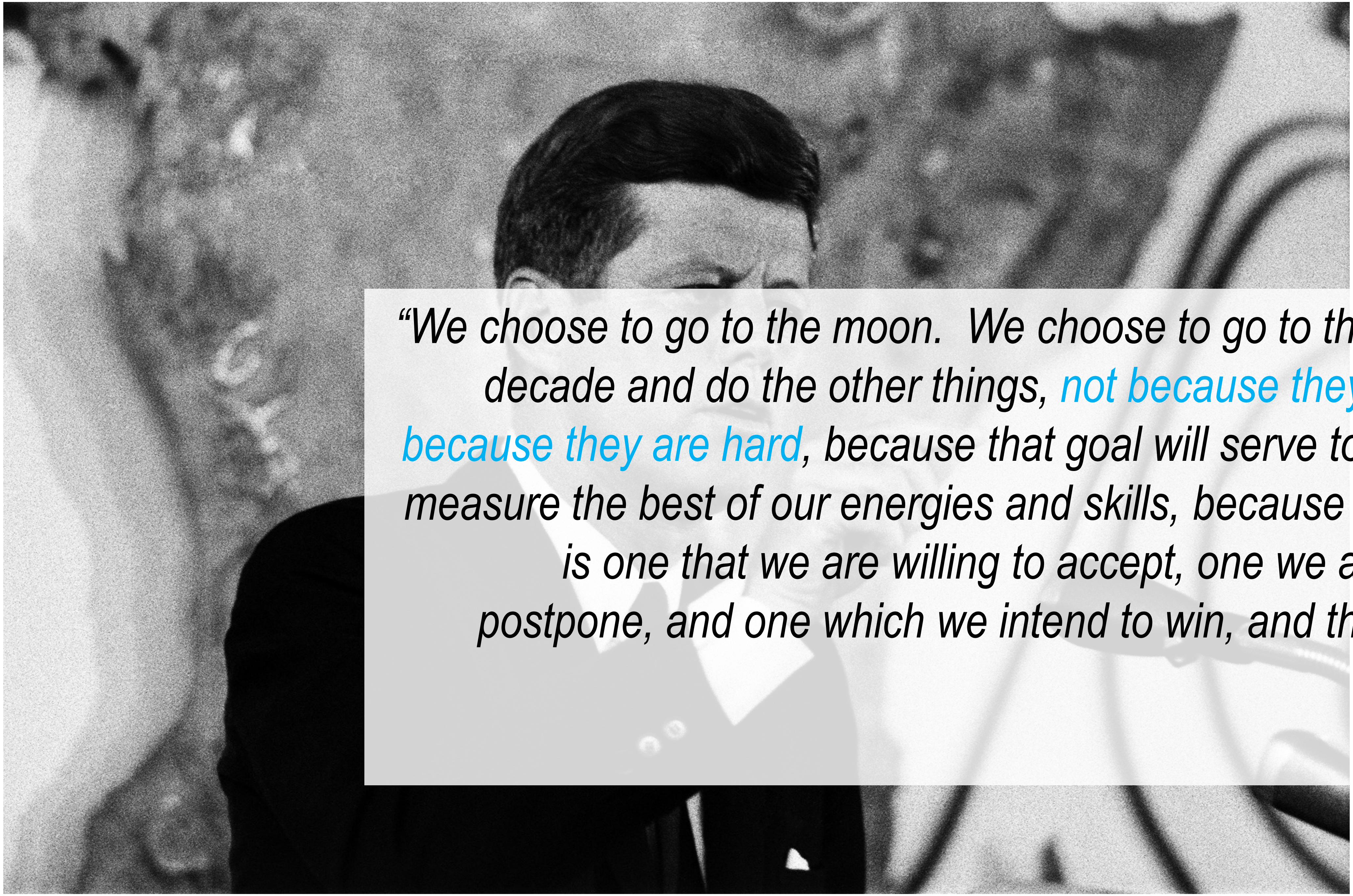
ZECURA Grand Finale

Traveling University as a catalyst for resilient city development

16.MARCH.2023 | RANAHANSA **DASANAYAKE** | SUNYANI, GHANA

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

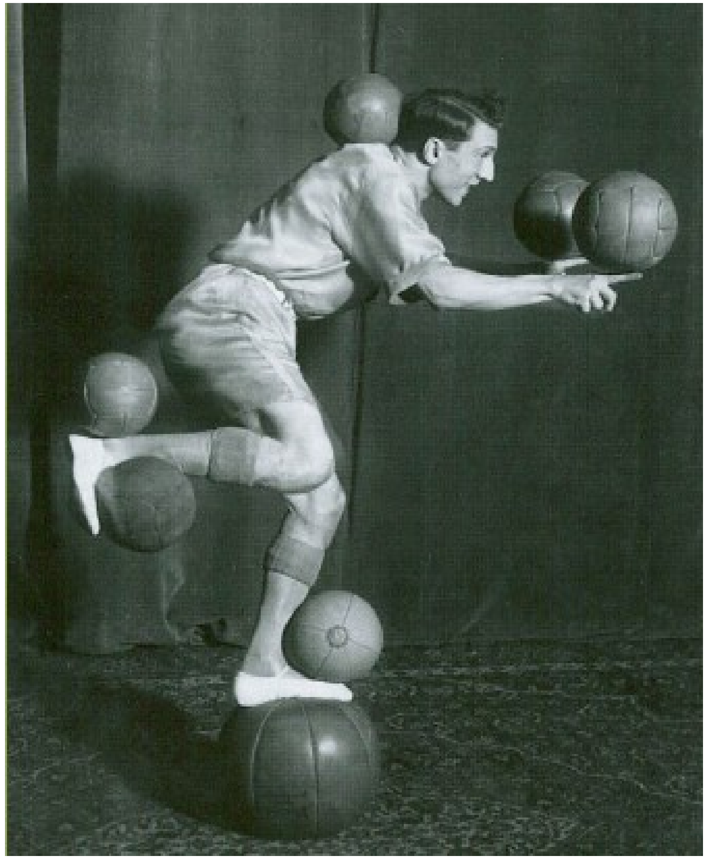
TU Challenges: get to know…

IMAGE SOURCE: Google Imagery, (2019)

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

ZECURA

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)

ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities

TU Challenges: get your bearing

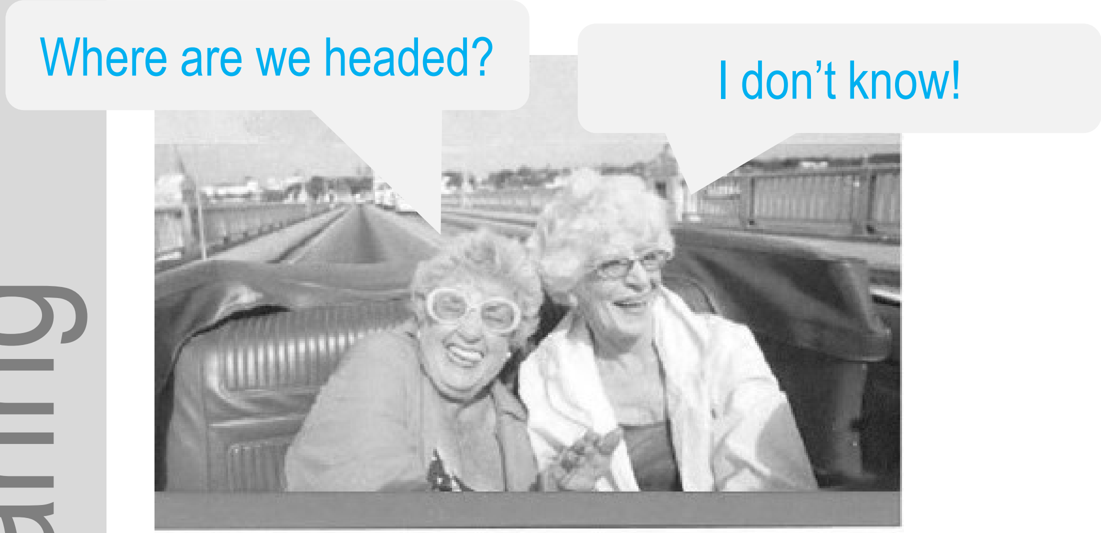


IMAGE SOURCE: Google Imagery, (2019)

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

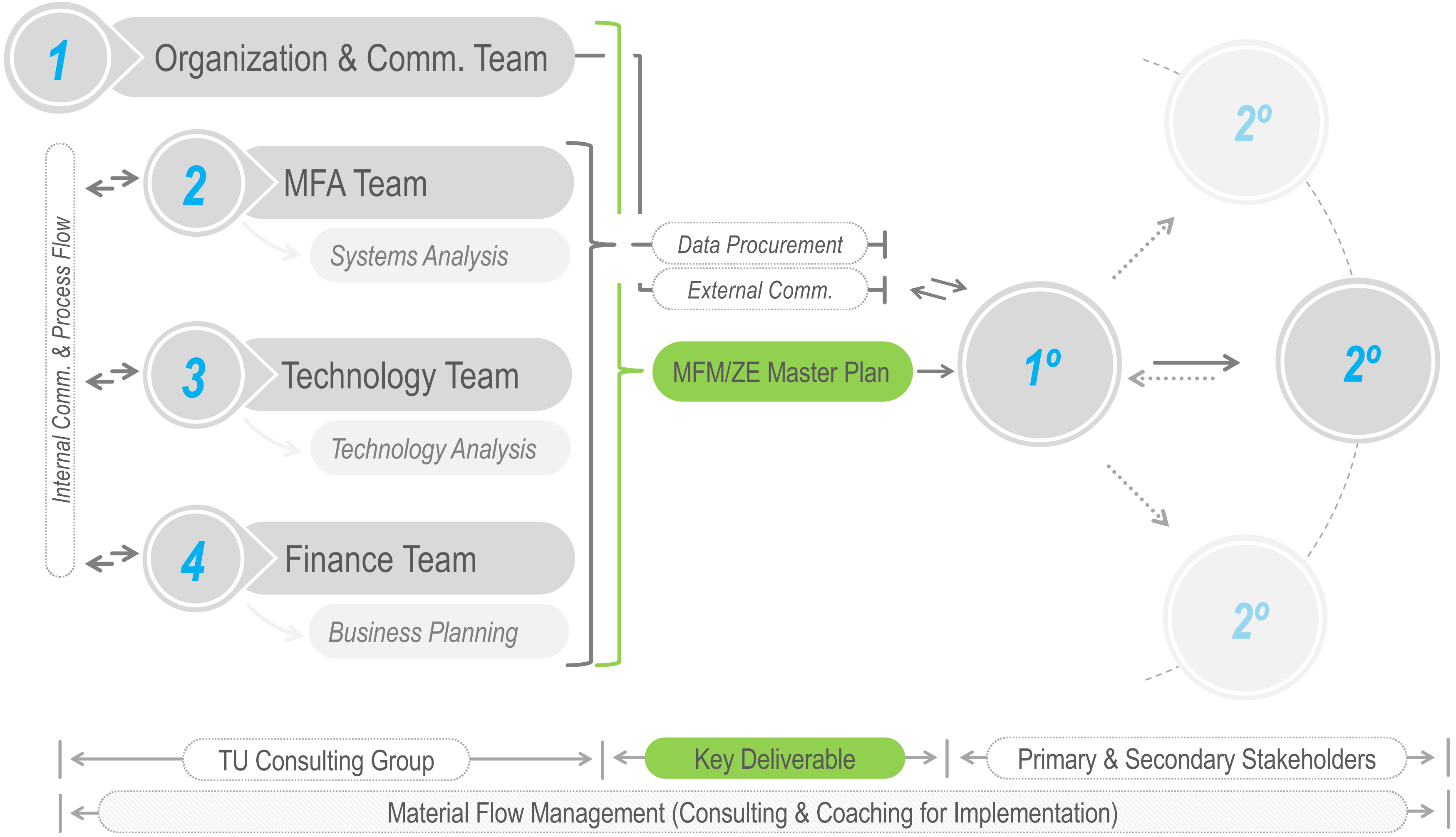
TU Challenges: take a deeper look

- Curiosity
- Practical
- *Hands-on*

IMAGE SOURCE: Google Imagery, (2019)

ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities

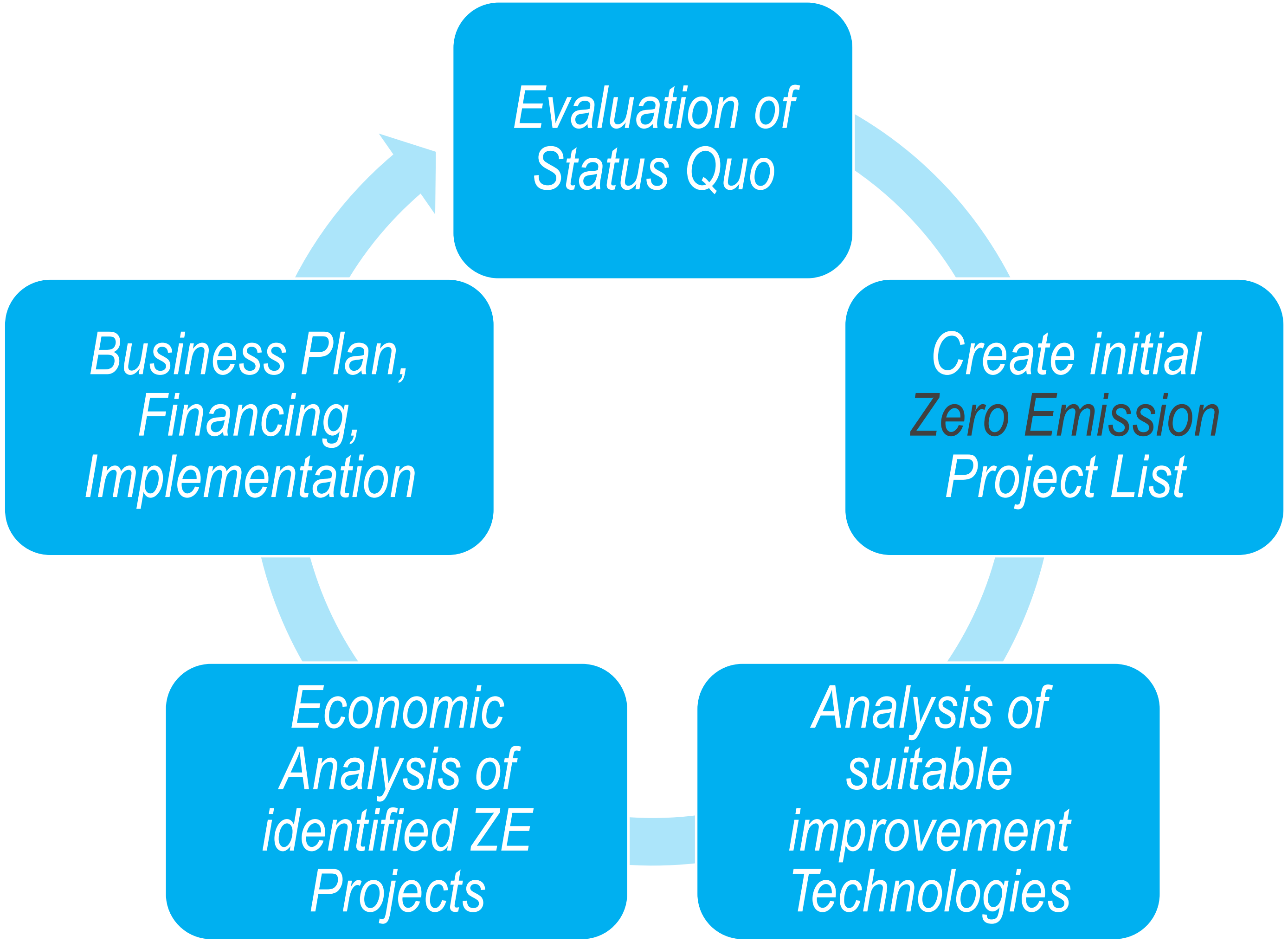
Travelling University: mechanism of delivery



Travelling University: mechanism of delivery

Process Steps	Generic Methods	Specific Methods
1 System Definition	1.A System Boundary: Temp./Spatial	
	1.B Stakeholders: 1º & 2º	
	1.C Regulations, Constraints & Critical Variables	
2 Systems Analysis	2.A Qualification of Material Flows	MFA/REC
	2.B Quantification of Material Flows	
3 Solutions Portfolio	Solution/Tech. Metrix	MCDA/M
4 Project Feasibility	4.A Financial Feasibility assessment	CF / NPV / IRR / PBP
	4.B Impacts assessment	RAV
5 MFM Master Plan	5.A ZE Road Map	
	5.B Implementation Plan, MRV Plan	

MFA: systemic method



ZECURA

We've been around the world

ZECURA

Transition to climate neutrality

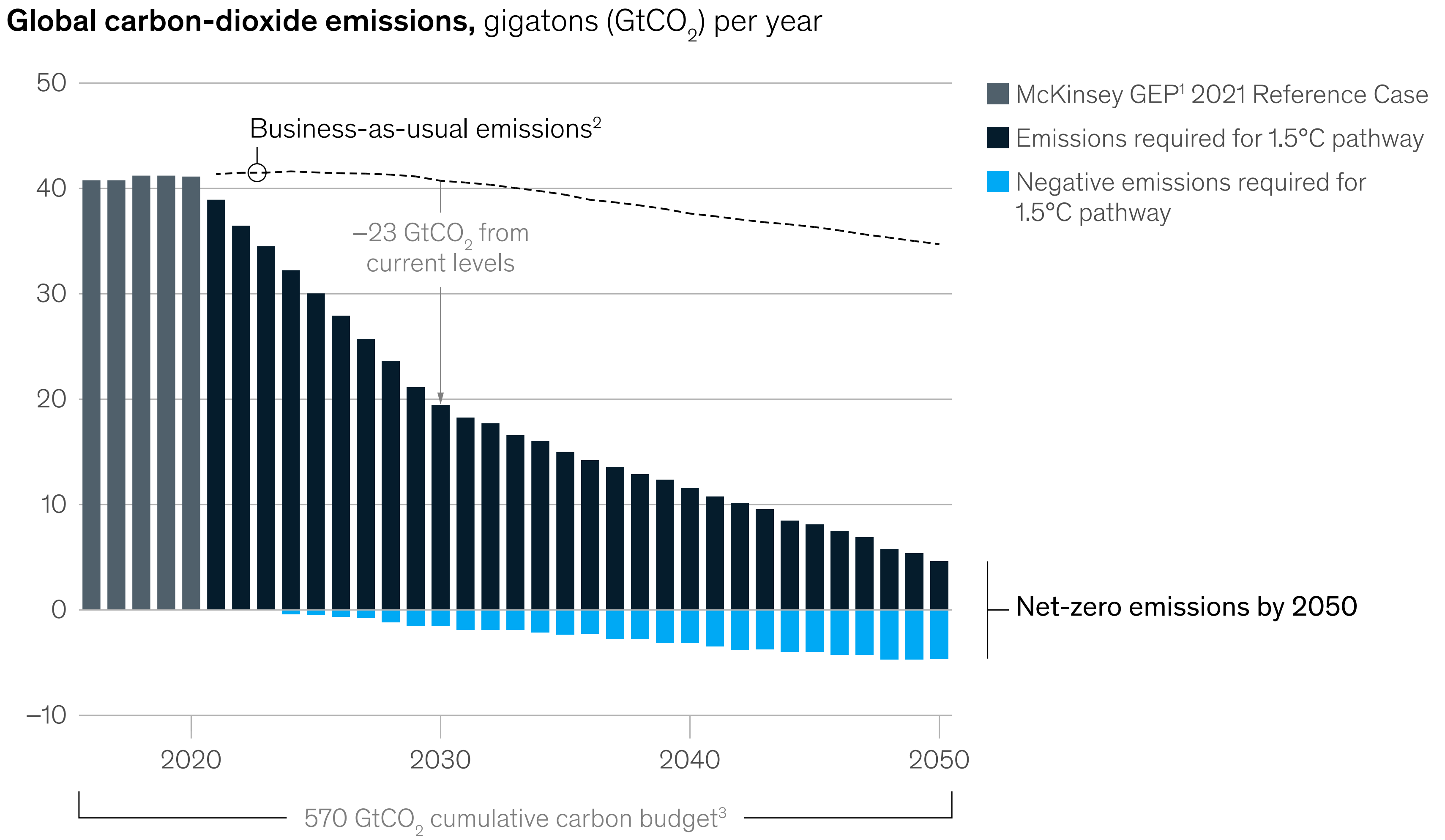


IMAGE SOURCE: https://www.mckinsey.com/capabilities/sustainability/our-insights/a-blueprint-for-scaling-voluntary-carbon-markets-to-meet-the-climate-challenge, (2022)

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*

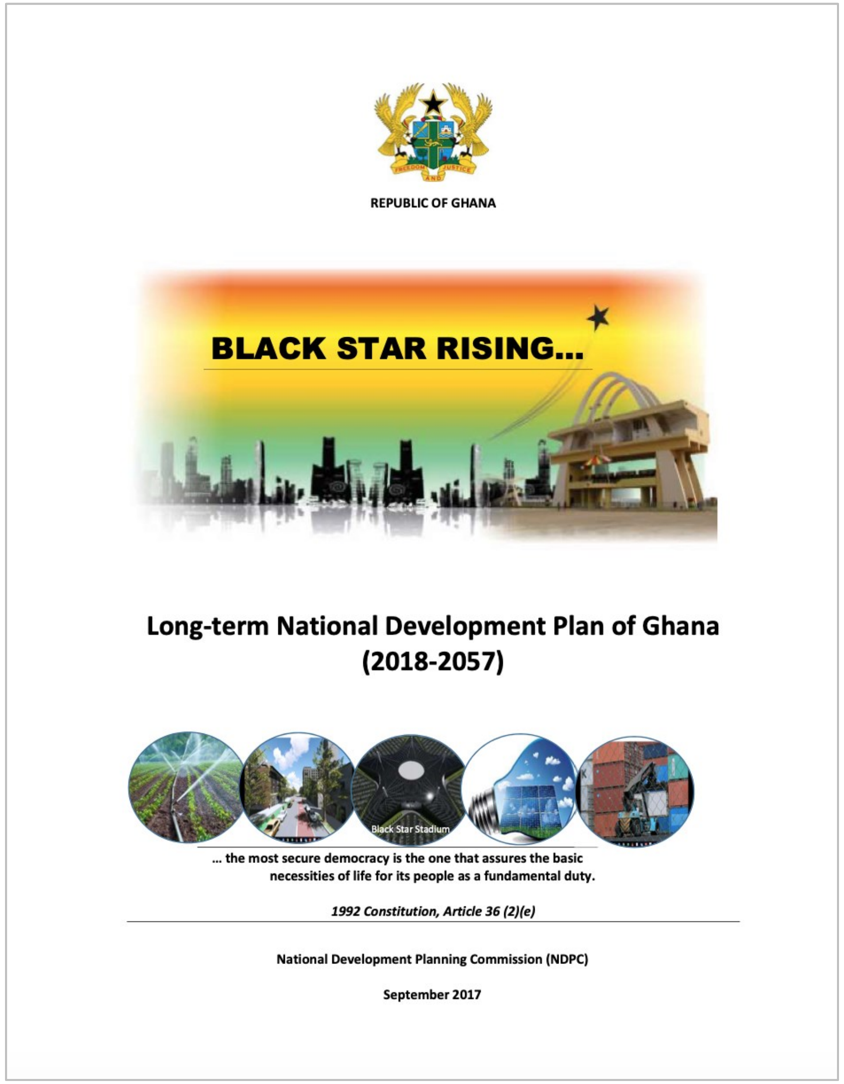
Supporting the vision(s)

"A just, free, prosperous and self-reliant nation that would play a leading and influential role in regional and global affairs. […] transformation meaning improvement in the living standards of Ghanaians in a structured, predictable and measurable manner over the 40 years of the plan in the economic, social, environmental and institutional spheres"

IMAGE SOURCE: https://ndpc.gov.gh/media/Long-term_National_Development_Plan_2018-2057.pdf; Accessed 12.03.2023

ZECURA

Supporting the vision(s)



a.) Build an industrialized, inclusive and *resilient economy*

b.) Create an equitable, healthy and prosperous society

c.) Build safe and well-planned communities, while *protecting the natural environment*

d.) Build effective, efficient and dynamic institutions for national development

e.) Strengthen Ghana's role in international affairs

—Specific objectives, LTNDP

IMAGE SOURCE: https://ndpc.gov.gh/media/Long-term_National_Development_Plan_2018-2057.pdf; Accessed 12.03.2023

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

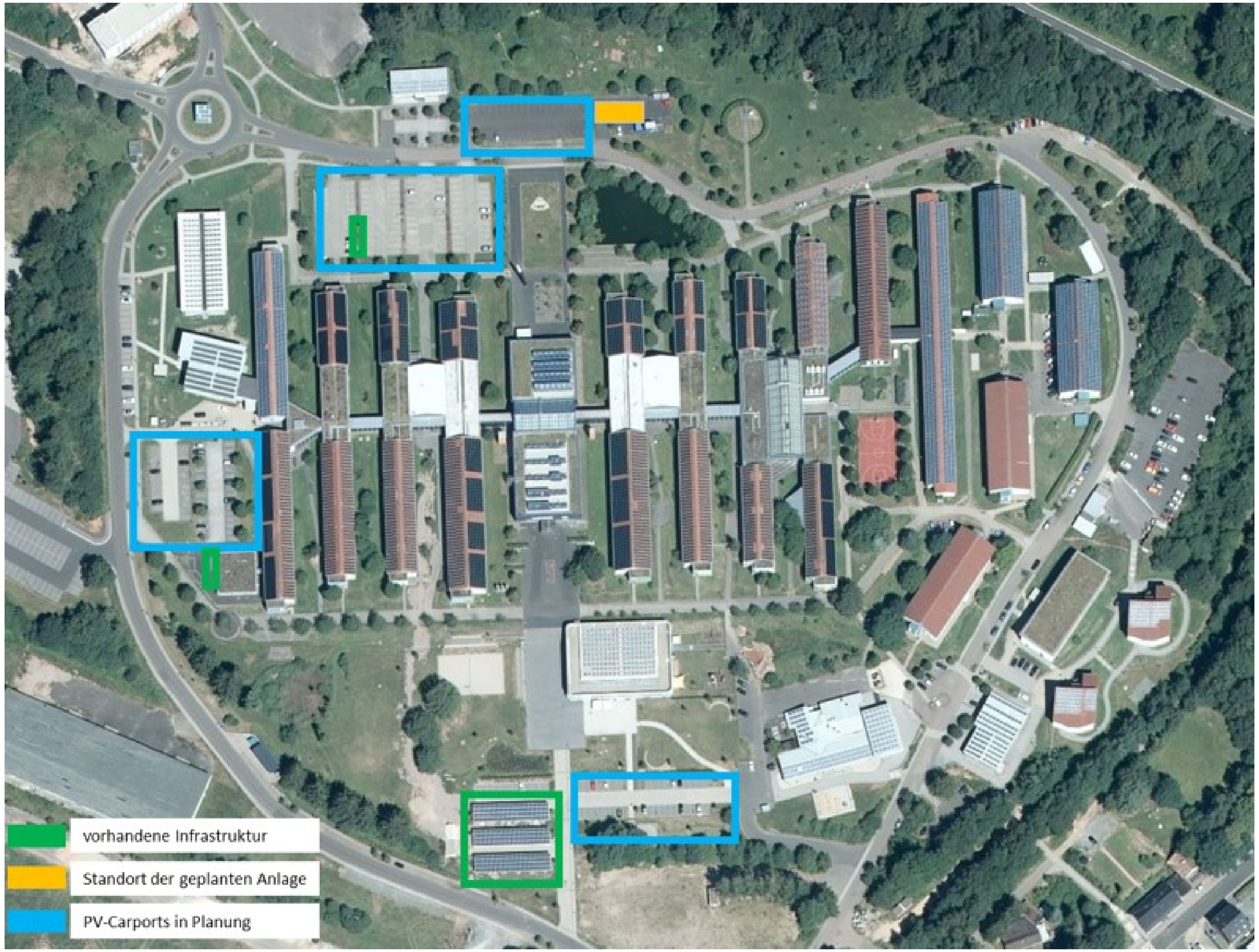
State-of-the art energy and resource efficiency technologies and strategies in place

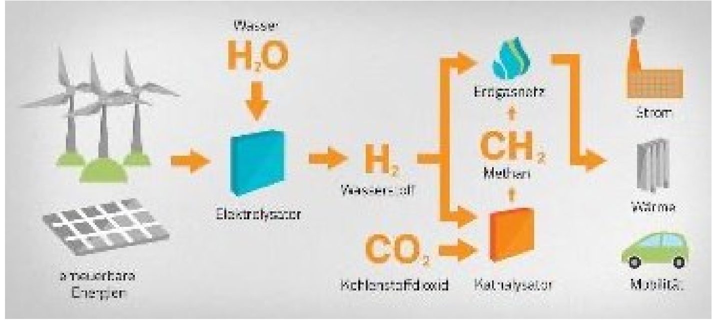
Zero Emission Building

Powered by the sun

ZECURA

Green hydrogen





ZECURA

An institute for change…

IfaS Institut für angewandtes Stoffstrommanagement

20 JAHRE

POTENZIALE ERKENNEN - PROZESSE OPTIMIEREN - MEHRWERT SCHAFFEN -

Our areas of expertise

International Project Management

Study and Qualification

Fundraising

Biomass and Cultural Landscape Development

Energy Effciency & Renewable Energies

E-mobility

Material Flow Management and Zero Emission

PR – Communication and Participation

ZECURA

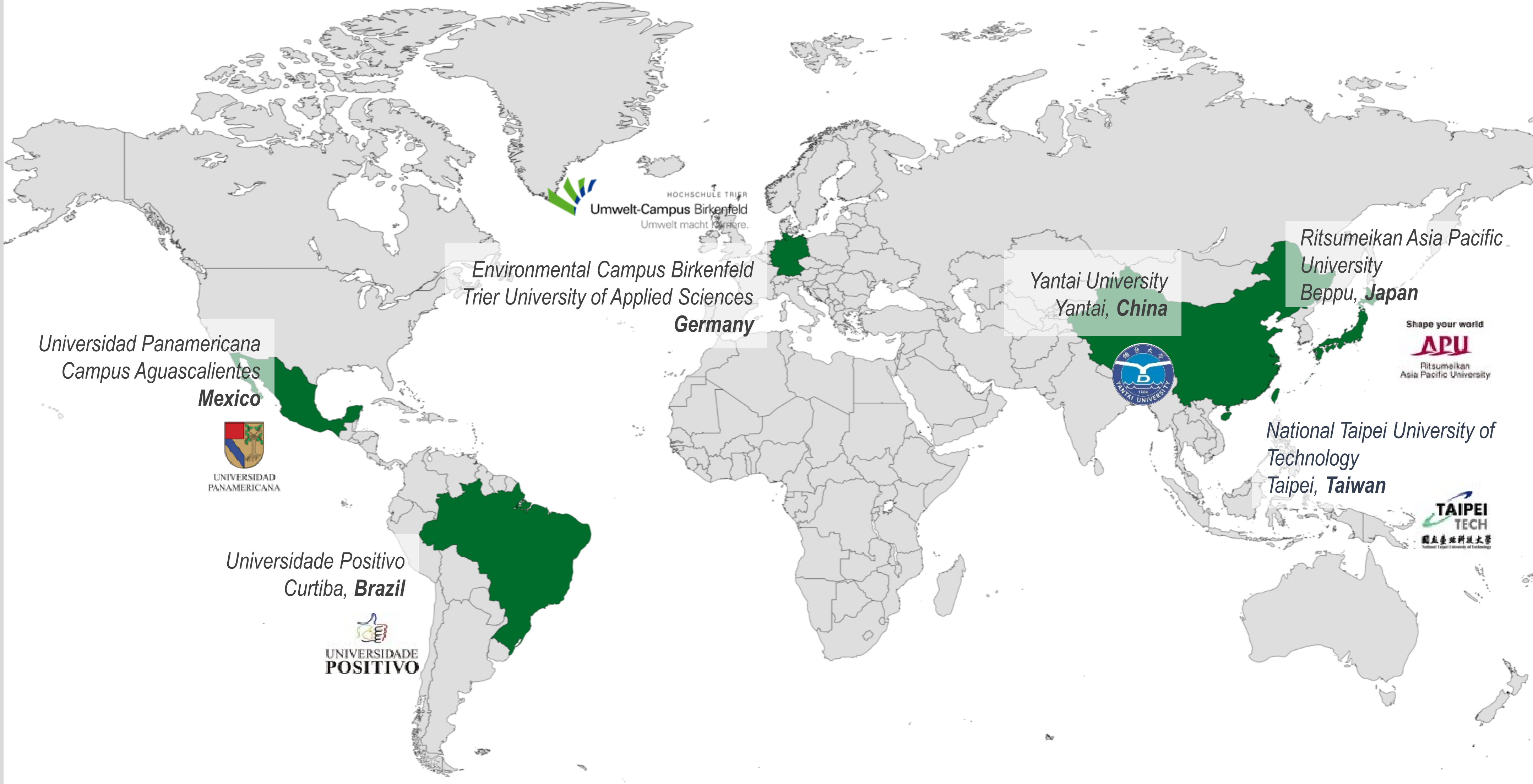
IMAT masters

IMAT INTERNATIONAL MATERIAL FLOW MANAGEMENT

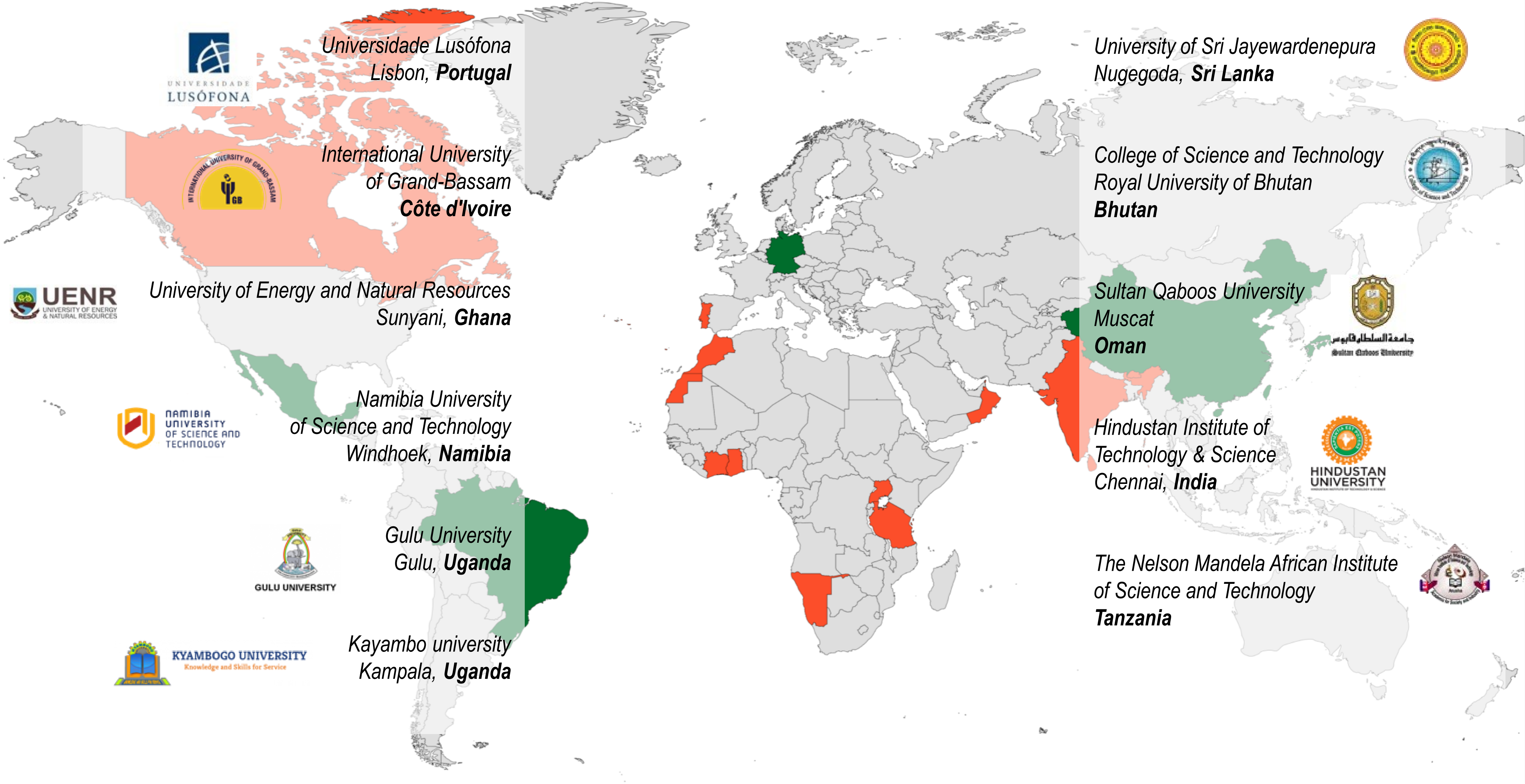
Joint education, research &
technology transfer for Circular Economy

ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities

IMAT-Network University (IMAT-NU)

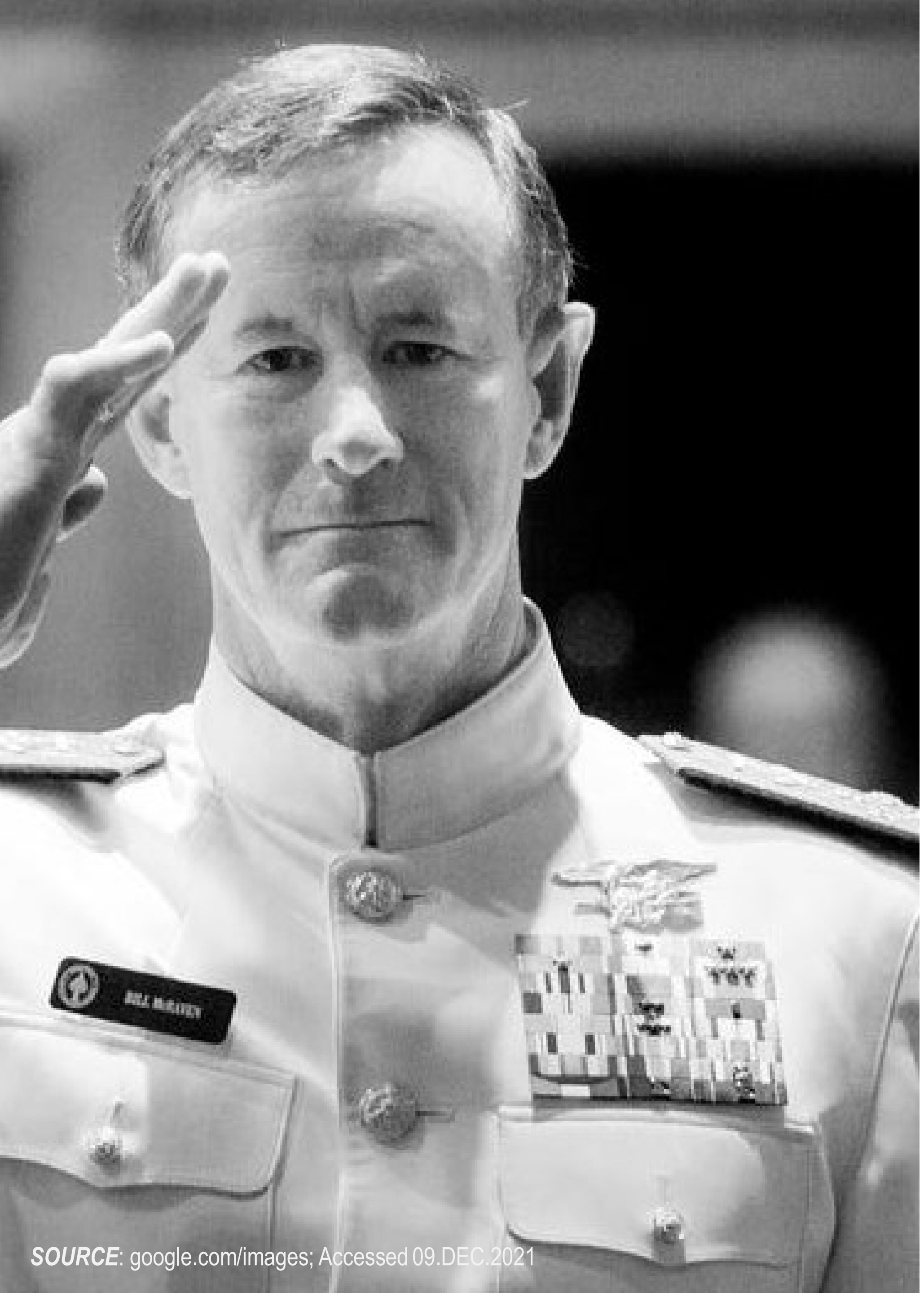


IMAT-NU: a growing network



*"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

DIAGNOSTIC SUMMARY:
ZERO EMISSION CAMPUS MASTER PLAN

IfaS Institut für angewandtes Stoffstrommanagement
Umwelt-Campus Birkenfeld | HOCHSCHULE TRIER
SPONSORED BY THE Federal Ministry of Education and Research

ZECURA

Zero-Emission Concepts for Urban Resilience in selected African cities

— Vision —

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

IfaS 20 Jahre Institut für angewandtes Stoffstrommanagement

Umwelt-Campus Birkenfeld | Hochschule Trier

SPONSORED BY THE Federal Ministry of Education and Research

ZECURA

Zero-Emission Concepts for Urban Resilience in selected African cities

— Mission —

“Our mission is to make Sunyani a resilient city; a city that withstands socio-political and environmental stressors and demographic change whilst accelerating its economic growth.

UENR will be the sustainability, technology and transport hub of Ghana through a secure, independent and sustainable economy, whilst sharing its knowledge with surrounding communities”.

IfaS 20 JAHRE Institut für angewandtes Stoffstrommanagement

Umwelt-Campus Birkenfeld | HOCHSCHULE TRIER

SPONSORED BY THE Federal Ministry of Education and Research

ZECURA

Zero-Emission Concepts for Urban Resilience in selected African cities

Research team

IfaS Institut für angewandtes Stoffstrommanagement

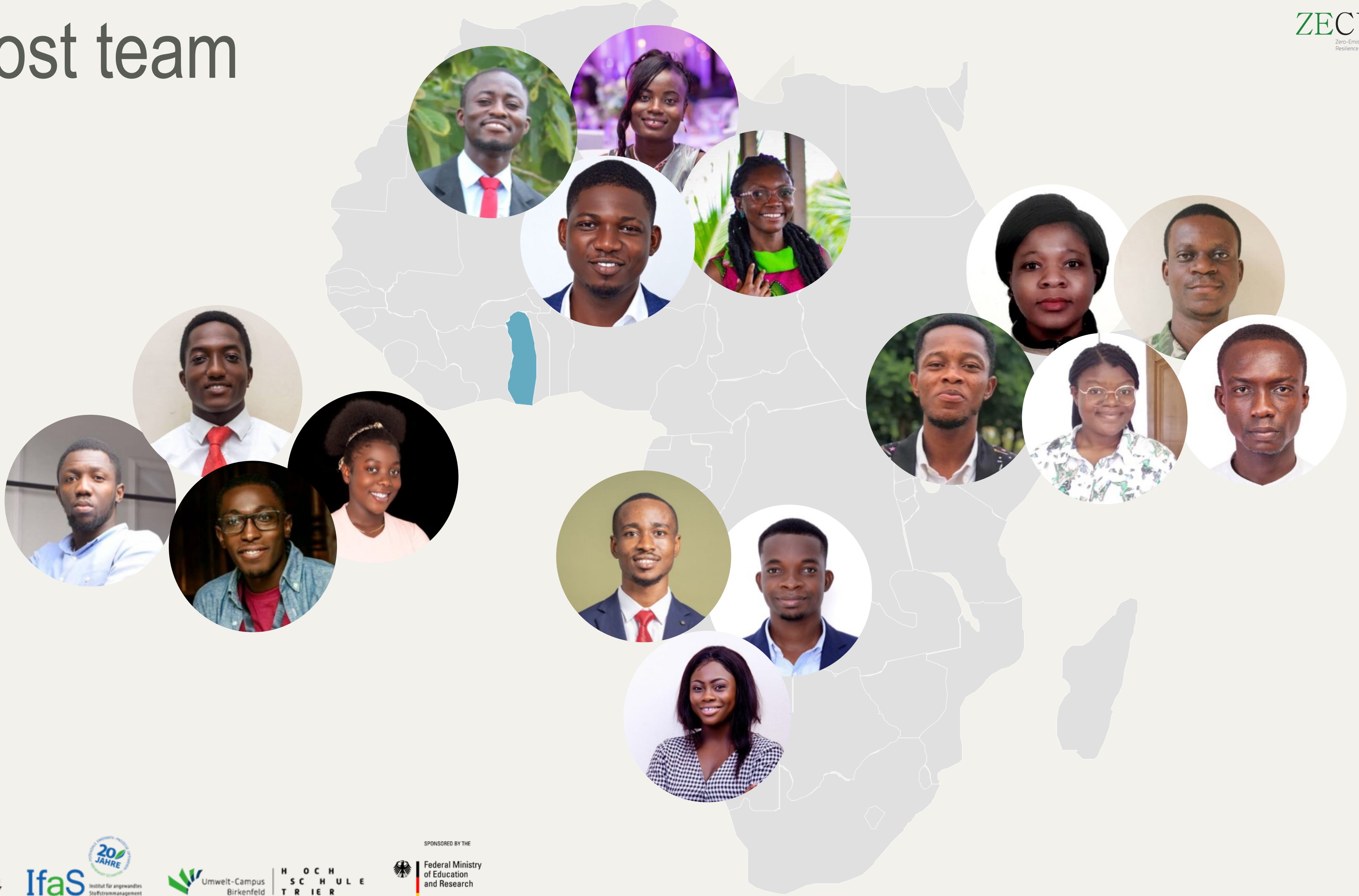
Umwelt-Campus Birkenfeld | HOCHSCHULE TRIER

SPONSORED BY THE Federal Ministry of Education and Research

Visiting team

SPONSORED BY THE
Federal Ministry of Education and Research

Host team



ZECURA

Zero-Emission Concepts for Urban Resilience in selected African cities

Critical parameters

Tariff	Unit	Value	Source
Electricity	GHS/kWh	1.73	PURC (1st Quarter, 2023)
Electricity service charge	GHS/month	12.43	PURC (1st Quarter, 2023)
Exchange rate	GHS/USD	12.28	
Water	GHS/m^3	12.15	PURC (1st Quarter, 2023)
Service charge	GHS/month	20.00	PURC (1st Quarter, 2023)
Petrol	GHS/L	13.80	GOIL (2023)
LPG	GHS/L	9.44	UENR
Diesel	GHS/L	13.80	GOIL (2023)

Emission factor	Unit	Value	Source
Petrol	kg CO_{2e}/L	2.3	IPCC
Diesel	kg CO_{2e}/L	2.68	IPCC
LPG	kg CO_{2e}/L	1.61	IPCC
Grid	kg CO_{2e}/kWh	0.495	2F2

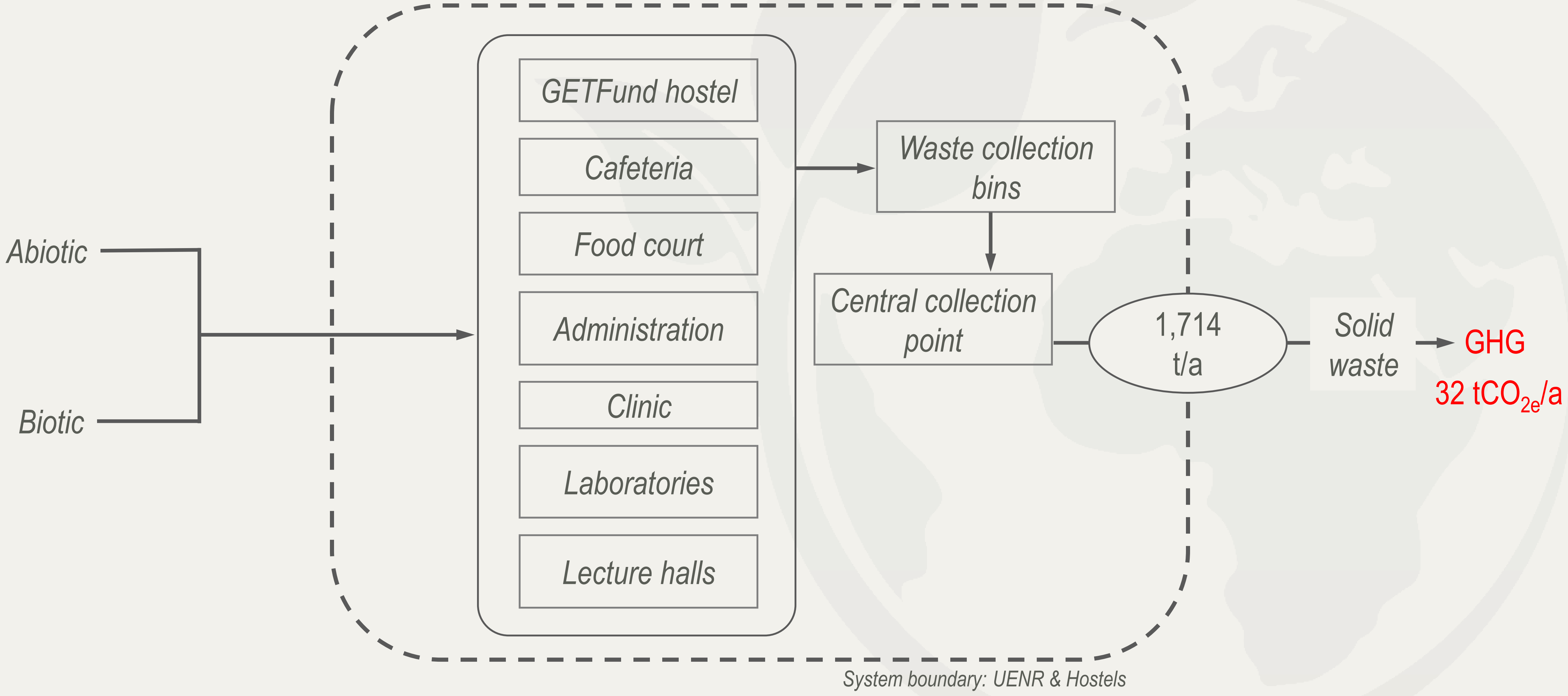
Contents

Solid waste

ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities

ZERO EMISSION CONCEPT — UENR

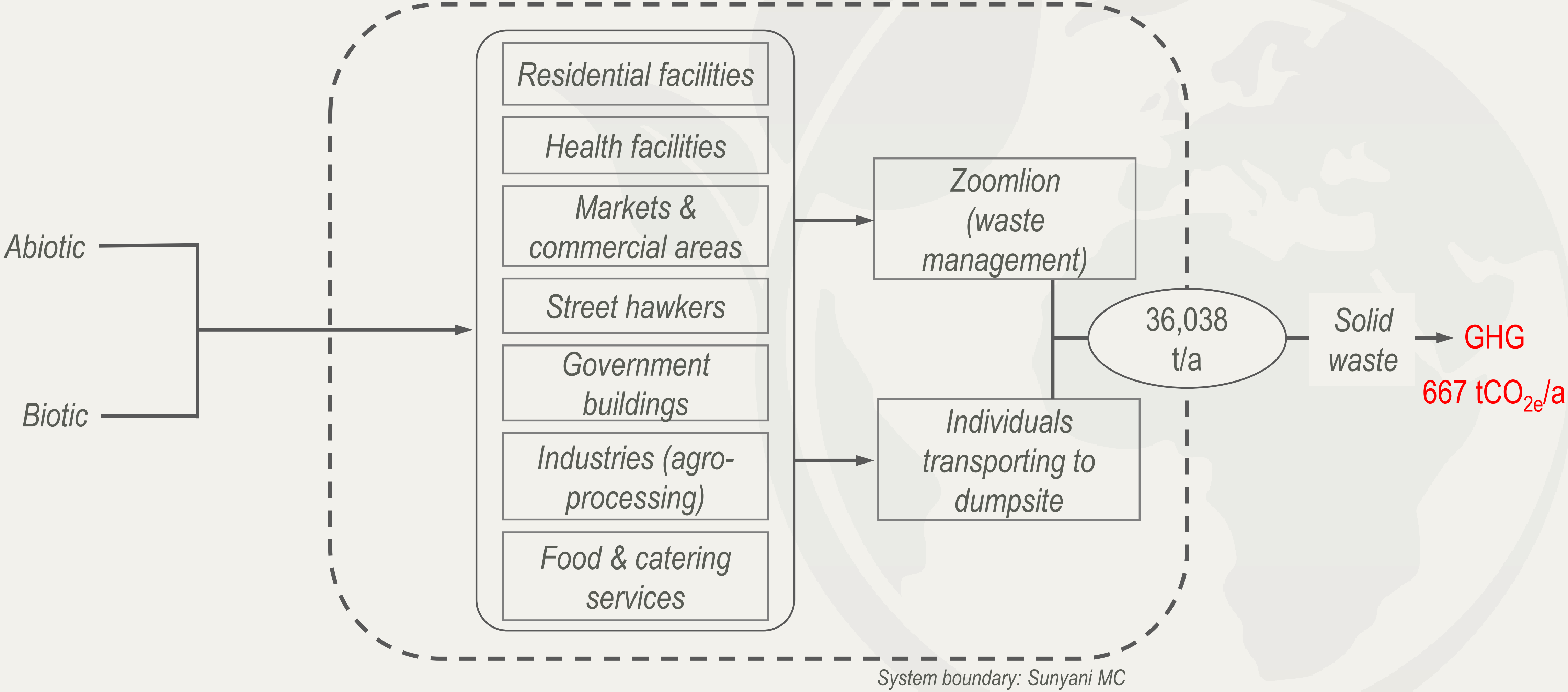
Status quo: solid waste (UENR, 2023)



Status quo: solid waste (UENR, 2023)

Waste collection point, UENR

Status quo: solid waste (Sunyani, 2023)



Status quo: solid waste (Sunyani, 2023)

MSW dump site, Sunyani

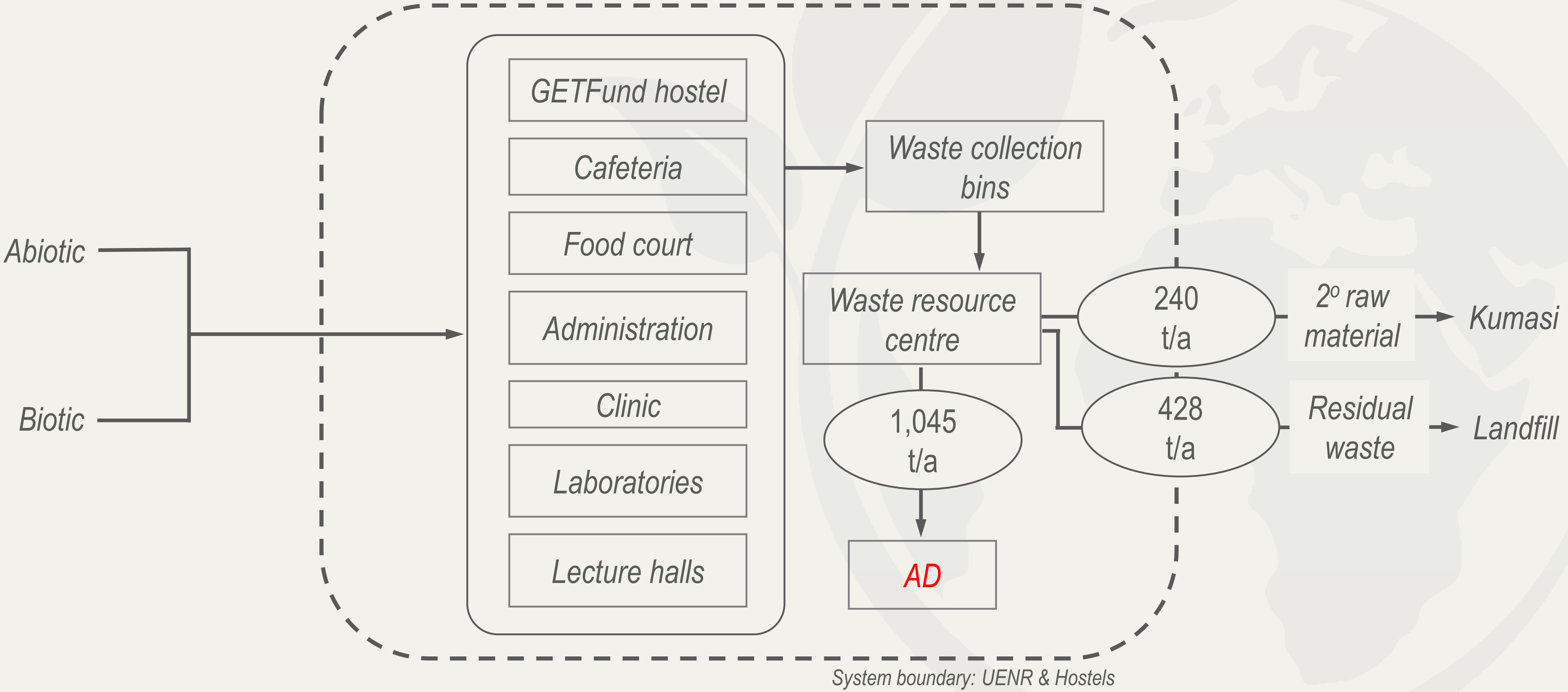
SPONSORED BY THE Federal Ministry of Education and Research

Ideas & strategies: resource mgt. (UENR, 202X)

Educational poster…

- Student-led UENR solid waste management team for ***waste reduction & segregation***
- 6 bins (e-waste, paper, residual, metals, plastic, organic)
- Education, ***repair cafe, furniture exchange, take back system, ecobots (PET-bottle), upcycling***
- Monitoring of waste reduction & segregation
- Coordination with stakeholders (plastic recycling plant, truck transportation service)
- Dissemination of knowledge and success of the waste mgt. programme

Biogas from OW (UENR, 202X)



Biogas from OW (UENR, 202X)

Parameter	Unit	Value
Estimated bio-methane production	m^3/a	67,949
Total heat generation potential	kWh/a	672,693
CHP unit's electrical efficiency	$\eta_{elec.}$	35%
CHP unit's thermal efficiency	$\eta_{thermal}$	50%
Electricity output	$kWh_{elec.}/a$	235,443
Heat output	$kWh_{thermal}/a$	336,346
Power: electrical	$kW_{elec.}$	109
Power: thermal	$kW_{thermal}$	155

NOTE: Biogas digester size (8% concentration of total solids with 40 days hydraulic retention time)

Biogas from OW (UENR, 202X)

ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities

Parameter	Unit	Amount
Estimated investment	USD	348,800
Total cost saving potential	USD/a	53,594
Maintenance (5% CAPEX)	USD/a	17,440
Simple payback	a	7+

Levelized cost of electricity (CHP biogas)	0.17 USD/kWh	(higher than grid)
Levelized cost of heat (CHP biogas)	0.12 USD/$kWh_{thermal}$	(same as LPG)
LPG equivalent fuel generation (from biogas)	46,831 L/a	
UENR LPG use (UENR, 2021)	3,814 L/a	
Surplus fuel from biogas	43,017 L/a	

The effluent of the biodigester can be used as liquid fertilizer for agriculture.

Srilak umaga, Janathakshan GTE, (2019)

IfaS 20 Jahre – Institut für angewandtes Stoffstrommanagement
Umwelt-Campus Birkenfeld | Hochschule Trier
Sponsored by the Federal Ministry of Education and Research

Urban resource centre (Sunyani, 202X)

ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities

Proposed resource recovery centre, Sunyani

SOURCE: Google Images (2022), Waste resource center & biogas plants in Germany, https://www.euractiv.com/section/energy-environment/opinion/biogas-in-germany-maintaining-momentum/

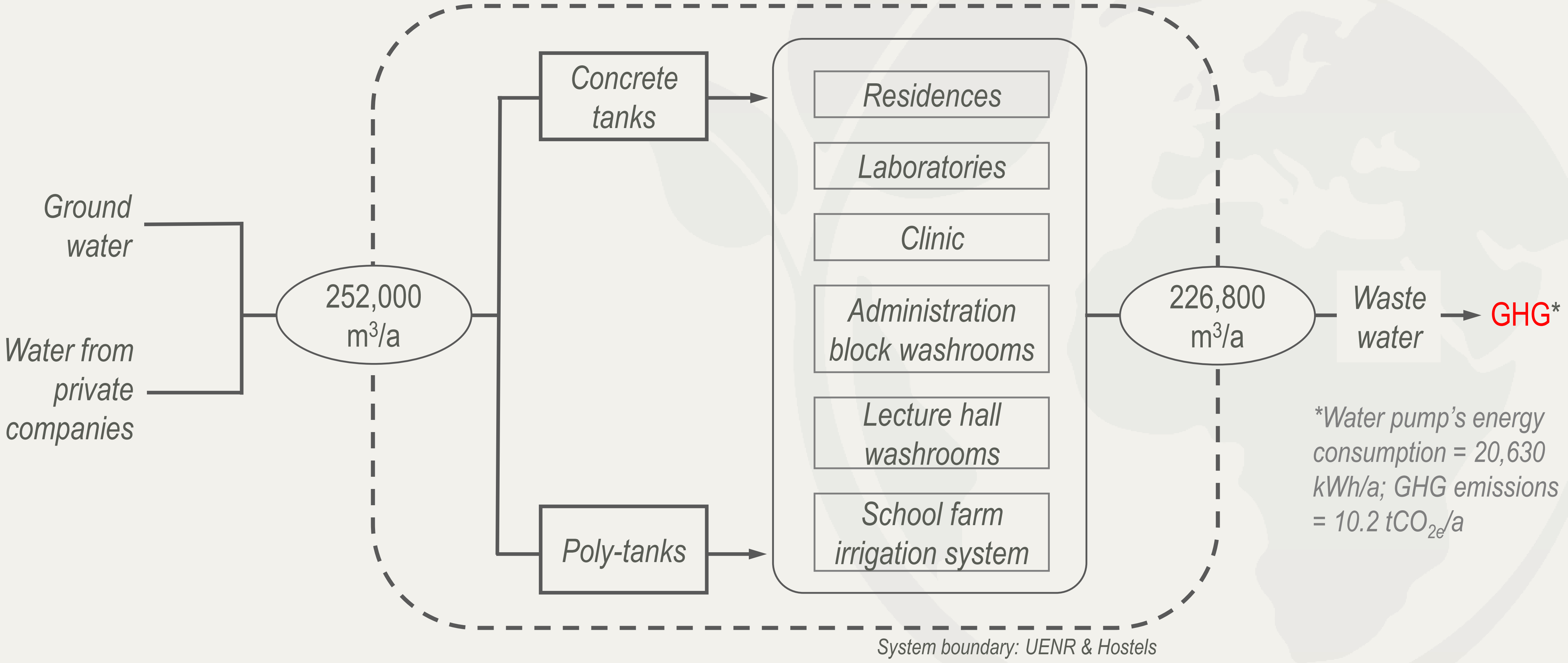
IfaS Institut für angewandtes Stoffstrommanagement
Umwelt-Campus Birkenfeld HOCHSCHULE TRIER
SPONSORED BY THE Federal Ministry of Education and Research

Freshwater & wastewater

ZERO EMISSION CONCEPT — UENR

Status quo: freshwater (UENR, 2023)

ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities



*Water pump's energy consumption = 20,630 kWh/a; GHG emissions = 10.2 tCO_{2e}/a

SPONSORED BY THE Federal Ministry of Education and Research

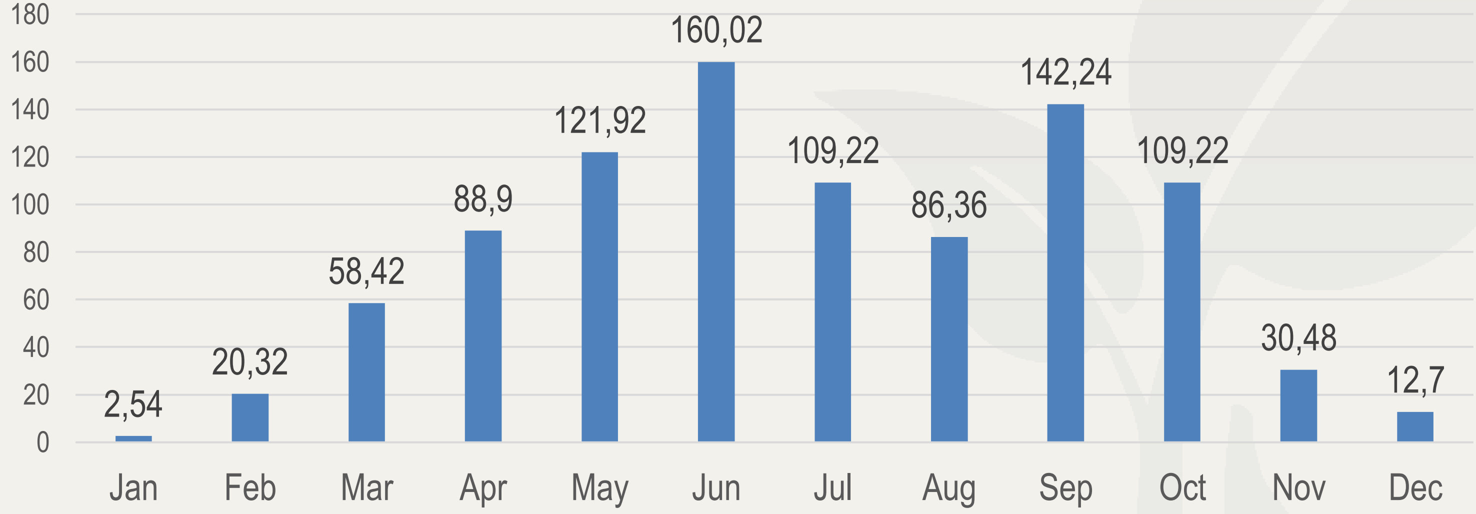
Status quo: wastewater (UENR, 2023)

Status quo: wastewater (Sunyani, 2023)

Ideas & strategies: water supply, water use efficiency and WWT (UENR, 202X)

I. Rainwater harvesting
II. Water-efficient cisterns
III. Water-efficient faucets
IV. Waterless urinals & nutrient recovery
V. WWT–NBS

Rainwater harvesting



Parameter	Unit	Amount
Catchment/roof area	m^2	5,960
Selected roof area (60%)	m^2	3,576
Annual rainfall	mm	942
Annual available water	m^3/a	2,863

SOURCE: https://weatherspark.com/y/38153/Average-Weather-in-Sunyani-Ghana-Year-Round

SPONSORED BY THE Federal Ministry of Education and Research

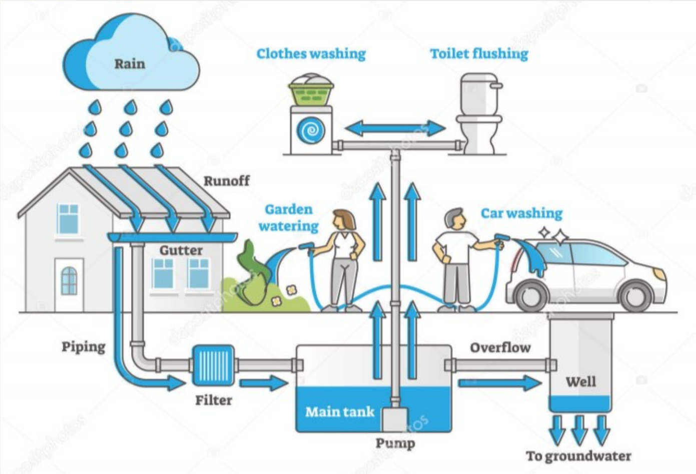
Rainwater harvesting

ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities

Reservoir for 480 m^3 of rainwater

NOTE: Approx. 40 days of rainfall volume

Parameter	Unit	Amount
Total construction cost	USD	21,475
Operating cost	USD/a	215
Monetary saving	USD/a	403
Levelized cost of service unit (LCoS)	USD/m³	0.93
Internal rate of return	%	-11



SOURCE: https://www.energy.gov/eere/femp/water-efficient-technology-opportunity-rainwater-harvesting-systems (2022), SOURCE: https://jrhwatermanagement.co.uk

IfaS Institut für angewandtes Stoffstrommanagement
Umwelt-Campus Birkenfeld | Hochschule Trier
SPONSORED BY THE Federal Ministry of Education and Research

Water-efficient cisterns

Parameter	Unit	Old	New
Water volume per use	L	8.5	4
Units	x	396	396
Usage	flushes/day	5	5
Annual water demand	m³/a	6,143	2,891
Saving potential	%		53
Estimated CAPEX	USD		9,920
Monetary savings	USD/a		3,218
Payback	a		3.3

SOURCE: https://jlplumbing.com/product/ce-watermark-toilet-water-tank-pneumatic-concealed-cistern/ (2022), https://toilet-guru.com/pressure.html (2022).

SPONSORED BY THE Federal Ministry of Education and Research

Water-efficient faucets

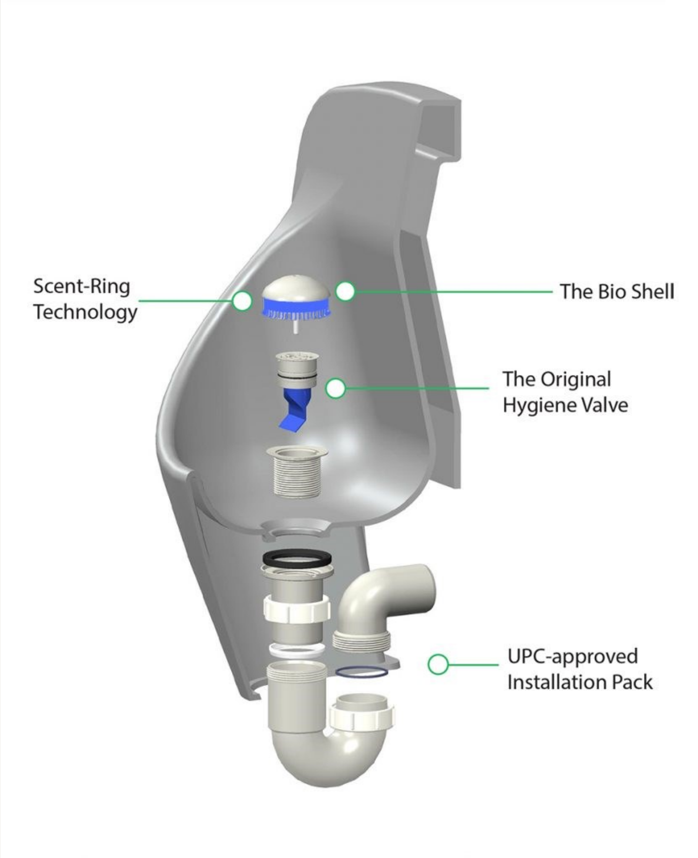
Parameter	Unit	Old	New
Water output	L/min	6	1.9
Units	x	200	200
Usage per day	min	10	10
Water demand annual	m³/a	4,380	1,387
Saving potential	%		68
Water savings annual	m³/a		2,993
Estimated CAPEX	USD		6,200
Monetary savings	USD/a		2,961
Payback	a		2.1

SOURCE: https://www.enware.com.au/products/general-commercial-tapware/enware-delabie-tempostop-time-flow-basin-pillar-tap-push-button/ (2022).

Waterless urinals

ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities

Parameter	Unit	Old	New
Water output	L/flush	2	0
Units	x	100	100
Usage per day	times	30	30
Water demand annual	m^3/a	2,190	0
Saving potential	%		100
Water savings annual	m^3/a		2,190
Odor trap cost	USD/a		20
Monetary savings	USD/a		2,147
Estimated CAPEX	USD		17,000
Payback	a		7.1



SOURCE: https://waterless.solutions/how-waterless-urinals-work

IfaS
Umwelt-Campus Birkenfeld
HOCHSCHULE TRIER
SPONSORED BY THE Federal Ministry of Education and Research

Nutrient recovery from urine as fertilizer

ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities

Estimated total urine collection 2,160 m^3/a

NOTE: from male washrooms at 50% collection ratio per day

Type of nutrient	Extractable amount [w/w]	Total extractable mass [t/a]
N - Nitrogen	13%	280.8
P - Phosphorus	1.5%	32.4

Extraction of N and P from 1 m^3 of pure urine can make a ***profit of 2.4 USD***

Total profit from recoverable nutrients in urine ***5,184 USD/a***

SOURCE: Surendra K. Pradhan et al, 2017, DOI: 10.1021/acs.est.6b05402, https://theconversation.com/we-found-a-way-to-turn-urine-into-solid-fertiliser-it-could-make-farming-more-sustainable-148877

WWT–NBS: constructed wetland

ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities

Parameters	Unit	UENR model
Wastewater volume treated	m^3/d	621.37
Wetland area	m^2	4,438
Estimated CAPEX	USD	266,301
Operating cost	USD/a	5,326
Treated water discharged	m^3/a	214,110

SOURCE: https://www.ysi.com, https://www.environmental-expert.com

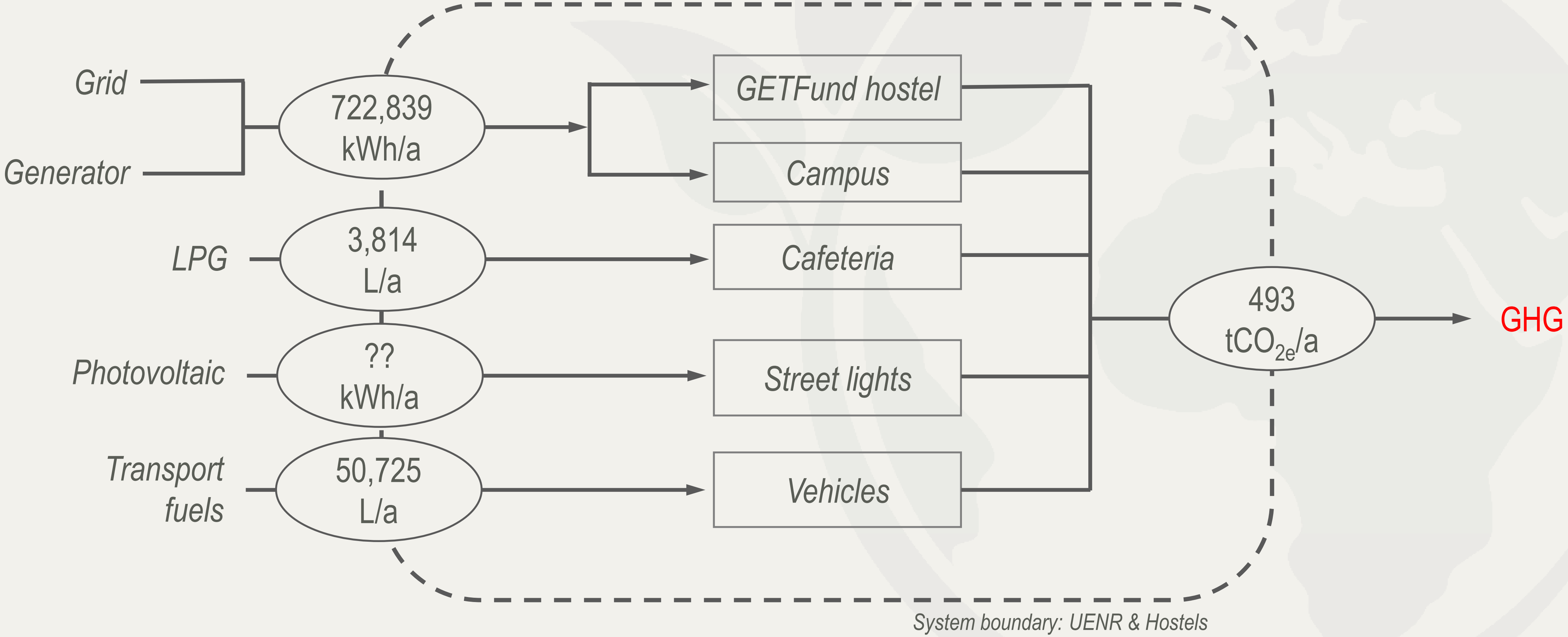
IfaS Institut für angewandtes Stoffstrommanagement
Umwelt-Campus Birkenfeld | HOCHSCHULE TRIER
SPONSORED BY THE Federal Ministry of Education and Research

ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities

Energy

ZERO EMISSION CONCEPT — UENR

Status quo: energy (UENR, 2023)



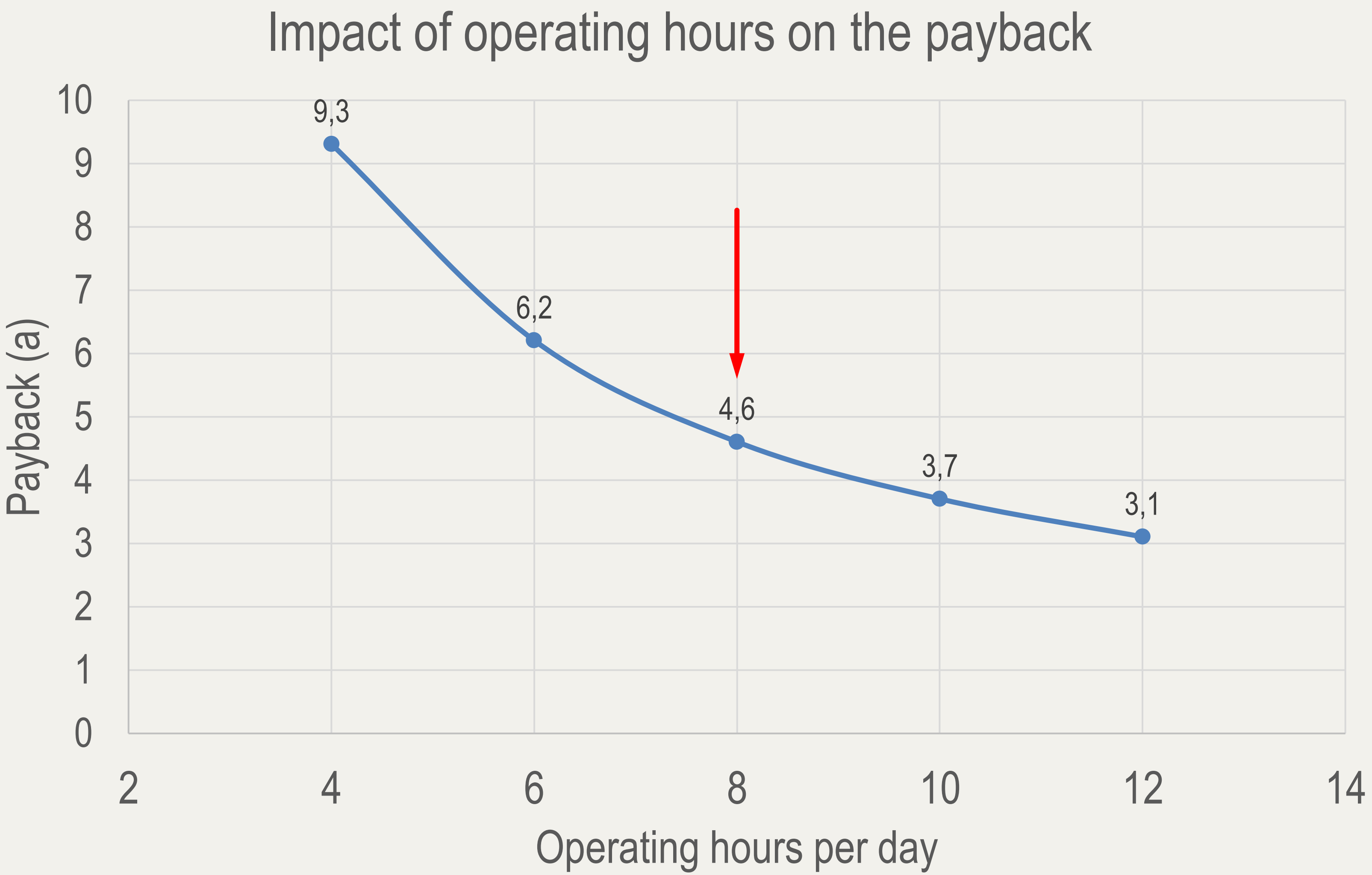
Ideas & strategies: energy efficiency (UENR, 2023)

I. Air-conditioning

II. Illumination

Energy-efficient air-conditioning

ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities



SOURCE: https://www.orionairsales.co.uk/daikin-air-conditioning-emura-ftxj50aw-crystal-white-wall-mounted-5kw18000btu-r32-a-240v50hz-6799-p.asp

IfaS Institut für angewandtes Stoffstrommanagement
Umwelt-Campus Birkenfeld | HOCHSCHULE TRIER
SPONSORED BY THE Federal Ministry of Education and Research

Energy-efficient illumination

ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities

Parameter	Unit	FTL T12 6ft	LED Low-tech	LED High-tech
Approx. cost per bulb	USD	10	60	100
Average lifespan	h	5,000	20,000	50,000
Power output *(without ballast)*	W	75	30	30
No. of bulbs needed *(50k hrs.)*	x	10	3	1
Operating hours	h/a	1,200	1,200	1,200
Total purchase price *(for 50k hrs.)*	USD	100	180	100
Total cost of electricity used *(50k hrs. at 0.141USD/kWh)*	USD	529	212	212
Total cost over 50k hours	USD	629	392	312
GHG emissions	tCO_{2e}/a	0.45	0.02	0.02
Cost per operational year	USD/a	15	9	7

SOURCE: Lanz Manufakture GmbH, (2023)

IfaS
Umwelt-Campus Birkenfeld | HOCHSCHULE TRIER
SPONSORED BY THE Federal Ministry of Education and Research

Ideas & strategies: energy efficiency (Sunyani, 202X)

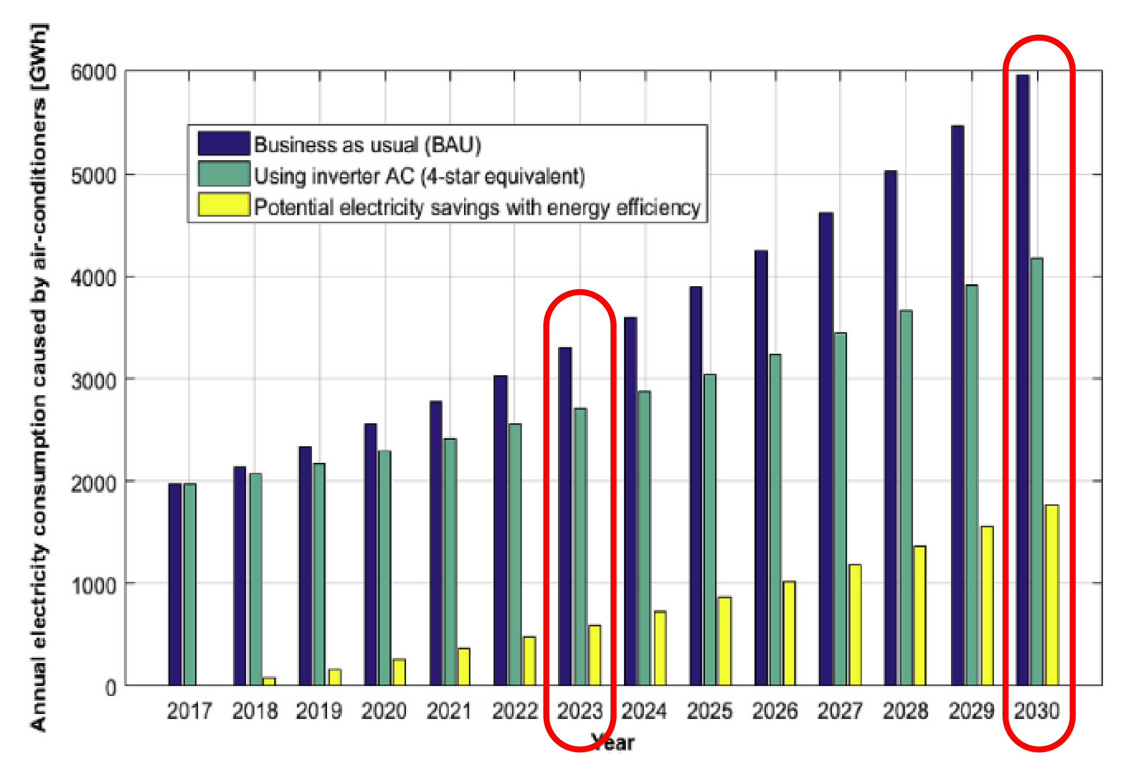
I. Energy-efficient buildings

Conventional dwellings vs green buildings

ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities

70% of electricity consumed in public and commercial buildings in Ghana is used to for air-conditioning.

Annual electricity consumption scenarios of A/C in Ghana



Average total electricity consumption in four roomed house or a small office building is around 6,000 kWh/a

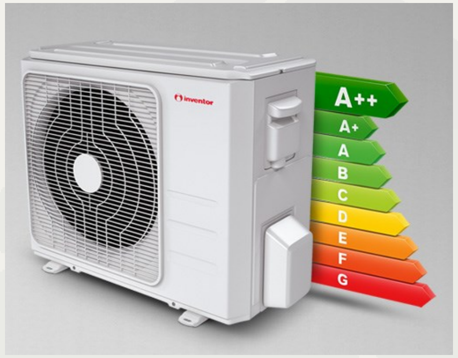
SOURCES: Richard Opoku et al. 2019, https://doi.org/10.1016/j.jclepro.2019.05.067, https://vicalexbrickghana.com/

ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities

Conventional dwellings vs green buildings

Energy efficiency options for four-roomed house or a small office building





Based on the most conservative assessment, 1,000 houses can save nearly ***420,000 USD/a***

SOURCES: https://www.mrmisty.co.uk/double-glazing-gasket-repairs , https://vicalexbrickghana.com/, https://www.inventorairconditioner.com/ , Richard Opoku et al. 2019, https://doi.org/10.1016/j.jclepro.2019.05.067

IfaS
Umwelt-Campus Birkenfeld | HOCHSCHULE TRIER
SPONSORED BY THE Federal Ministry of Education and Research

ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities

Renewable energy

IfaS Institut für angewandtes Stoffstrommanagement
Umwelt-Campus Birkenfeld HOCHSCHULE TRIER
SPONSORED BY THE Federal Ministry of Education and Research

Status quo: renewable energy (UENR, 2023)

Solar irrigation system, UENR

Solar street lights, UENR

Engineering laboratory, UENR

Ideas & strategies: renewable energy (UENR, 202X)

I. Photovoltaic-based energy generation
II. eMobility

ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities

Photovoltaic potential

Parameter	Unit	Value
Available rooftop area	m^2	5,900
Useable rooftop area	m^2	4,000
PV power generation	kWh/a	1,445,973
Direct own consumption	kWh/a	630,478
PV power surplus (export)	kWh/a	815,495

Specific annual yield 1,730 kWh/kWp

Simulated installed capacity 836 kWp

SOURCE: Google images, (2023)

Photovoltaic potential

Estimated CAPEX 668,528 USD

*NOTE: unitary turnkey price **800** USD/kWp*

Parameter	Unit	Value
Potential solar coverage, UENR	%	81
Annual energy cost savings	USD/a	88,821
Feed-in income *(0.046 USD/kWh)*	USD/a	37,513
Operating expenditure *(O&M = 5% CAPEX)*	USD/a	33,426
Net annual income *(first year)*	USD/a	92,908
CO_{2e} savings primary	tCO_{2e}/a	716
Levelized cost of energy	USD/kWh	**0.0476**
Payback	a	**7.2**

Grid electricity > LCoE PV

0.141 USD/kWh

0.0476 USD/kWh

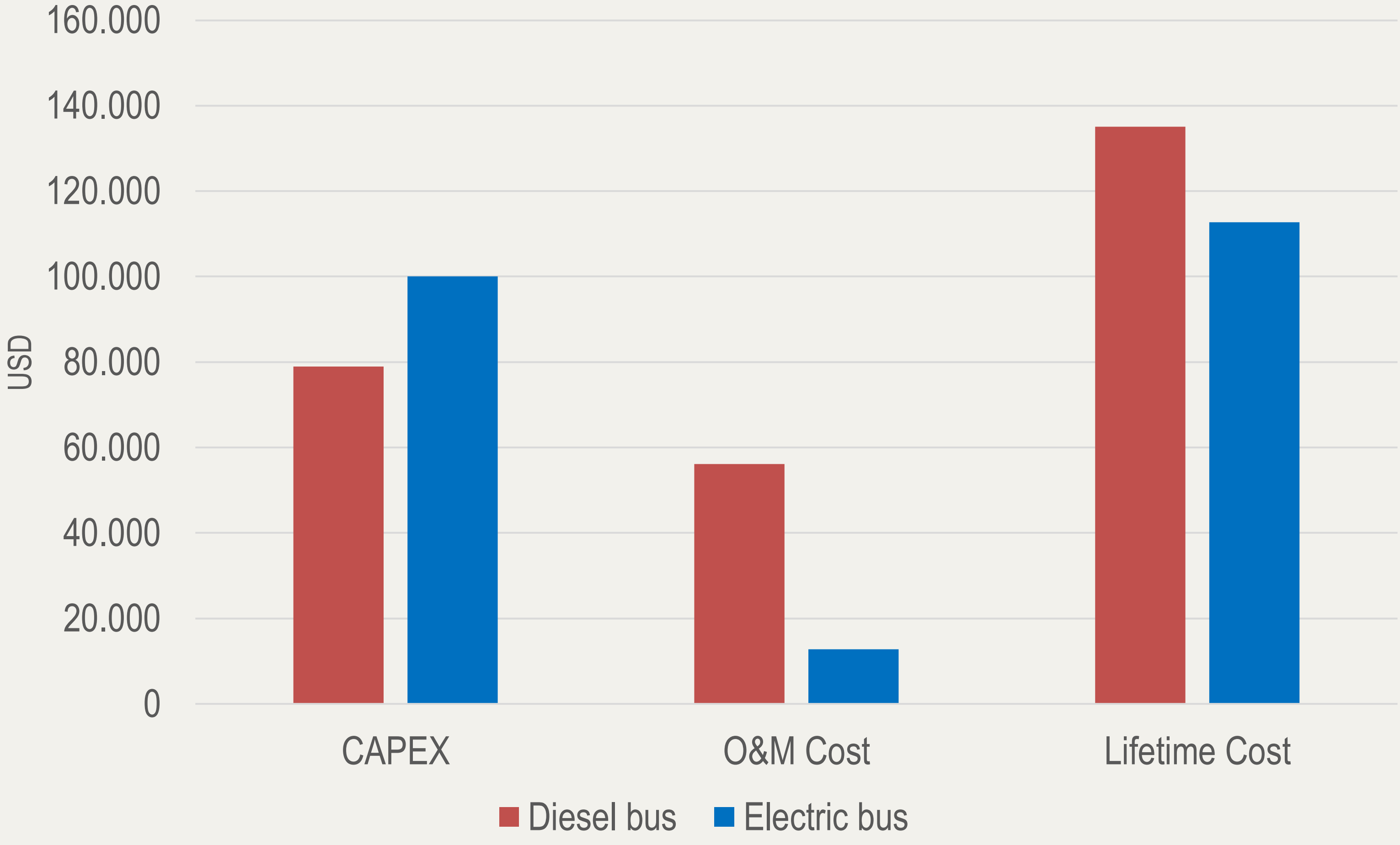
PV energy surplus

815,495 kWh/a

ZERO EMISSION CONCEPT — UENR

Diesel bus vs electric bus

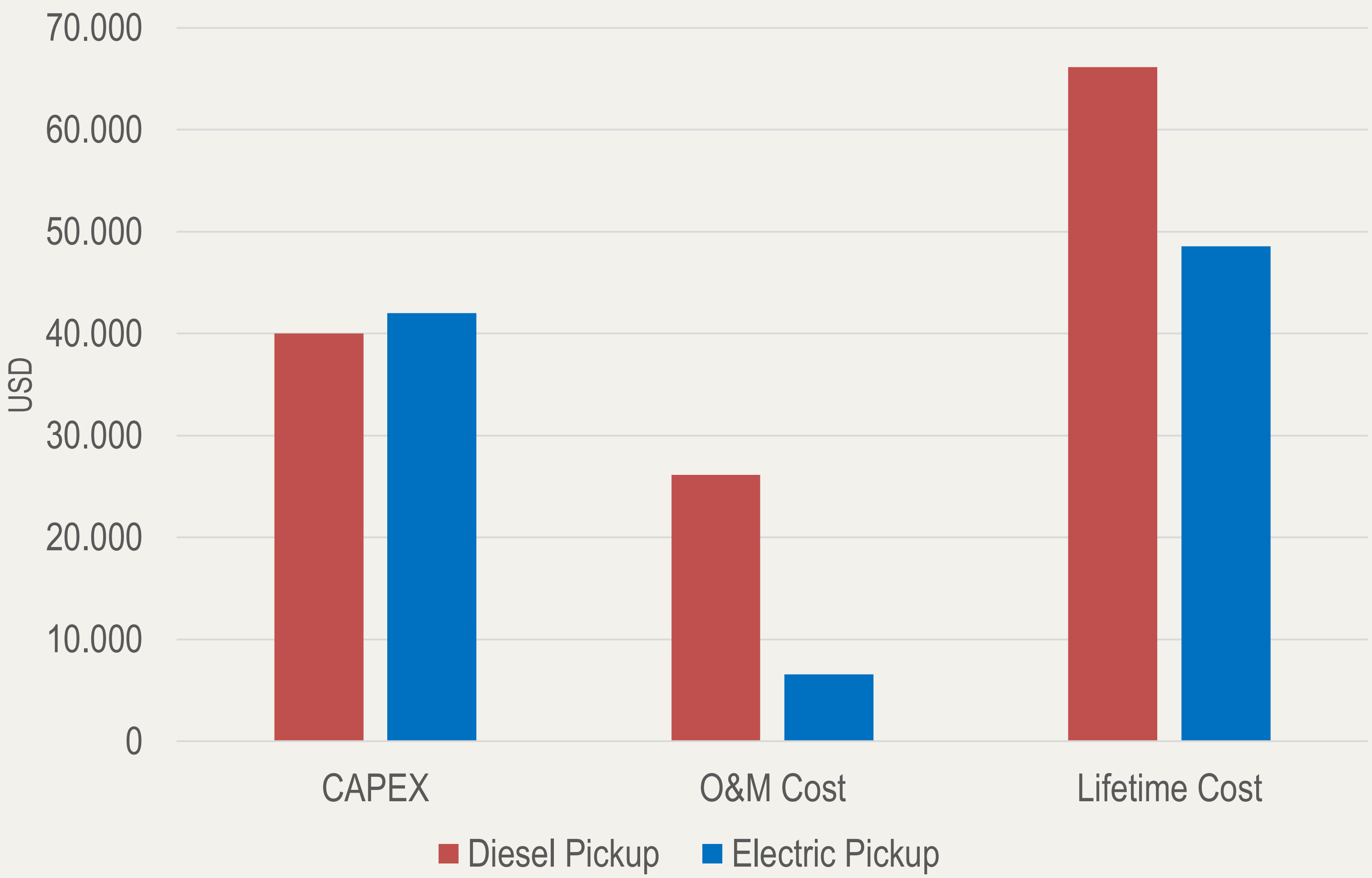
ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities



IfaS Institut für angewandtes Stoffstrommanagement
Umwelt-Campus Birkenfeld | HOCHSCHULE TRIER
SPONSORED BY THE Federal Ministry of Education and Research

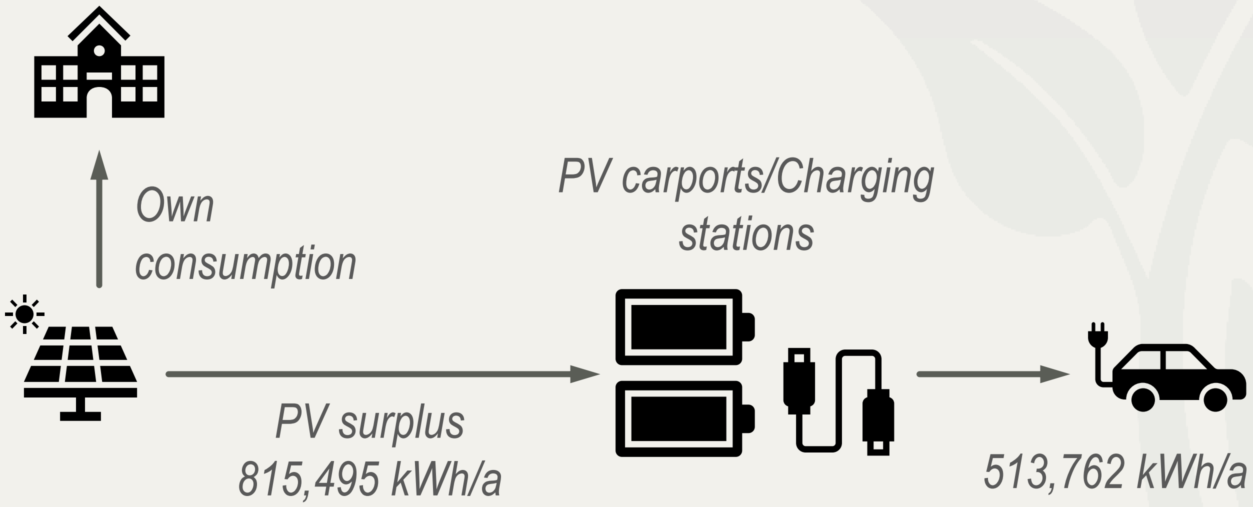
ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities

Diesel pickup vs electric pickup



pickup-trucks/

Electromobility potential



NOTE: Charging/discharging and cable losses 20%, losses in stationary mode 10%

Average energy consumption of electric vehicles: 0.4 – 0.6 kWh/km

(Incl. all losses—vehicle battery + performance)

1,027,524 km/a equivalent

171,254 liters of diesel equivalent

(average 6 km/L of diesel)

Cost savings: 192,400 USD/a

Emission savings : 461 tCO_{2e}/a

Electromobility potential

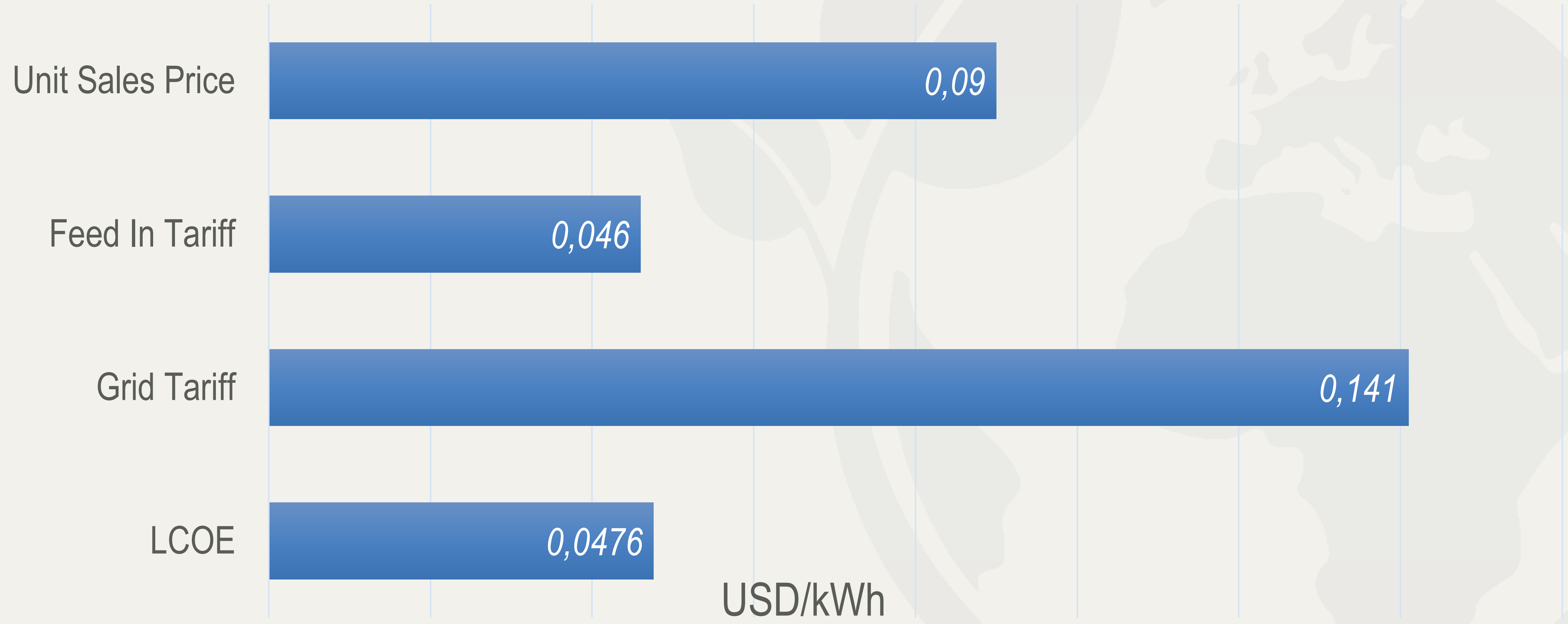
800 EVs

Estimated number of electric vehicles that the excess energy can service

ZECURA

Zero-Emission Concepts for Urban Resilience in selected African cities

Tariffs per kWh



Revenue projection

37,000
USD/a

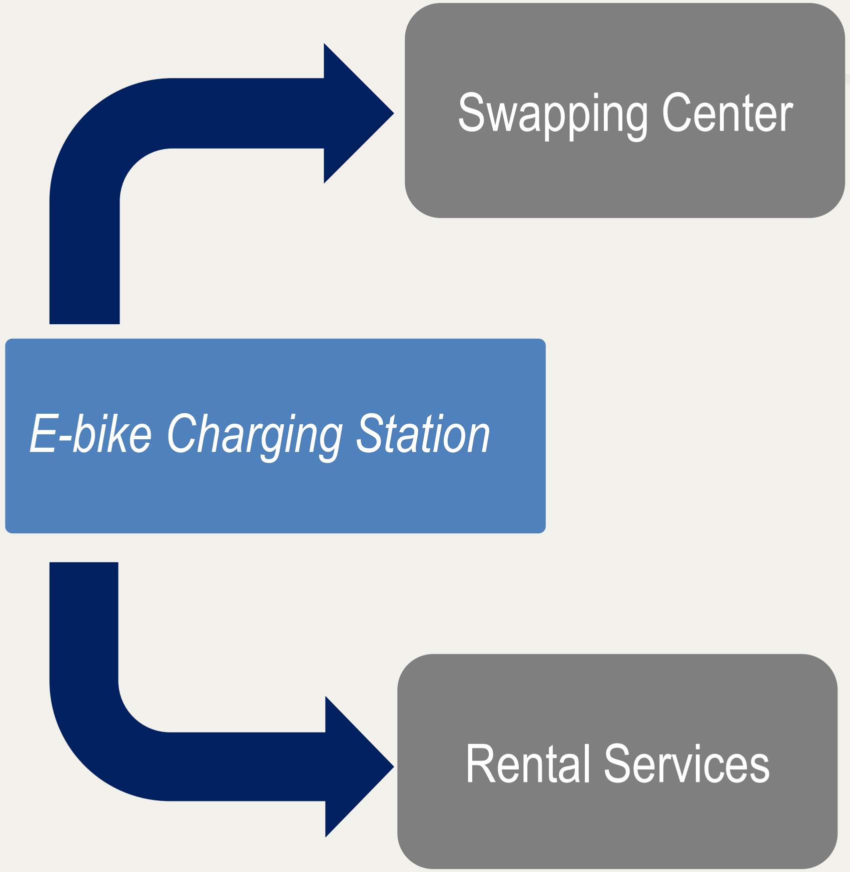
Revenue generated from sale of electricity to the grid

70,000
USD/a

Revenue generated from sale of electricity by the ESC

Revenue sources: servicing of EVs, EV sales, sale of spare parts

Electro mobility *(a regional example; Uganda)*



SOURCE: https://www.zem.bo/

What to achieve …

Capacity building: awareness of the systems

Repair & maintenance support: providing jobs to non-educated workers

Establishing a circular economy: within the university energy circuit

SPONSORED BY THE Federal Ministry of Education and Research

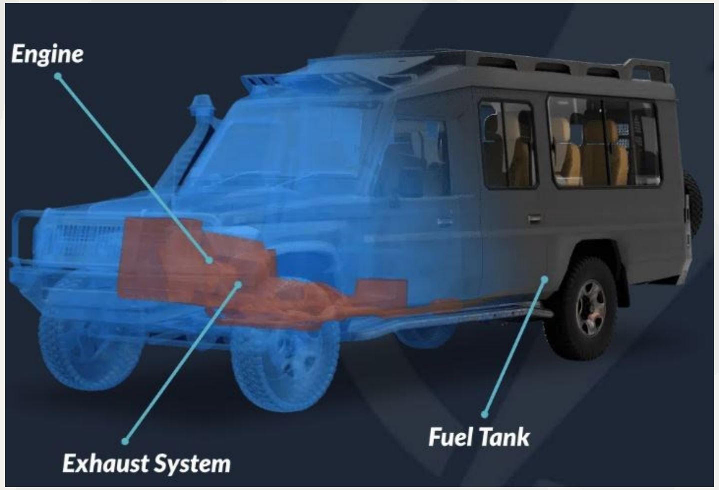
eMobility *(a regional example; Tanzania)*

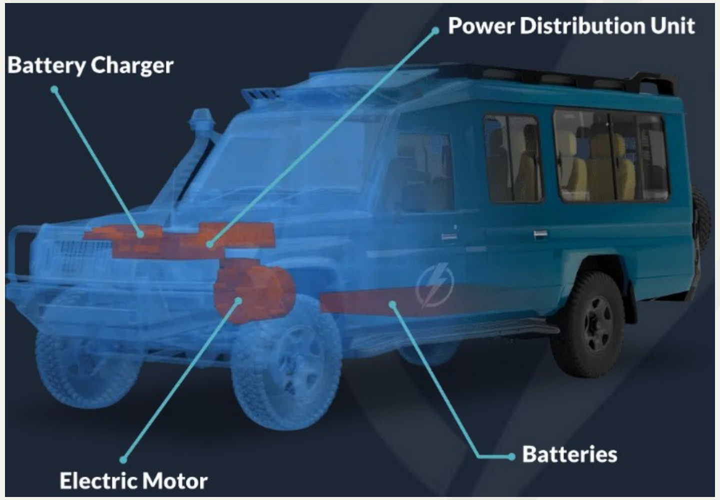
ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities

Converting an ICE to an electric system.

Removing the existing internal combustion engine and replacing it with a complete electrical system i.e. an electric motors, battery system, onboard charger, information display.

Extending the lifespan of the vehicle by retrofitting; reduce the life cycle emissions.





SOURCE: https://e-motion.africa/

RE potential: future prospect

ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities

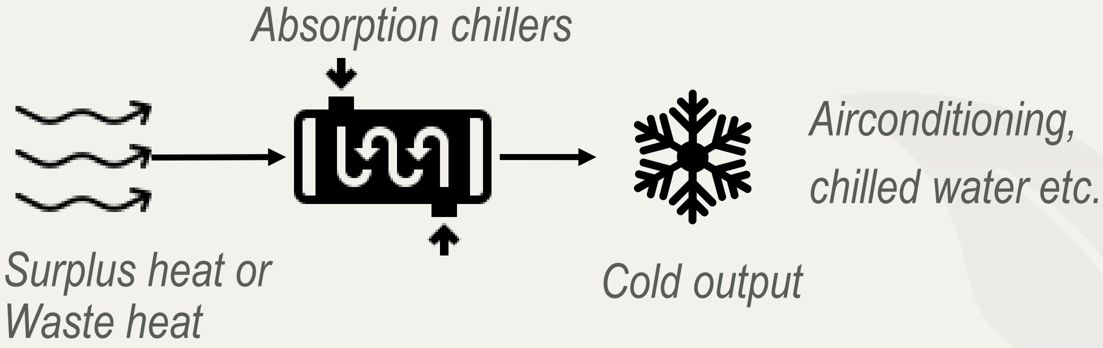
Available potentials

Based on the current evaluation, surplus of **314,350** $kWh_{thermal}$/a heat and, **815,400** $kWh_{elec.}$/a of electricity are available,

What can we do other than eMobility?

- Vapor absorption chillers, heat-to-cold, biomass, biogas, solar thermal
- Organic Rankine Cycle (ORC) generators
- H_2 Green hydrogen from PV and bio-methane

Cooling from heat: absorption chiller



Reduce or eliminate the compression ratio of AC units and in return it reduces the ***electricity consumption***

Can support low hot water intake (+60 ºC)

Absorption chillers generally has low COPs

If the feed temperature is low, the COP is low (0.5 – 1.5)

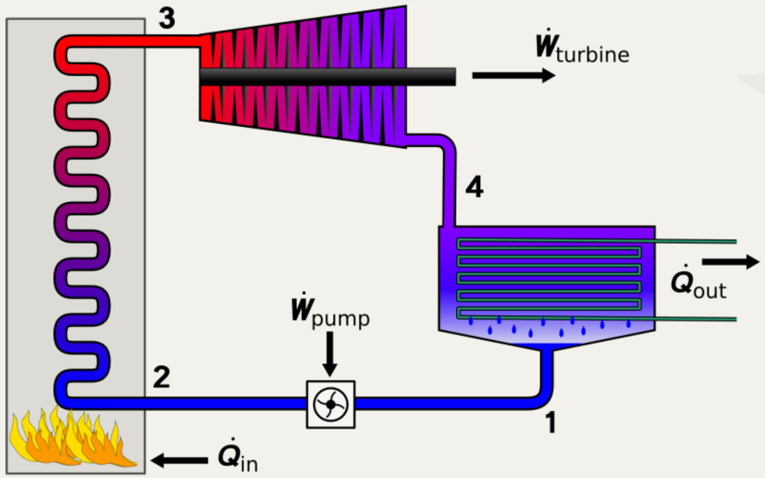
Parameter	Unit	Amount
Total heat surplus	$kWh_{thermal}/a$	314,352
Estimated cooling demand (UENR)	kWh_{cold}/a	665,160
Cold output of the VAC	kWh_{cold}/a	238,907
VAC coverage	%	36
LCoE cold	USD/kWh_{cold}	**0.27**

Current cold energy price for UENR = **0.061** USD/kWh_{cold}

SOURCES: *http://worldenergy.co.kr/en/portfolio-item/2aa-2/, https://coolingbestpractices.com, https://www.lg.com/global/business/download/airsolution/Absorption_Chillers[20200716_141453721].pdf*

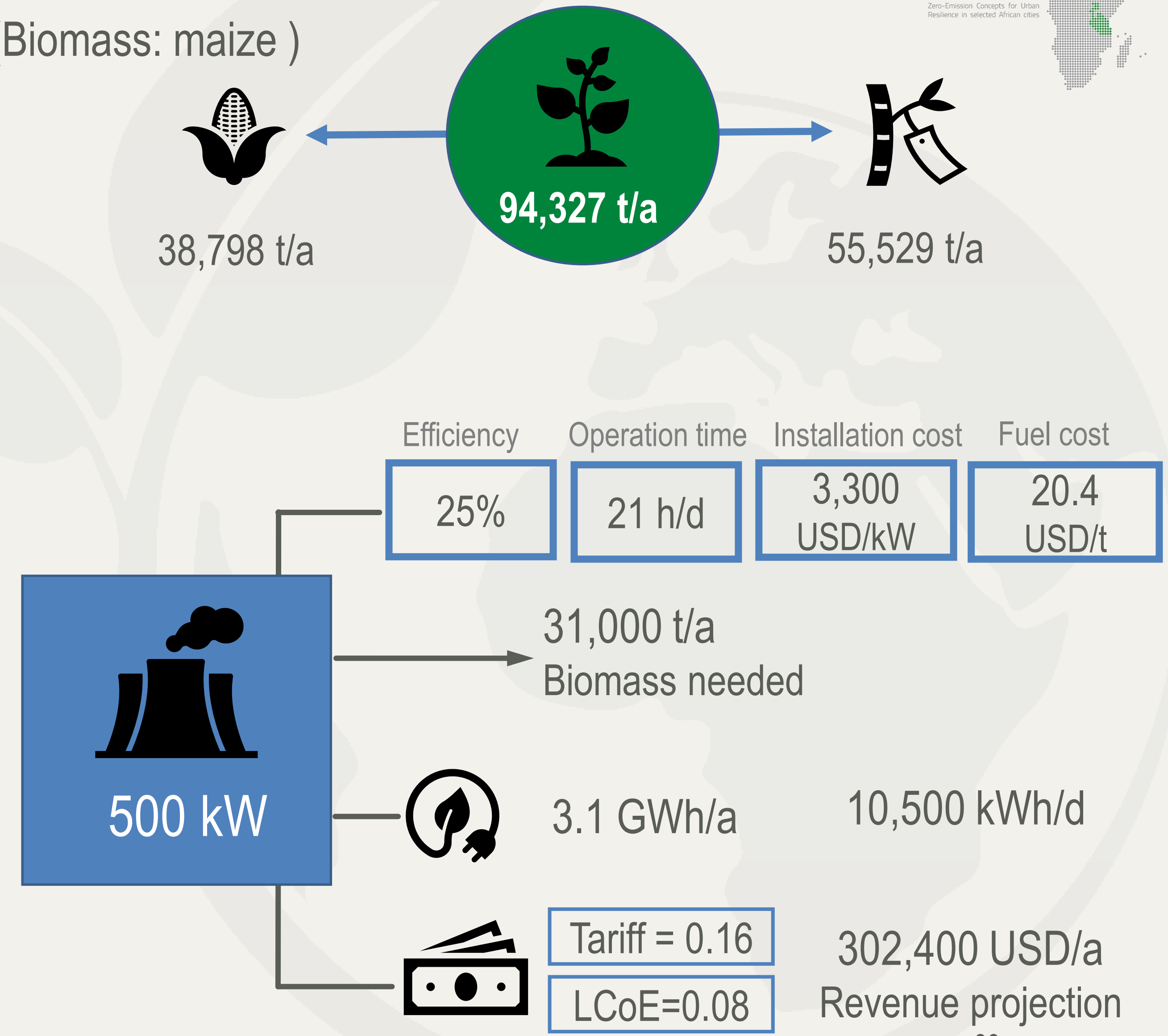
SPONSORED BY THE Federal Ministry of Education and Research

Organic Rankine Cycle (Biomass: maize)



- Combustion
- Vaporization of working fluid
- Mechanical to electrical energy
- Heat exchange for crop processing

SOURCE: Google images, (2023)

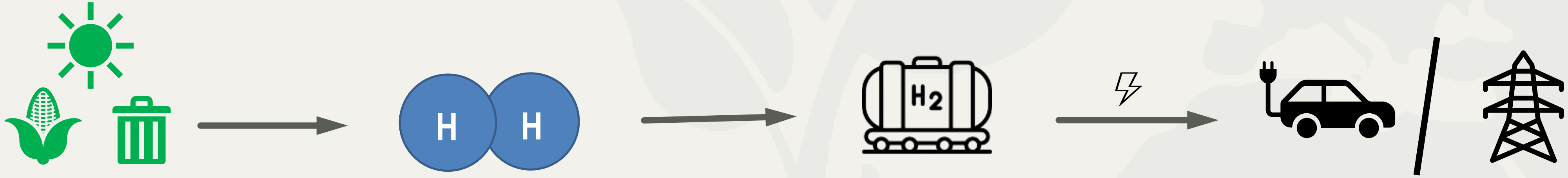


IfaS Institut für angewandtes Stoffstrommanagement
Umwelt-Campus Birkenfeld | HOCHSCHULE TRIER
SPONSORED BY THE Federal Ministry of Education and Research

Renewable energy & green H_2 potential

ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities

Surplus from biogas and PV



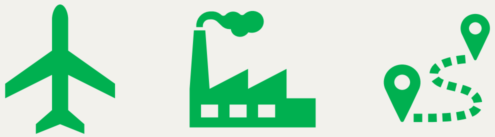
Available methods:

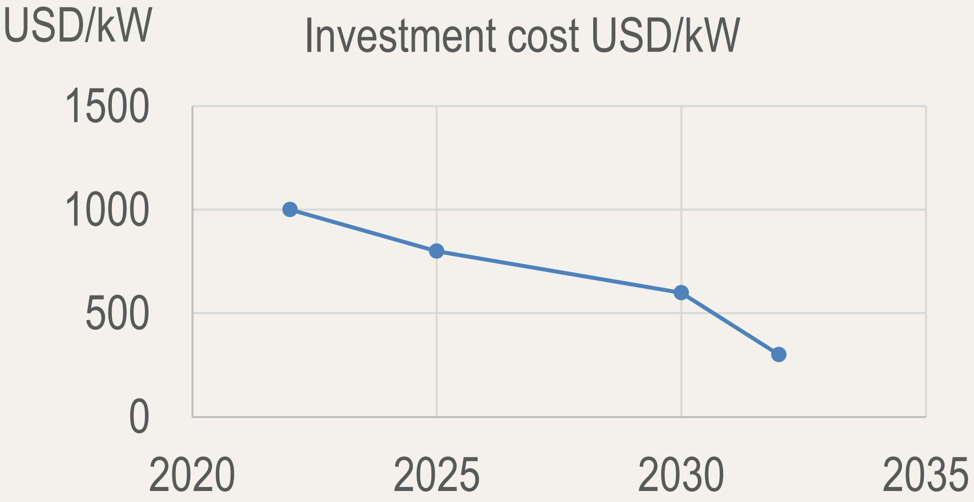
1. Electrolysis
2. Steam methane reforming (SMR)
3. Partial oxidation (POX)
4. Autothermal reforming (ATR)

IfaS
Umwelt-Campus Birkenfeld | HOCHSCHULE TRIER
SPONSORED BY THE Federal Ministry of Education and Research

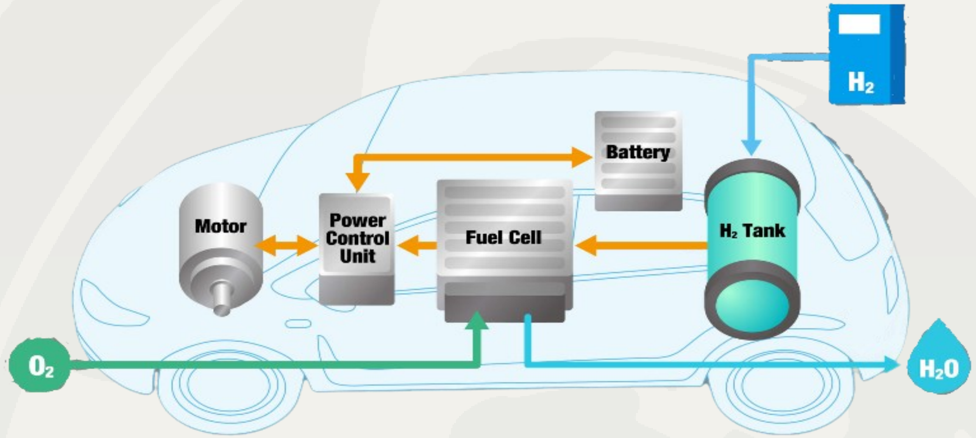
Future prospects

Uses of green hydrogen



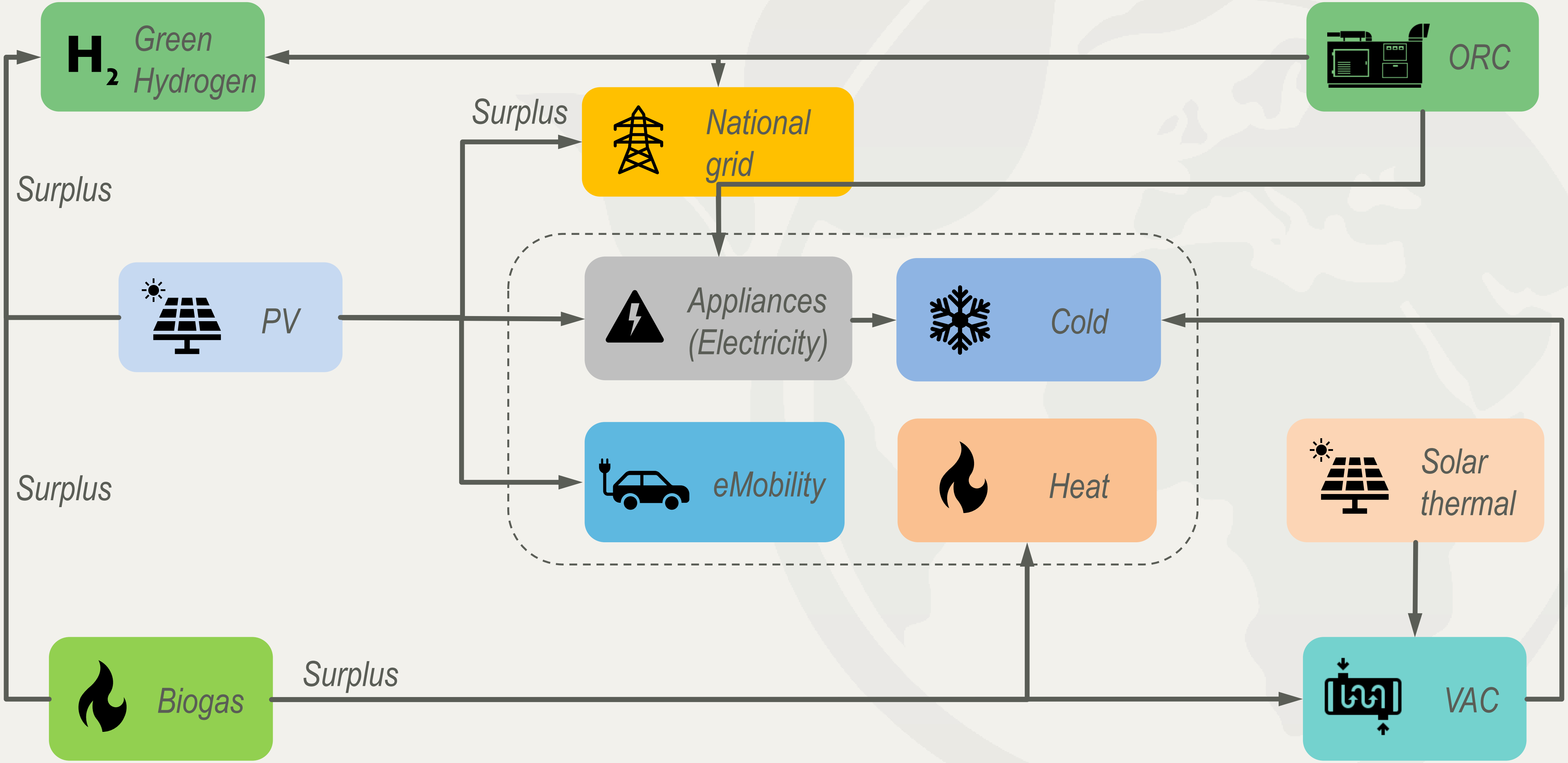


SOURCE: (*Toyota-Hydrogen-Fuel-Cell-Powered-Bus-Arrives-in-Ireland.Jpg* (963×519), n.d.)



Estimated total H_2 production is **11.8 t/a** from the surpluses of PV

Proposed energy supply model UENR



ZECURA

Zero-Emission Concepts for Urban Resilience in selected African cities

Sustainability impacts

IfaS Institut für angewandtes Stoffstrommanagement
Umwelt-Campus Birkenfeld HOCHSCHULE TRIER
SPONSORED BY THE Federal Ministry of Education and Research

Financial impacts potential (UENR, 202X)

ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities

Waste segregation
- 97,605 USD/a savings
- 30,500 USD CAPEX
- 0.31 years payback

Water efficient faucets
- 2,961 USD/a savings
- 6,200 USD CAPEX
- 2.1 years payback

Water efficient cisterns
- 3,218 USD/a savings
- 9,920 USD CAPEX
- 3.3 years payback

Biogas plant
- 53,594 USD/a savings
- 348,800 USD CAPEX
- 6.5 years payback

IfaS Institut für angewandtes Stoffstrommanagement
Umwelt-Campus Birkenfeld | Hochschule Trier
SPONSORED BY THE Federal Ministry of Education and Research

Financial impacts potential (UENR, 202X) *contd.*

Waterless urinals
- 2,147 USD/a savings
- 17,000 USD CAPEX
- 7.1 years payback

PV production
- 88,821 USD/a savings
- 668,528 USD CAPEX
- 7.2 years payback

Air-conditioners
- 29,718 USD/a savings
- 276,000 USD CAPEX
- 9.3 years payback

Rainwater harvesting system
- 682 USD/a savings
- 35,756 USD CAPEX
- Payback not estimated

Financial impacts potential (UENR, 202X) *contd.*

NPK recovery

- 5,184 USD/a savings
- CAPEX not estimated
- Payback not estimated

Reed Bed Wastewater Treatment

- 5,326 USD/a savings
- 266,301 USD CAPEX
- Payback not estimated

E-Bus

- 4,013 USD/a savings
- 100,000 USD CAPEX
- Payback not estimated

E-Pickup

- 1,843 USD/a savings
- 42,000 USD CAPEX
- Payback not estimated

Financial impacts potential (UENR, 202X) *contd.*

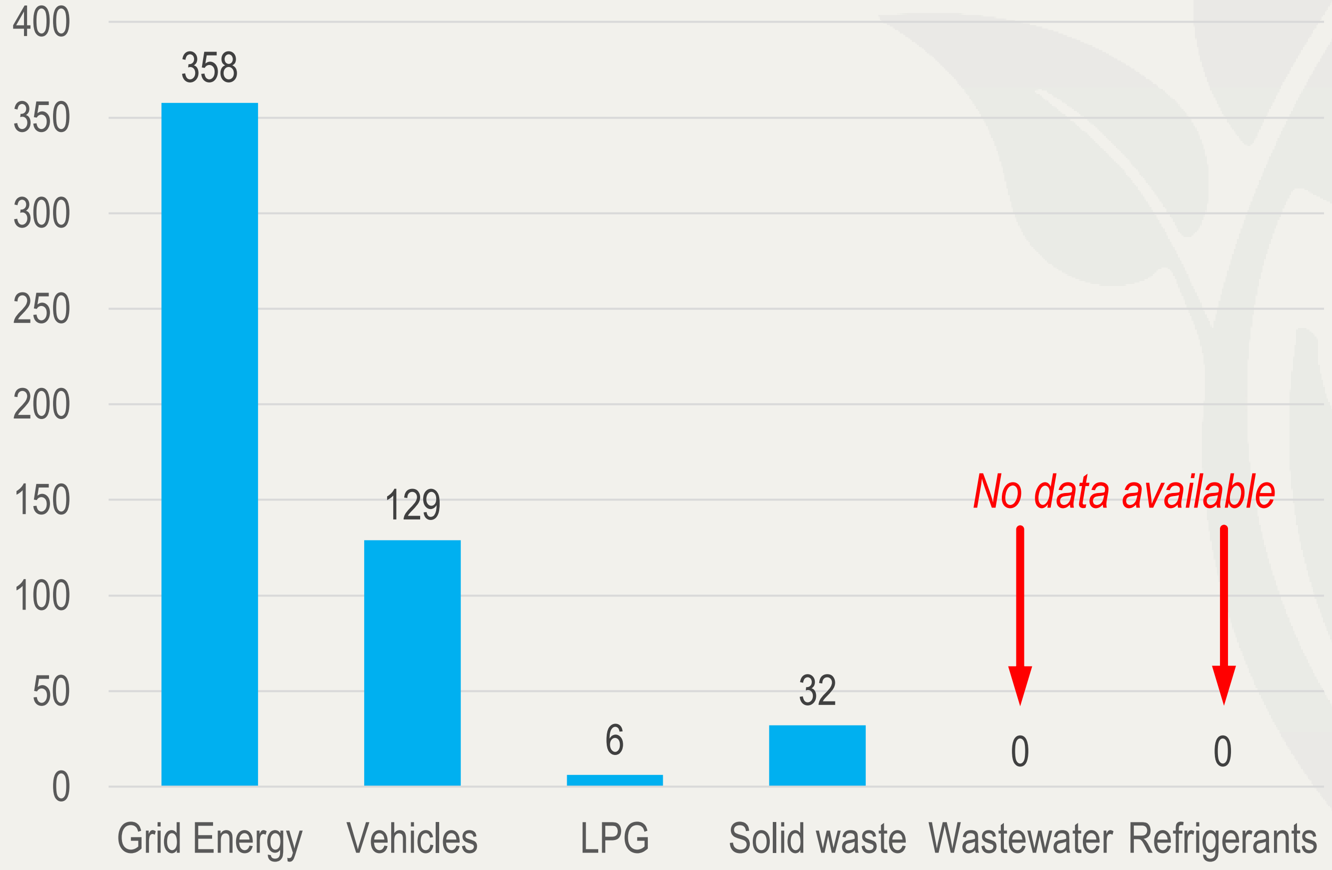
Total

- 284,415 USD/a savings
- 1,801,005 USD CAPEX
- 6.33 years payback

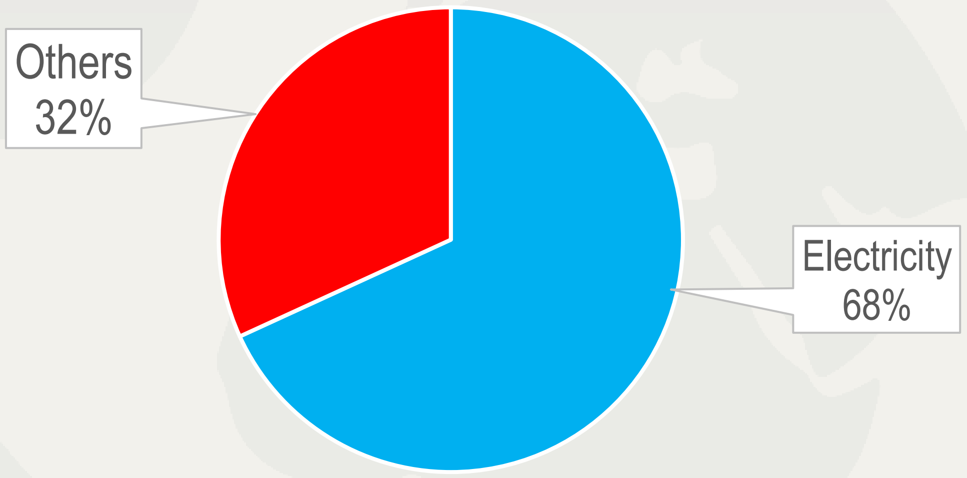
Environmental impacts (UENR, status quo)

ZECURA Zero-Emission Concepts for Urban Resilience in selected African cities

GHG emissions per sector [tCO_{2e}/a] (2021)



GHG emissions per sector [%] (2021)

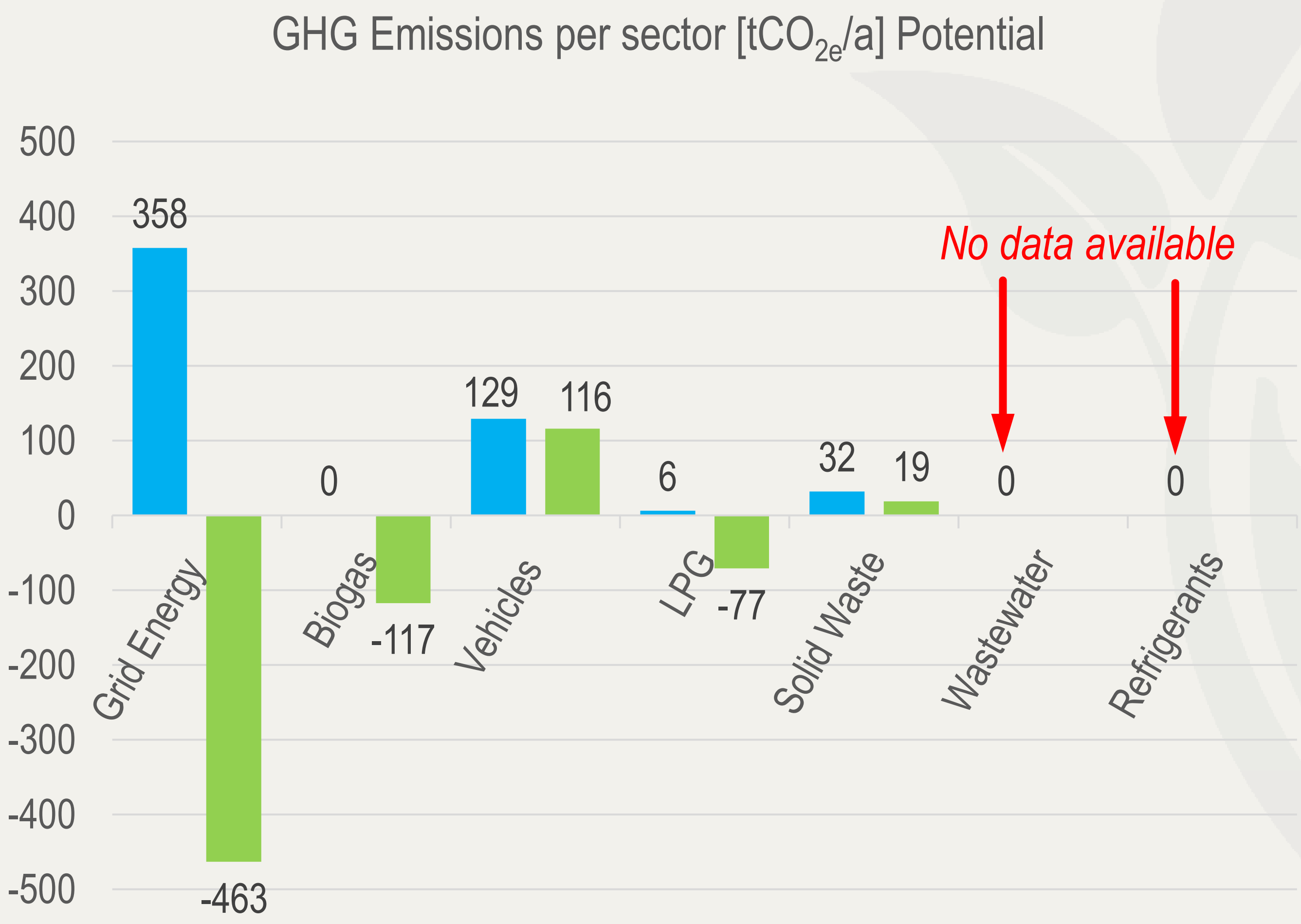


Total GHG:	525 tCO_{2e}/a
GHG emissions per capita (UENR):	0.038 $tCO_{2e}/ca \cdot a$
GHG emissions per capita (Ghana):	0.6 $tCO_{2e}/ca \cdot a$

IfaS Institut für angewandtes Stoffstrommanagement · Umwelt-Campus Birkenfeld · Hochschule Trier · Sponsored by the Federal Ministry of Education and Research

Environmental impacts potential (UENR, 202X)

ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities



Total GHG: –619 tCO_{2e}/a

GHG emissions per capita (UENR): –0.045 $tCO_{2e}/ca\cdot a$

GHG emissions per capita (Ghana): 0.6 $tCO_{2e}/ca\cdot a$

IfaS 20 Jahre
Umwelt-Campus Birkenfeld
HOCHSCHULE TRIER
SPONSORED BY THE Federal Ministry of Education and Research

Social impacts potential (UENR, 202X)

ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities

Water
- 1 direct jobs
- 0 indirect jobs

Energy
- 9 direct jobs
- 0 indirect jobs

Waste
- 6.5 direct jobs
- 7 indirect jobs

Total
- 16.5 direct jobs
- 7 indirect jobs

IfaS 20 JAHRE Institut für angewandtes Stoffstrommanagement
Umwelt-Campus Birkenfeld | HOCHSCHULE TRIER
SPONSORED BY THE Federal Ministry of Education and Research

The complete picture…

ZECURA

Zero-Emission Concepts for Urban Resilience in selected African cities

Thank you!

SPONSORED BY THE

Federal Ministry of Education and Research

IfaS Institut für angewandtes Stoffstrommanagement

Umwelt-Campus Birkenfeld

HOCHSCHULE TRIER