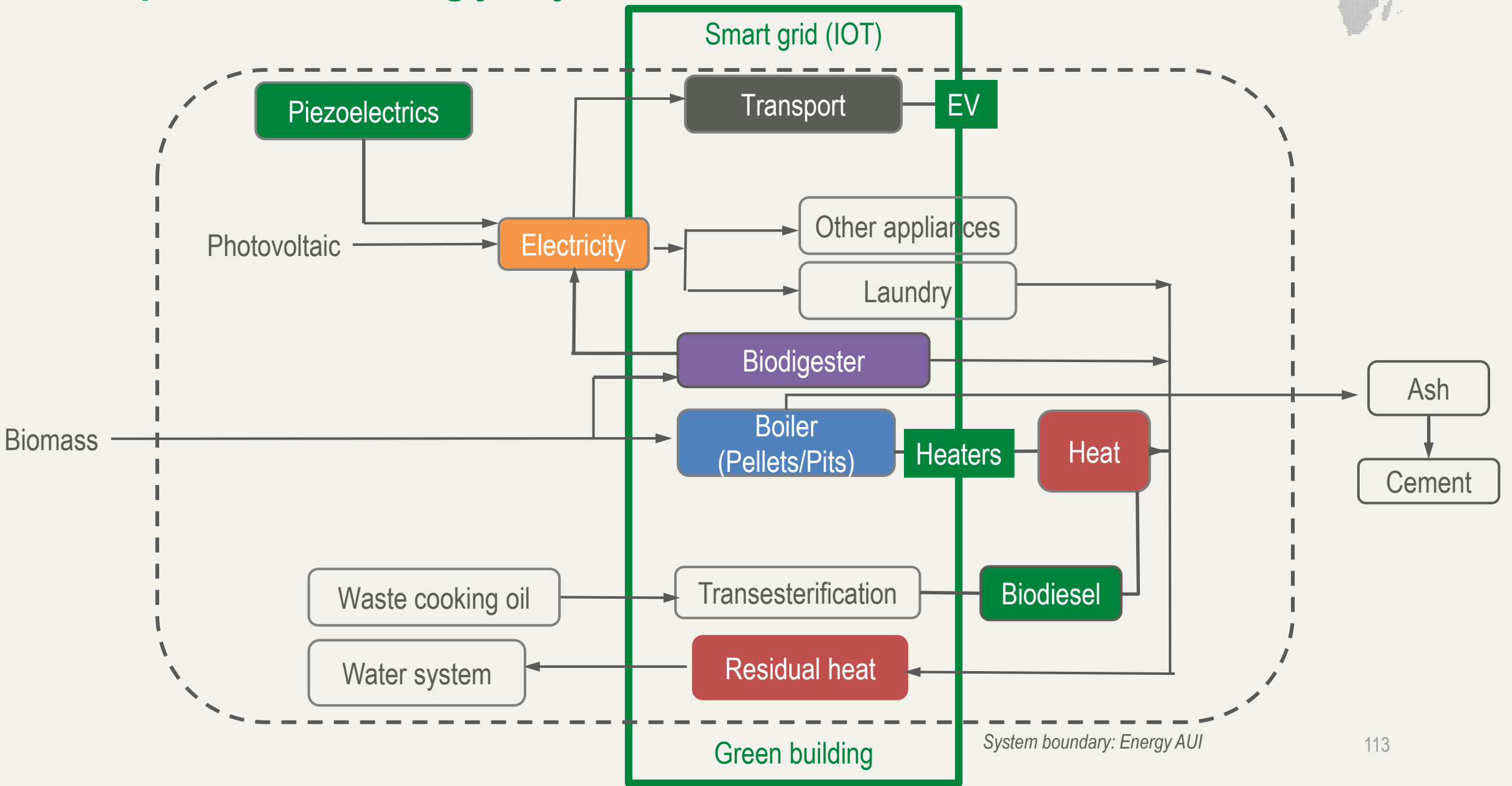
Proposed research suggestions (AUI, 202X)





SOURCE: https://www.slideshare.net/El-Rayes/vibration-energy-harvesting-in-action-real-world-case-studies

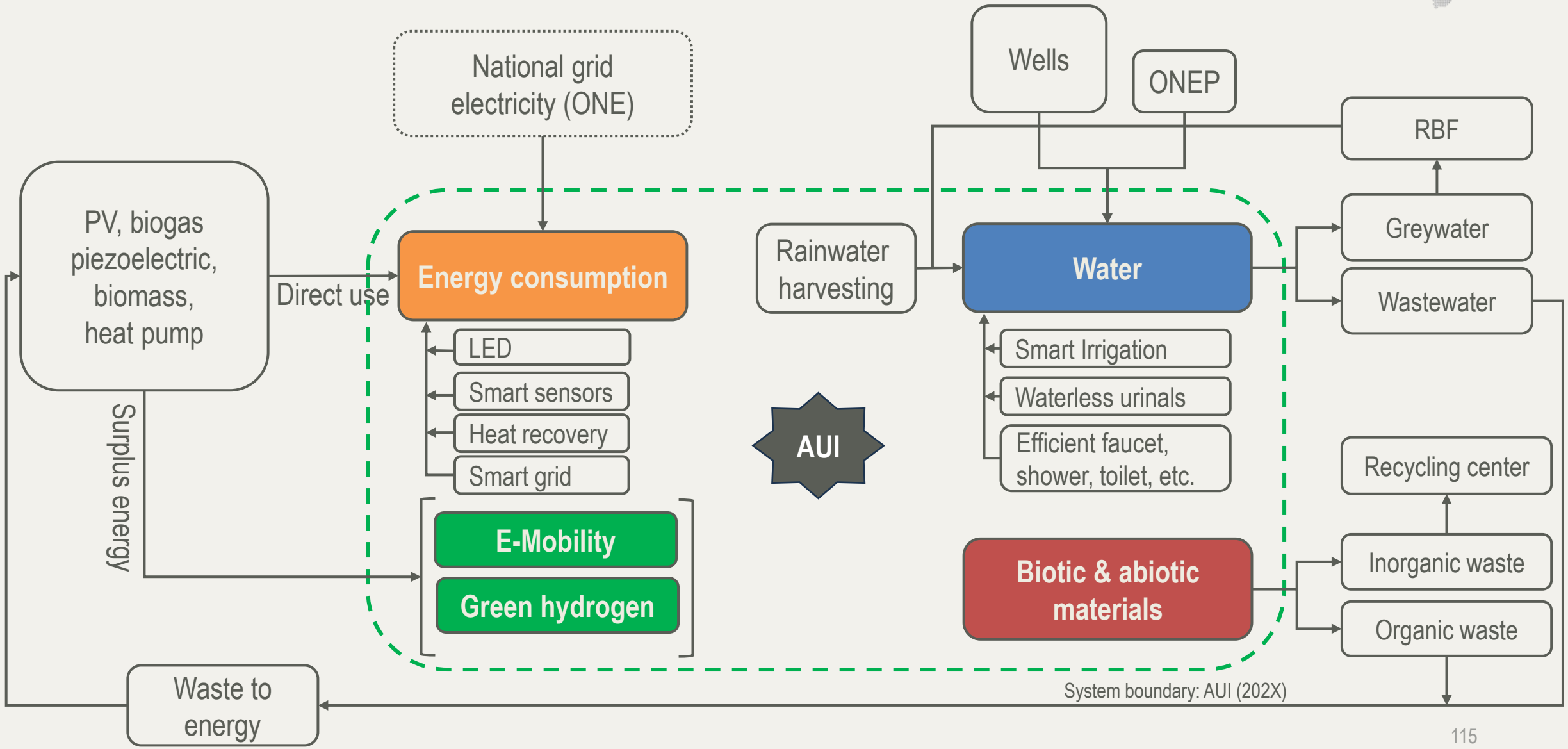
Proposed energy syncs (AUI, 202X)



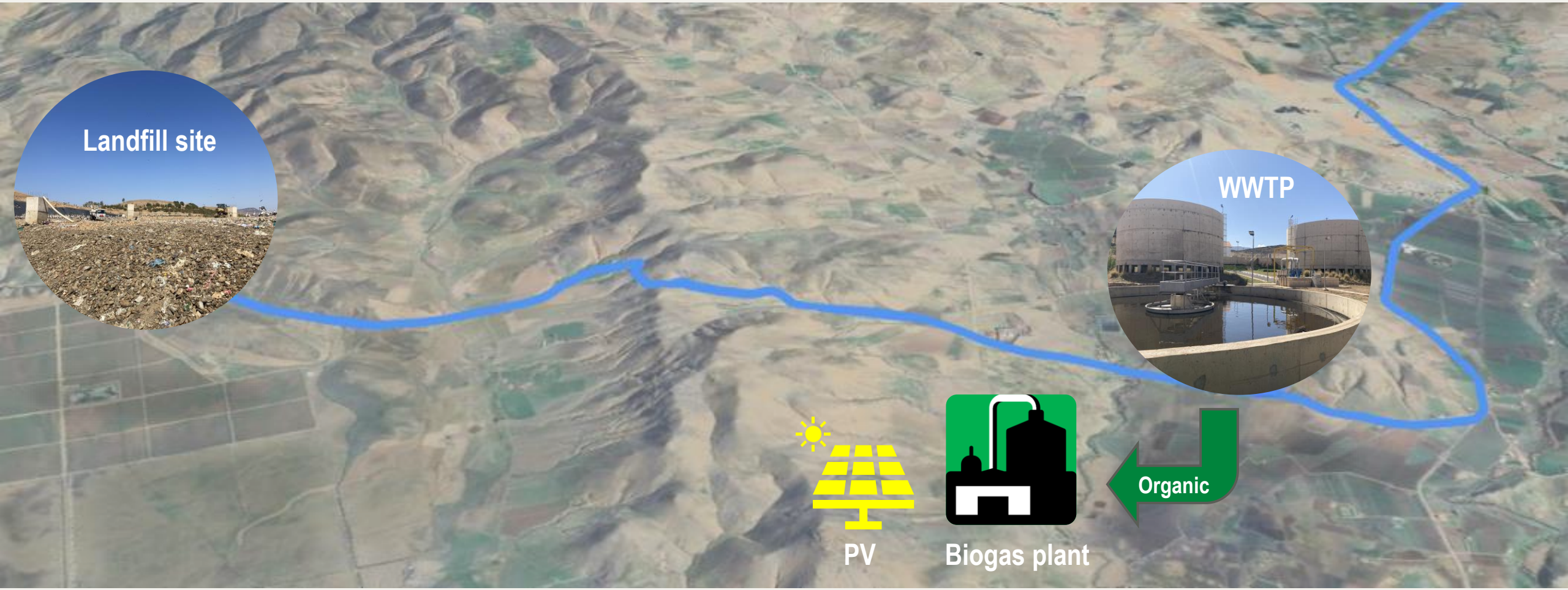
System boundary: Energy AUI

Interlinking technologies towards zero emission

Interlinking technologies towards zero emission (AUI, 202X)



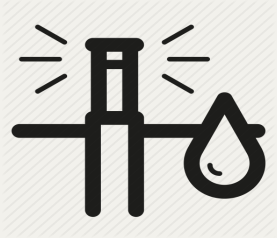
Techno-spatial plan for optimized material flows of Azrou



Financial and environmental benefits

Investments/savings (AUI, 202X)

Smart irrigation system



154,000 MAD
54,700 MAD/a

Pellets

30,800 MAD
9 tCO_{2e}/a

Rainwater harvesting

768,570 MAD
59,000 MAD/a

Biogas

673,700 MAD
642,700 MAD/a
39 tCO_{2e}/a

Heat recovery

1,200,000 MAD
177,500 MAD/a
37 tCO_{2e}/a

EV

9,009,600 MAD
442,800 MAD/a
108 tCO_{2e}/a

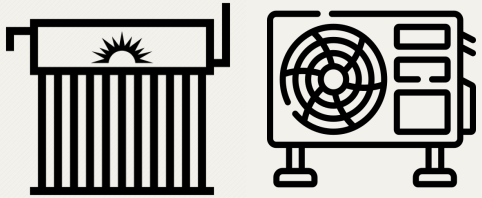
Waste management

589,000 MAD/a

PV

25,450,000 MAD
4,273,000 MAD/a
3,717 tCO_{2e}/a

Heat pump and solar thermal



582,300 MAD
193,800 MAD/a
157 tCO_{2e}/a

Reed bed filtration system

1,687,500 MAD
261,300 MAD/a
13 tCO_{2e}/a

Investment Savings Emission

SOURCE: *Flaticon (2023)*

Financial and environmental benefits

(AUI, 202X)

Total investment

40,000,000 MAD

Annual savings

7,000,000 MAD/a

Payback period: +6 years

Avoided GHG emissions

4,100 tCO_{2e}/a

SDGs


SUSTAINABLE DEVELOPMENT GOALS
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS

شكرا جزيلا على حسن انتباهكم!

Thank you very much!