SEMINÁRIO TÉCNICO ECONOMIA CIRCULAR

6 - 7 OUTUBRO

Gestão de fluxos materiais

Cândida Rocha
Diretora do Mestrado em Engenharia do Ambiente
Faculdade de Engenharia da Universidade Lusófona

UNIVERSIDADE LUSÓFONA

Faculdade de engenharia

AÇORES 2020

GOVERNO DOS AÇORES

PORTUGAL 2020

UNIÃO EUROPEIA

ORGANIZAÇÃO

GOVERNO DOS AÇORES

Secretaria Regional do Ambiente e Alterações Climáticas

UNIVERSIDADE

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Universidade Lusófona

Mestrado em Engenharia do Ambiente

Faculdade de Engenharia

CANDIDATAR-ME A ESTE CURSO

Valores

Candidatura

Matrícula e Inscrição

1.º Ano/ Tronco comum	Semestre	ECTS
Alterações Climáticas e Estratégias de Descarbonização	1º Semestre	6
Caracterização e Remediação de Solos e Aquíferos	1º Semestre	6
Gestão Ambiental e Sustentabilidade	1º Semestre	6
Gestão, Tratamento e Valorização de Resíduos	1º Semestre	6
Sistemas Energéticos Sustentáveis	1º Semestre	6
Avaliação de Impacte Ambiental	2º Semestre	6
Economia Circular e Gestão de Fluxos Materiais	2º Semestre	6
Gestão da Qualidade do Ar	2º Semestre	6
Gestão e Comunicação de Risco	2º Semestre	6
Técnicas de Tratamento de Água e Efluentes (Gestão e Tratamento)	2º Semestre	6

2.º Ano/ Tronco comum	Semestre	ECTS
Modelação e Análise de Sistemas Ambientais	1º Semestre	6
Projeto e Investigação em Engenharia do Ambiente	1º Semestre	12
Seminários em Engenharia do Ambiente	1º Semestre	12
Dissertação	2º Semestre	30

Universidade Lusófona

Curso Livre em Economia Circular e Descarbonização

Faculdade de Engenharia

QUERO RECEBER INFORMAÇÕES SOBRE O CURSO

Valores

A este ciclo de estudos/programa de formação aplicam-se as tabelas de emolumentos em vigor na Universidade Lusófona para o presente ano letivo

Universidade Lusófona

Licenciatura em Bioeconomia Circular e Tecnologia

Faculdade de Engenharia

Valores

Candidatura

Matrícula e Inscrição

Universidade Lusófona

Licenciatura em Engenharia do Ambiente

Faculdade de Engenharia

CANDIDATAR-ME A ESTE CURSO

Valores

Candidatura

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Universidade Lusófona

Pós-Graduação em Economia Circular - Ambiente como Fator de Sustentabilidade

Valores

Candidatura

Matrícula e Inscrição

Século XX

Guerra à Escala Mundial

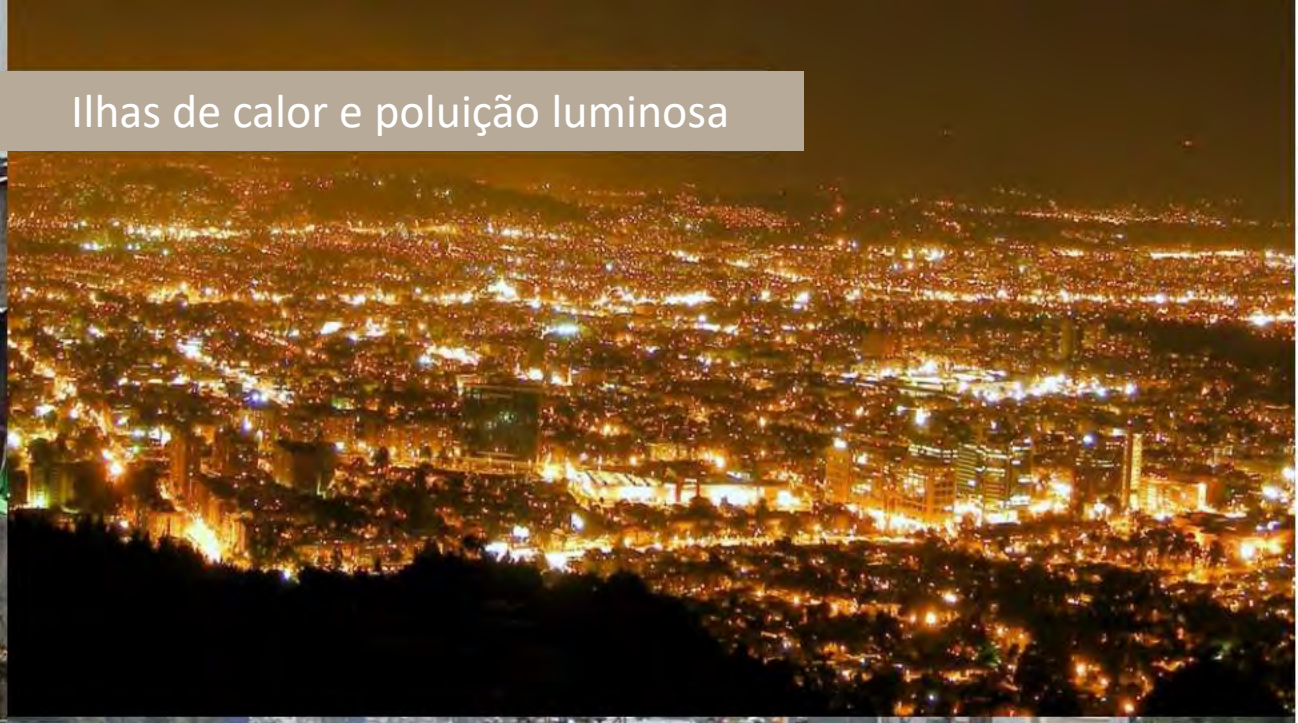
Desenvolvimento Industrial
+
Construção de Grandes Infraestruturas

Essencial para a disponibilização de bens e serviços necessários ao aumento dos **níveis de conforto** e de **qualidade de vida** dos cidadãos

Dinâmica de desenvolvimento muito assente no **consumo de matérias-primas** sem preocupações de natureza ambiental.

Poluição da água

Ilhas de calor e poluição luminosa



Resíduos

Poluição sonora e do ar

SOURCE: google.com/images. (2019): accessed 02.APR.2019

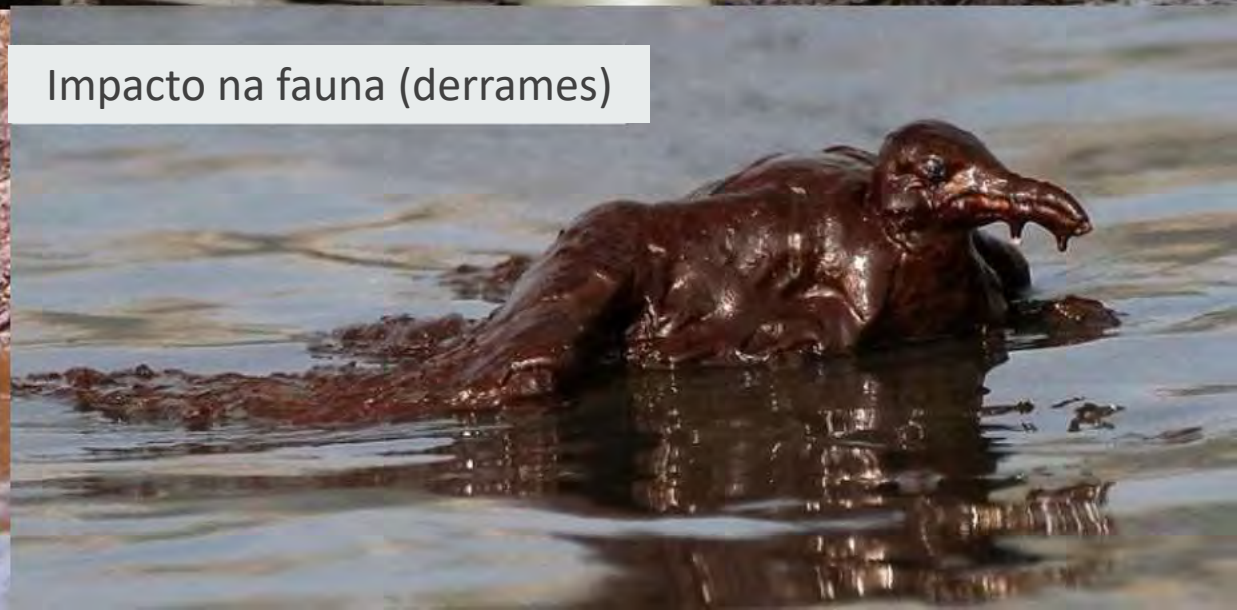
Degradação do solo. Canadá

Destruição da floresta nativa e terras indígenas. Equador

Poluição da água

SOURCE: google.com/images, (2019.); accessed 02.APR.2019

Impacto na fauna (derrames)



Destruição de ecossistemas. China

Destruição de habitats. Filipinas

Poluição da água (atividades mineiras). Equador

SOURCE: google.com/images, (2019.); accessed 02.APR.2019

Várias formas de poluição. Nova Zelândia

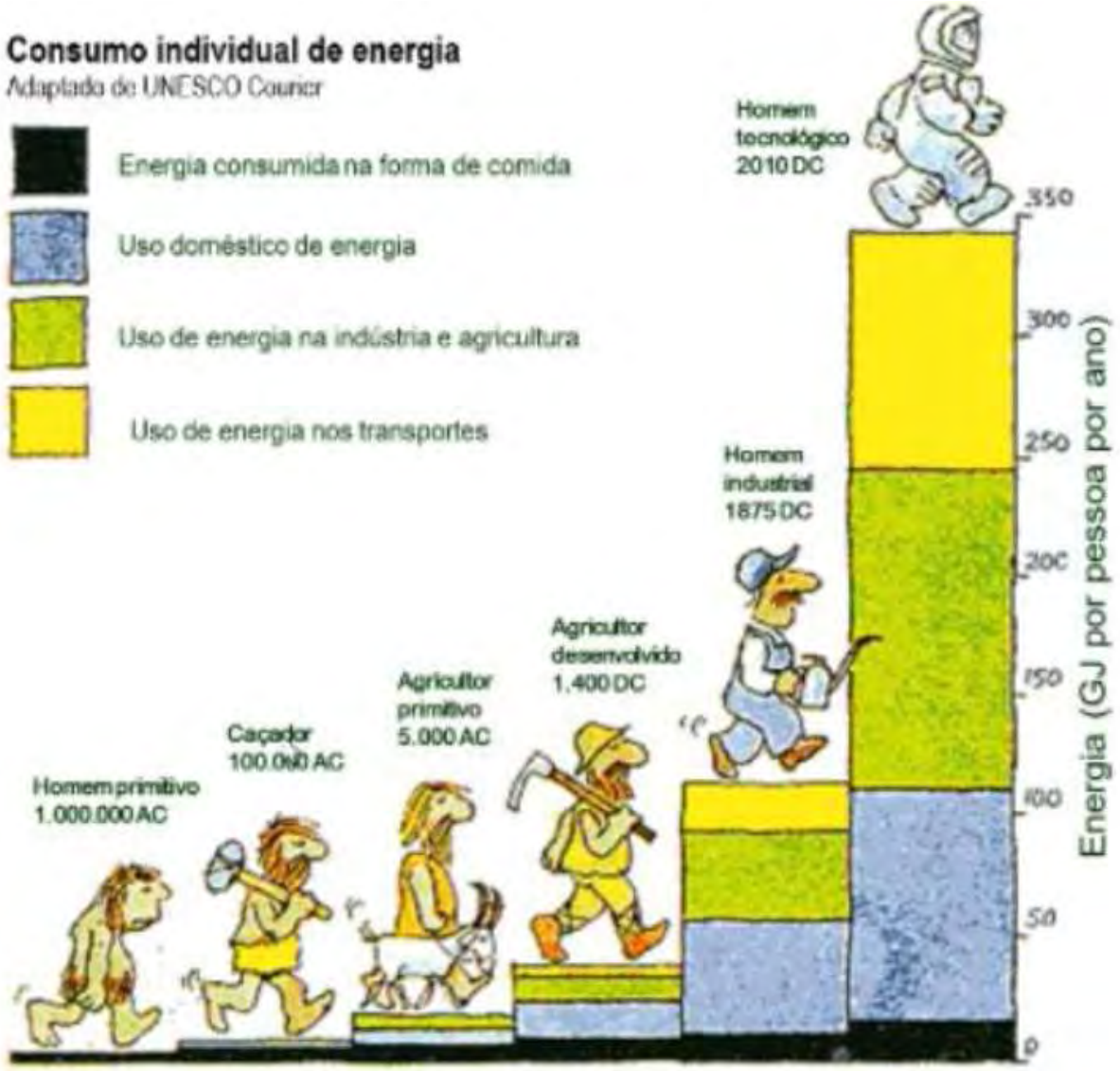
Grandes desafios e tendências

...mas a população "apenas" cresceu 4,4 vezes

Em 1920 o mundo ➔ 50 EJ

16 X

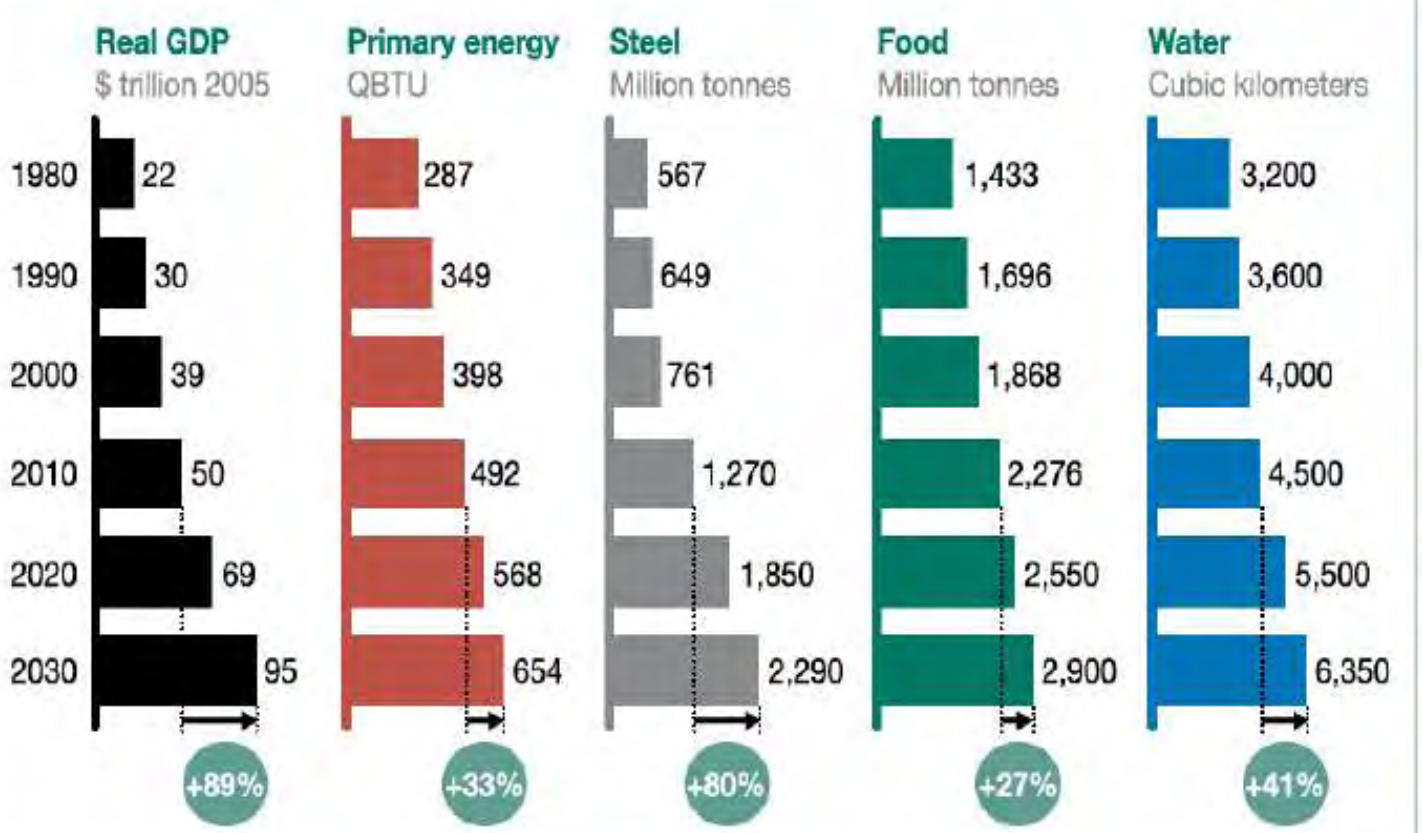
Em 2020 o mundo ➔ 800 EJ



Grandes desafios e tendências

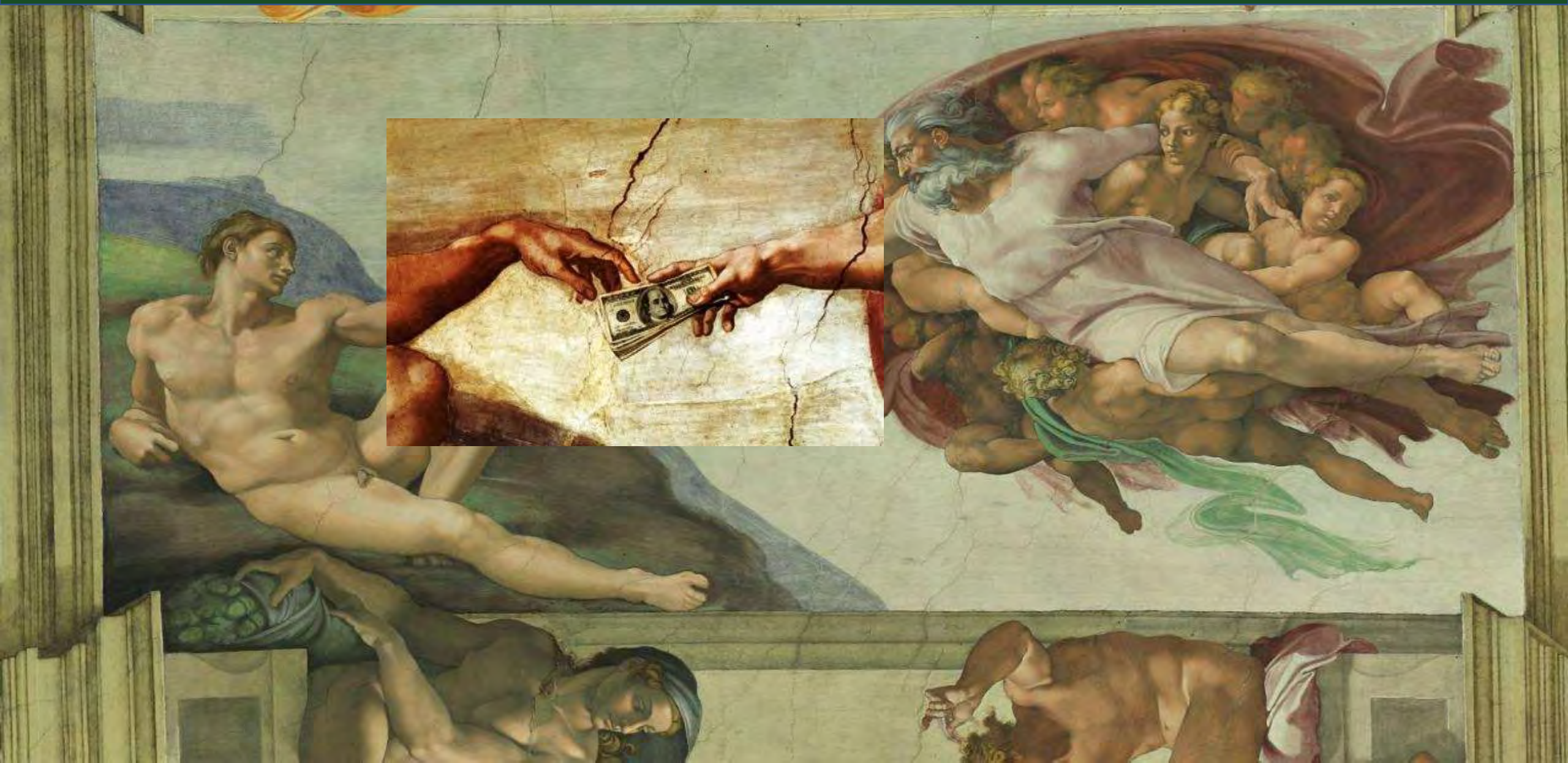
Grandes desafios e tendências

Figure 1. Historical and estimated growth in demand for resources from 1980 to 2030.



SOURCE: McKinsey & Co Global Institute (2011). Resource Revolution: Meeting the world's energy, materials, food, and water needs, p. 35. New York. Available at: http://www.mckinsey.com/Features/Resource_revolution.

Grandes desafios e tendências



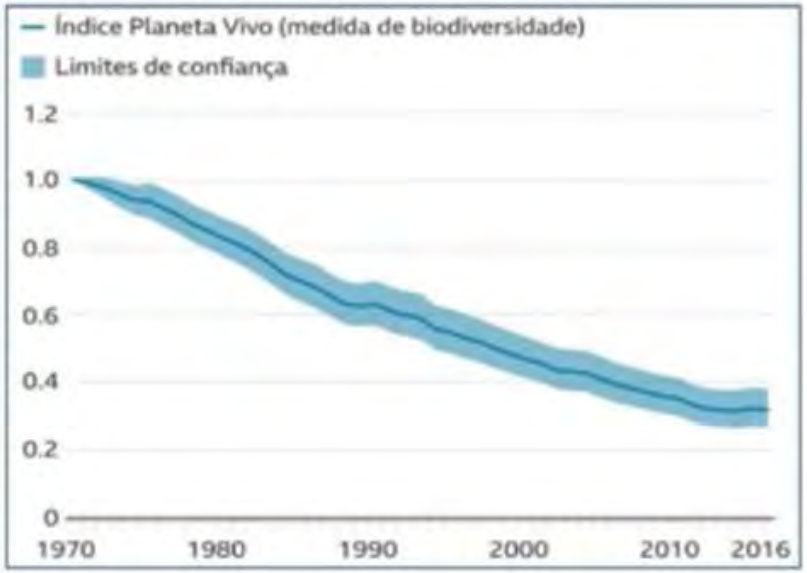
Grandes desafios e tendências

Grandes desafios e tendências

Por cima das nossas cabeças paira uma **ameaça** que é real, mas que **não conhecemos bem** e que não sabemos quando se irá embora. As **zoonoses** (doenças infeciosas transmitidas pelos animais aos humanos) estão em alta e a piorar (ex. SIDA, ébola, malária, dengue, varicela, poliomielite, zika e agora a pandemia COVID-19).

Temos **interferido** tão fortemente na **natureza** que fomos agora **atacados por ela**. Esquecemos que em **habitats bem conservados** e com **grande diversidade de espécies**, os **vírus** distribuem-se facilmente **nesses ecossistemas não afetando o ser humano**,

Grandes desafios e tendências



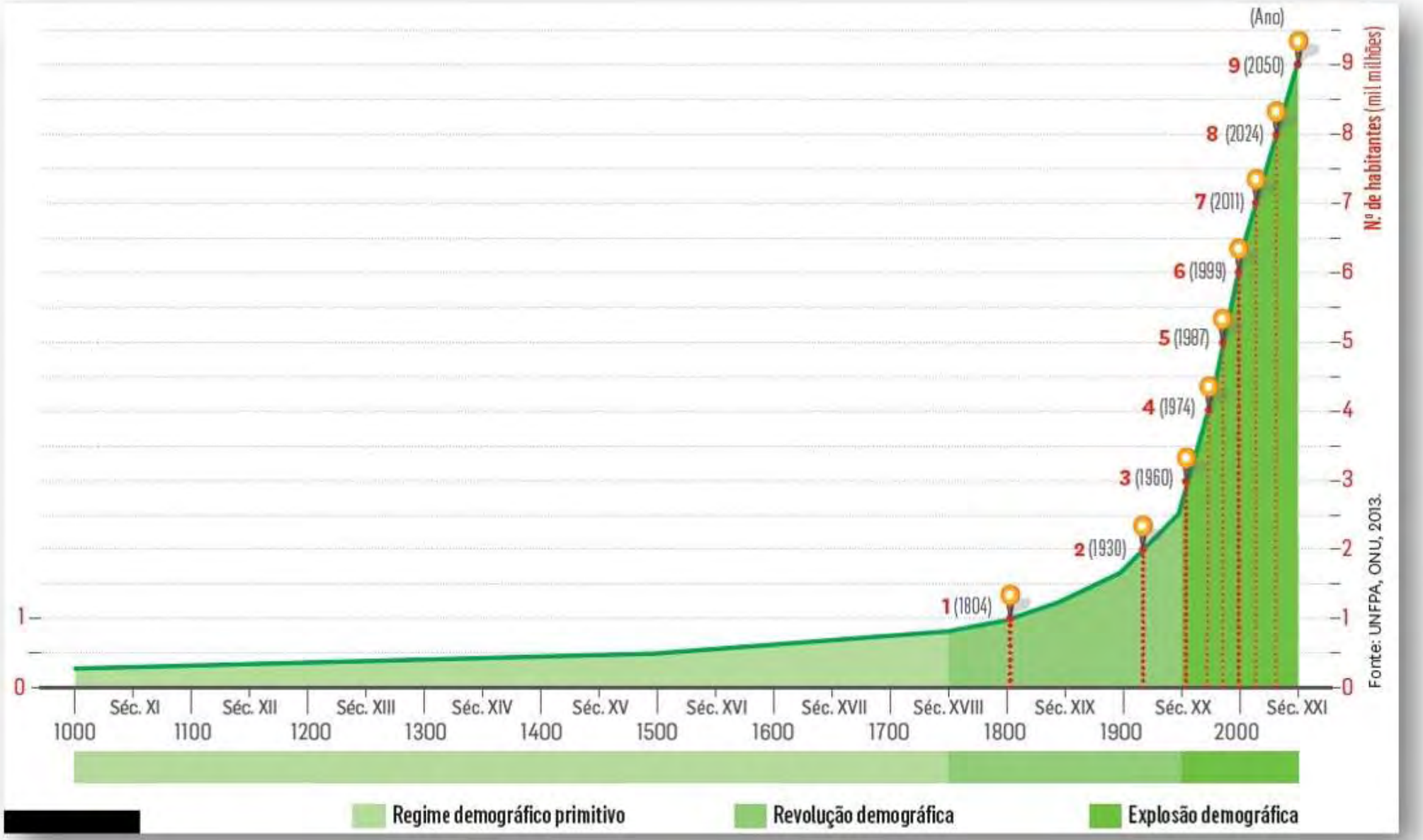
Em 1970s, **66%** do mundo era selvagem.

Em 1990, a natureza selvagem caiu para **59%**.

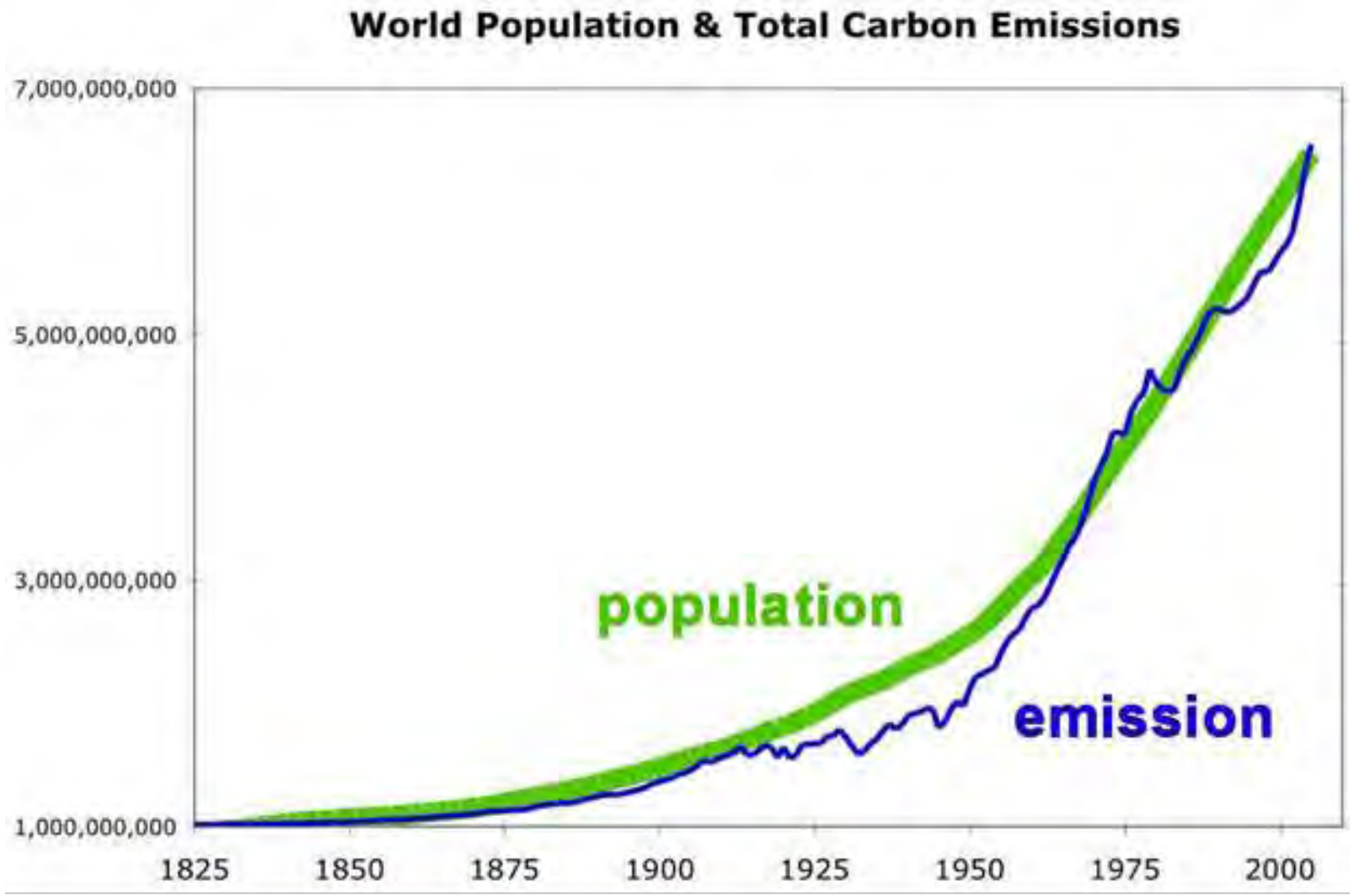
Atualmente, a natureza selvagem ocupa apenas **33%** do planeta

- ✓ Mas também houve boas notícias. No início da pandemia em **Veneza**, aos sujos canais **regressaram águas límpidas** e até os peixes, e a poluição do ar diminuiu abruptamente.
- ✓ Em Portugal e Espanha a **poluição do ar** e as emissões de gases com efeito de estufa **caíram a pique**, com potencial para **salvar milhares de vidas**

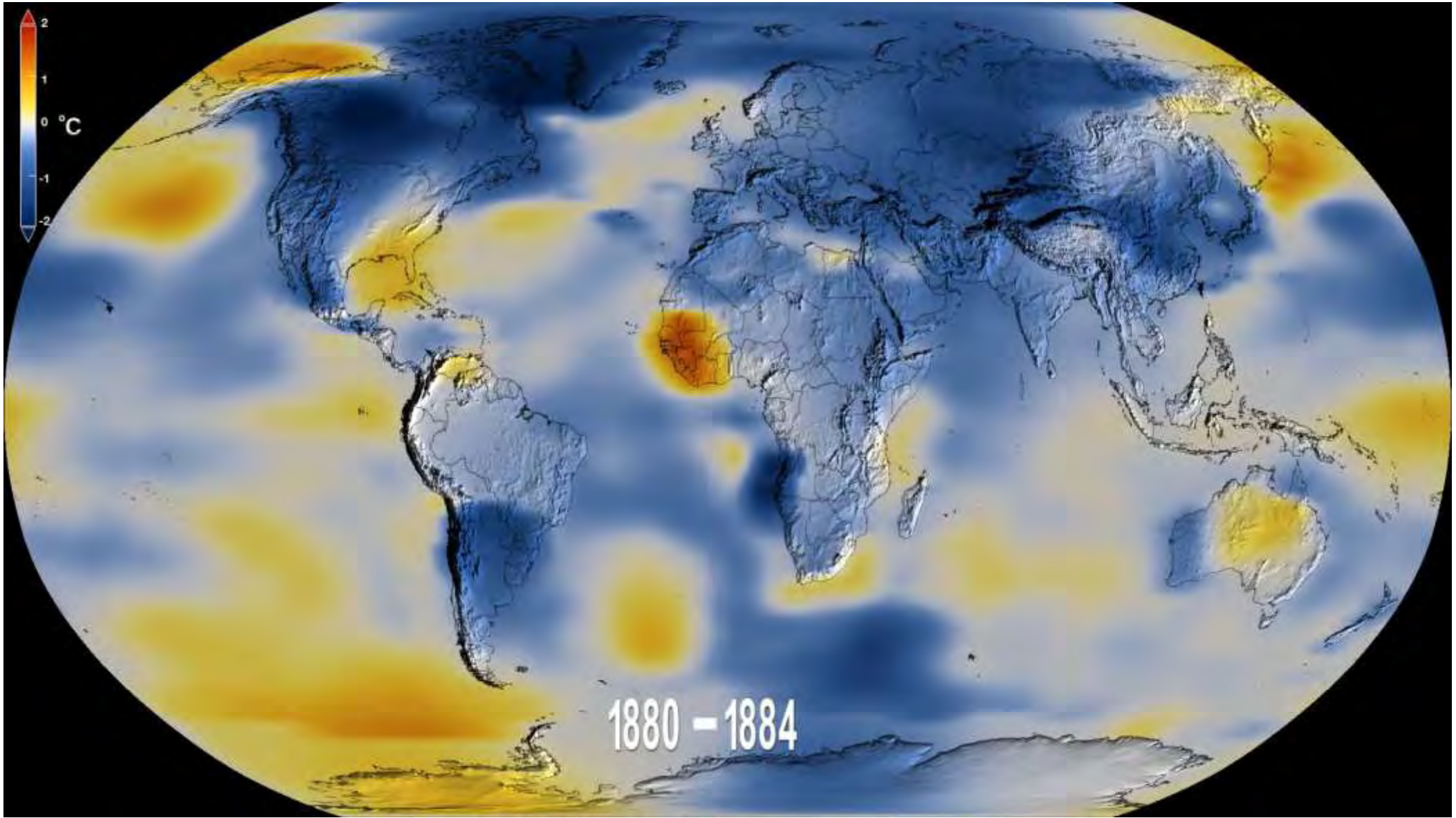
Grandes desafios e tendências



Grandes desafios e tendências

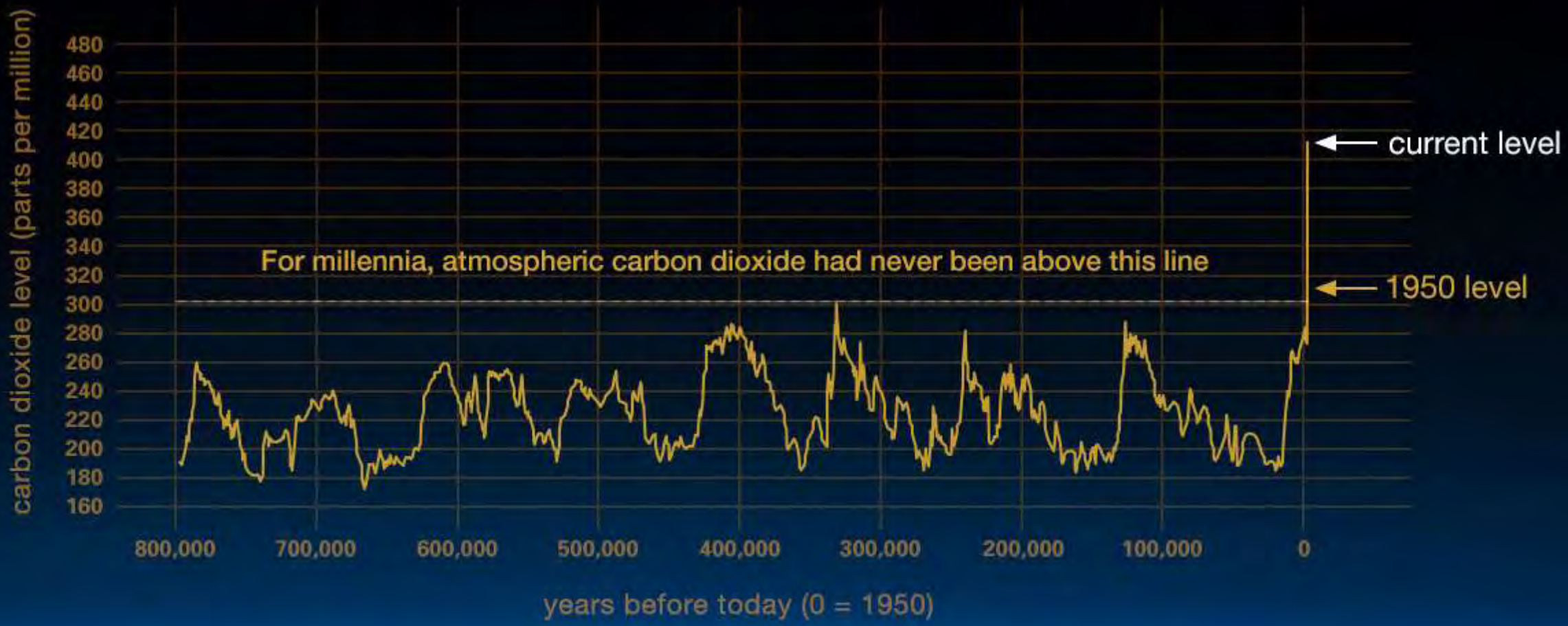


Grandes desafios e tendências



Climate.nasa.gov

Grandes desafios e tendências



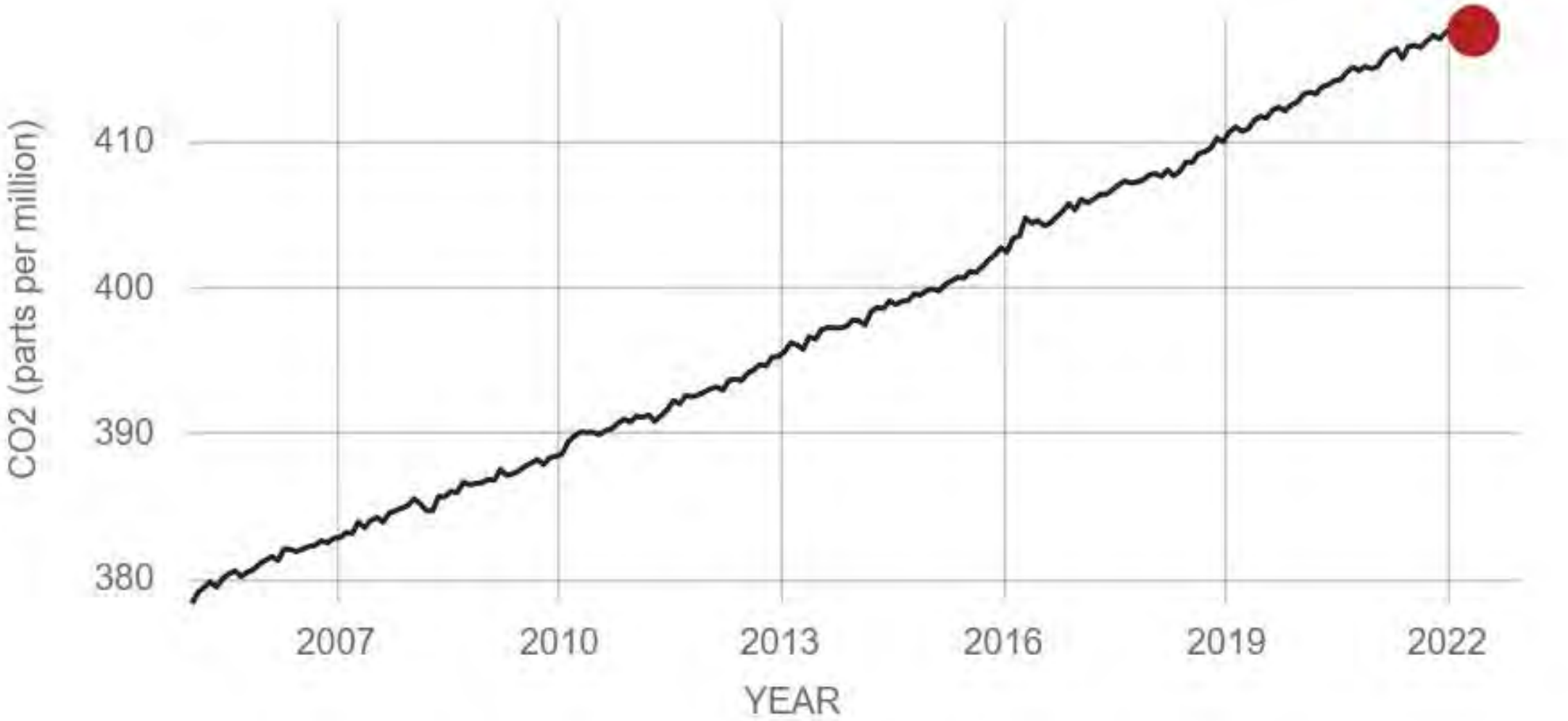
DIRECT MEASUREMENTS: 2005-PRESENT

Carbon Dioxide

Data source: Monthly measurements (average seasonal cycle removed). Credit: NOAA

LATEST MEASUREMENT: May 2022

418 ppm



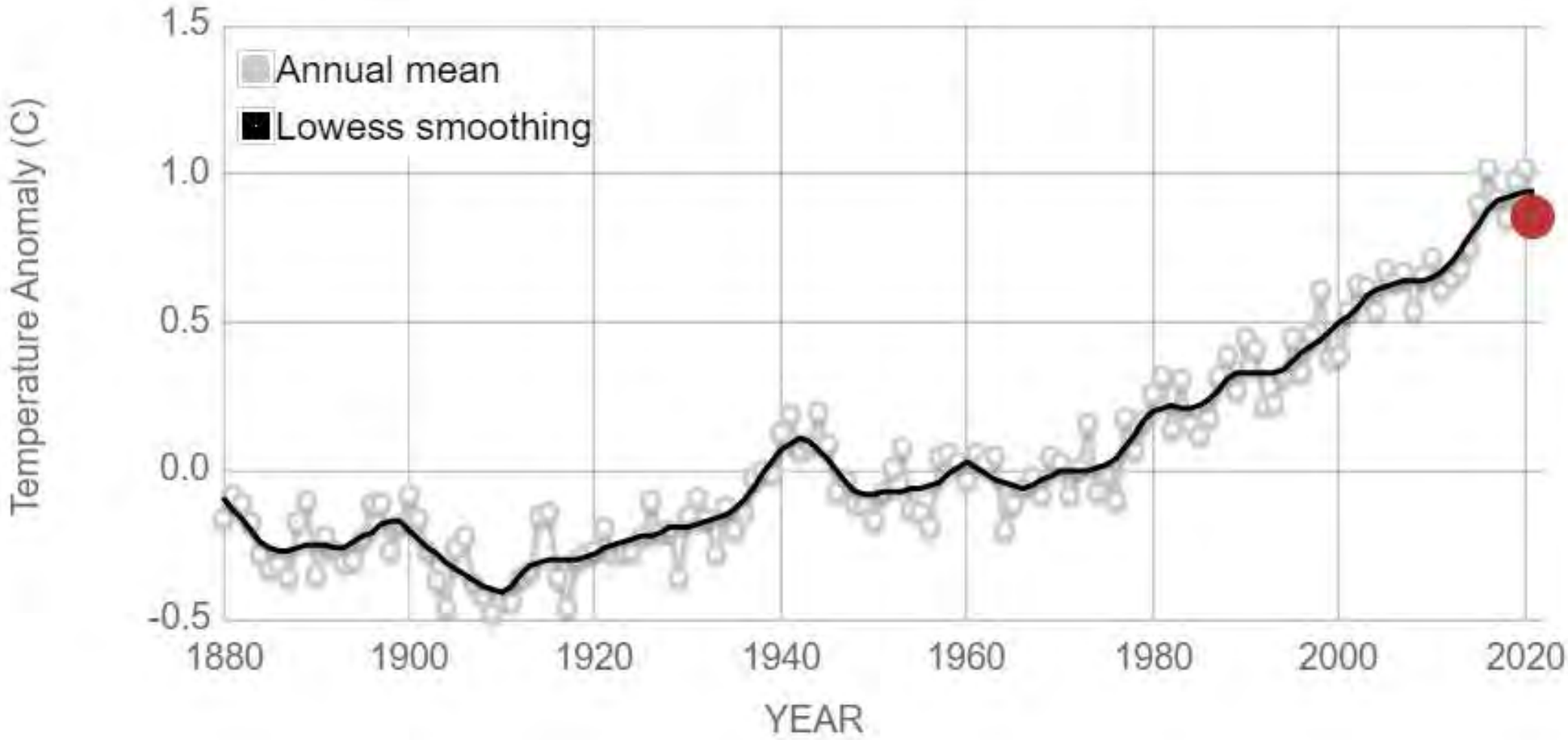
Global Temperature

GLOBAL LAND-OCEAN TEMPERATURE INDEX

Data source: NASA's Goddard Institute for Space Studies (GISS).
Credit: NASA/GISS

LATEST ANNUAL AVERAGE ANOMALY: 2021

0.85 °C | 1.53 °F



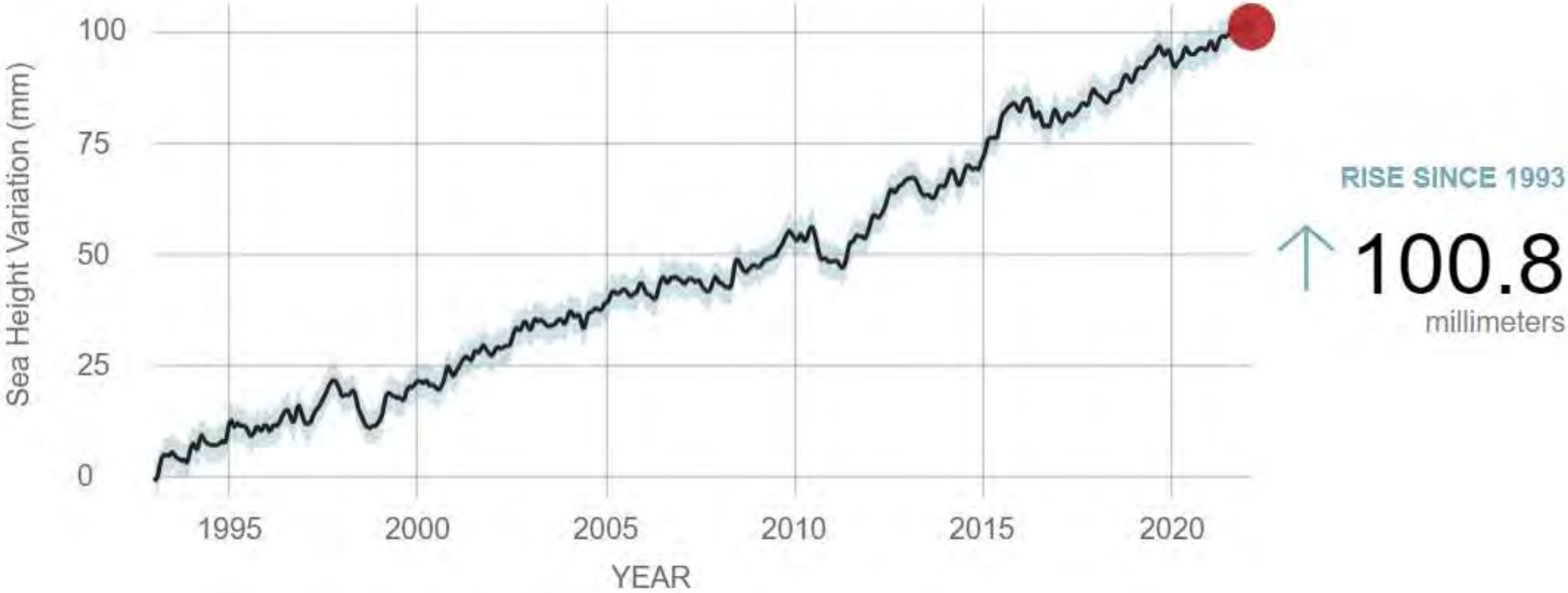
Sea Level

SATELLITE DATA: 1993-PRESENT

Data source: Satellite sea level observations.
Credit: NASA's Goddard Space Flight Center

LATEST MEASUREMENT: February 2022

101 (± 4.0) mm



RISE SINCE 1993

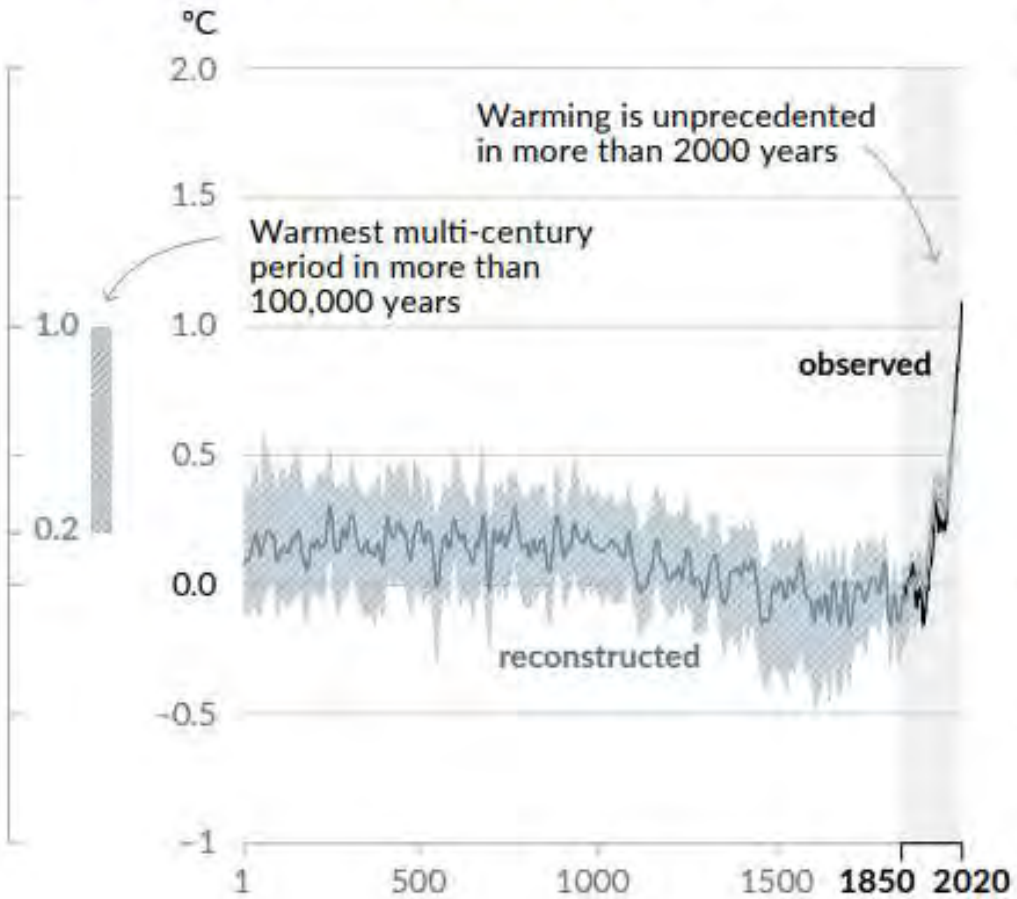
100.8
millimeters


Don’t try to blame
~~otters~~ others!

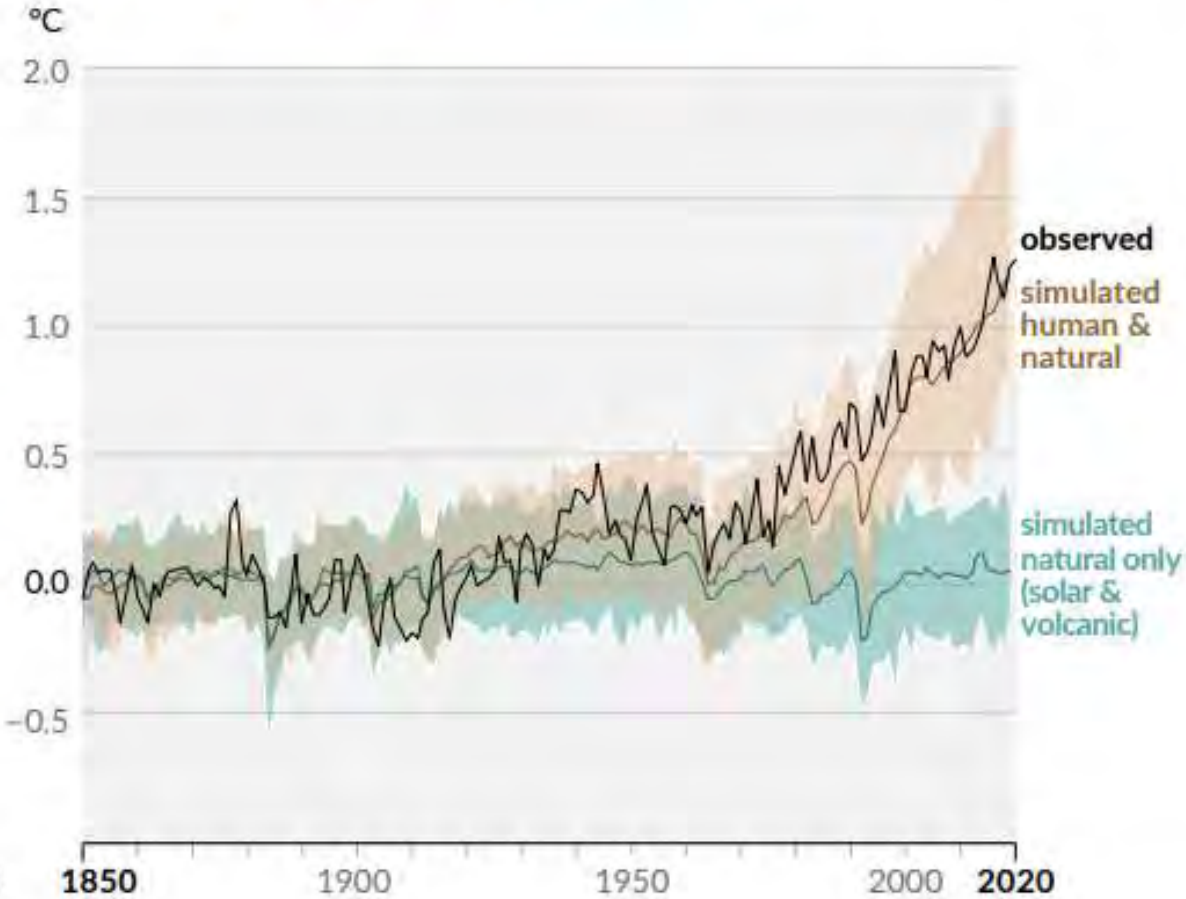
Human influence has warmed the climate at a rate that is unprecedented in at least the last 2000 years

Changes in global surface temperature relative to 1850–1900

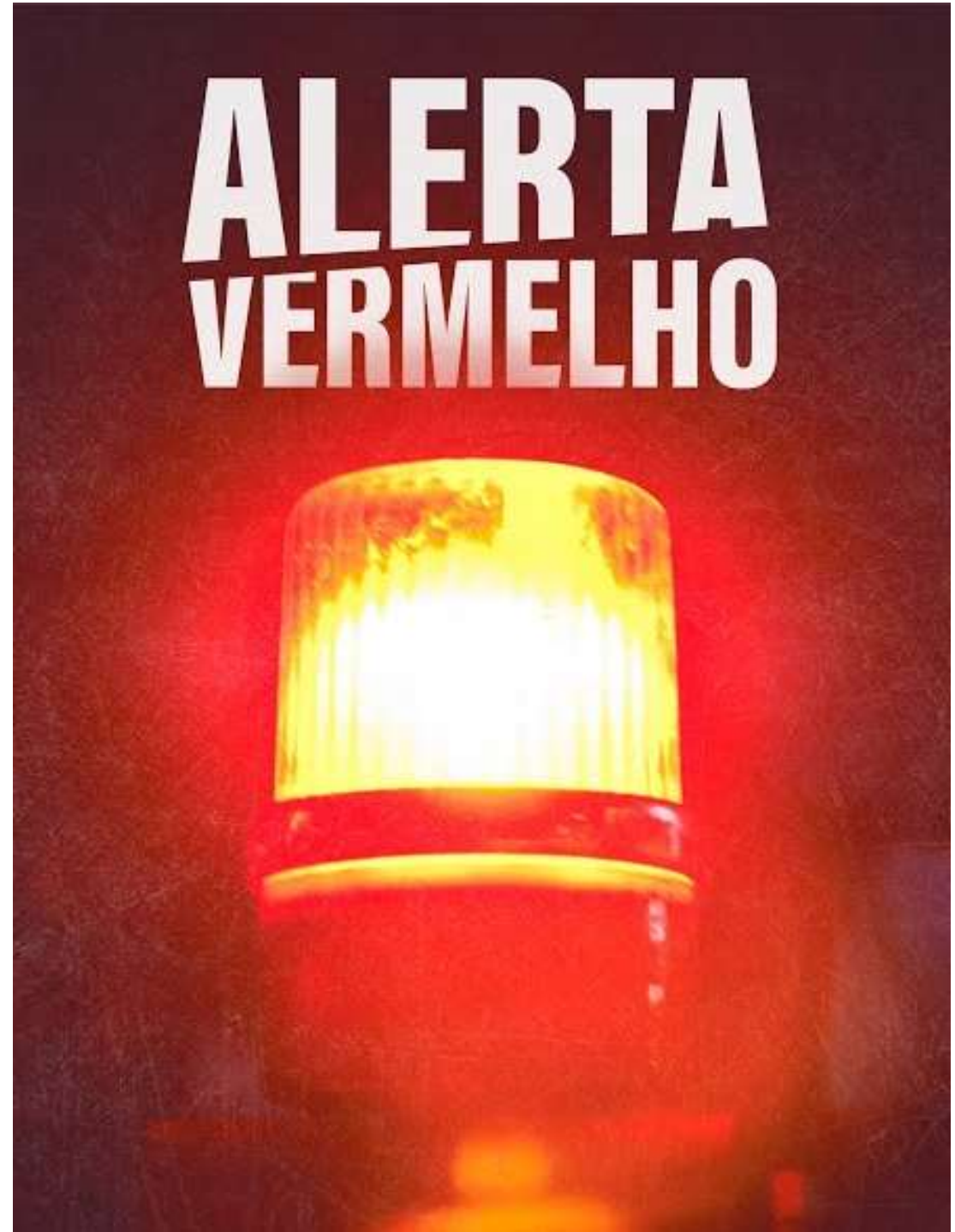
(a) Change in global surface temperature (decadal average) as reconstructed (1–2000) and **observed** (1850–2020)



(b) Change in global surface temperature (annual average) as **observed** and simulated using human & natural and only natural factors (both 1850–2020)



IPCC, AR6


ALERTA
VERMELHO


LUFKIN
AMPSCOT
LUFKIN

Heat wave in France, the capital Paris recorded 33 °C, instead of the usual 21°C for a month of June

A group of tourists protect themselves from the sun with umbrellas; temperatures above 43 °C were recorded

Madrid, Espanha
4 de agosto, 2018

A female orangutan covers her head with a cloth on a hot summer day at the Madrid zoo

In Portugal, of the 96 IPMA stations, 16 exceeded the maximum temperature of 45 °C. The city of Lisbon recorded a new maximum of 44°C

Police flag melted tar areas due to high temperature

Floods in Central and Eastern China killed more than 500 people and caused $33 billion in damage in summer 2016

A third of Bangladesh's territory was flooded in August 2017. Southeast Asia suffered devastating monsoons in which more than 1400 died in India, Bangladesh and Nepal.

The Mekong River Delta in Vietnam suffered the worst drought in 90 years

Hurricane Irma passes through Cuba. In addition to devastating winds that reached 300 km/h, the storm also caused heavy rains and flooding.

Consequences of Hurricane Irma. 95% of the island was destroyed.

On October 15th, 443 forest fires were registered in the national territory. They caused 45 deaths and about 70 wounded.

Praia de Pedrogão, Portugal

14 de outubro, 2018

Scene after the passage of Hurricane Leslie, tiles that flew off, broken windows, damaged cars, streets covered in sand and debris...


Austrália, 2022
Third episode of flooding since March this year in the region

Coisas que derretem

Coisas que nos preocupam que derretam

O modelo atual – Modelo Linear

Modelo Linear

Assenta no pressuposto de que existe uma disponibilidade ilimitada de matérias primas que estão na base de muitos dos produtos e serviços atuais.

Não se preocupa com:

- Minimização dos impactes ambientais ao longo do ciclo de vida do produto e durante a sua utilização;

- Minimização dos resíduos resultantes da produção e do consumo desses bens.


REA
PORTAL DO ESTADO DO AMBIENTE
PORTUGAL

Produção e capitação de resíduos urbanos em Portugal continental

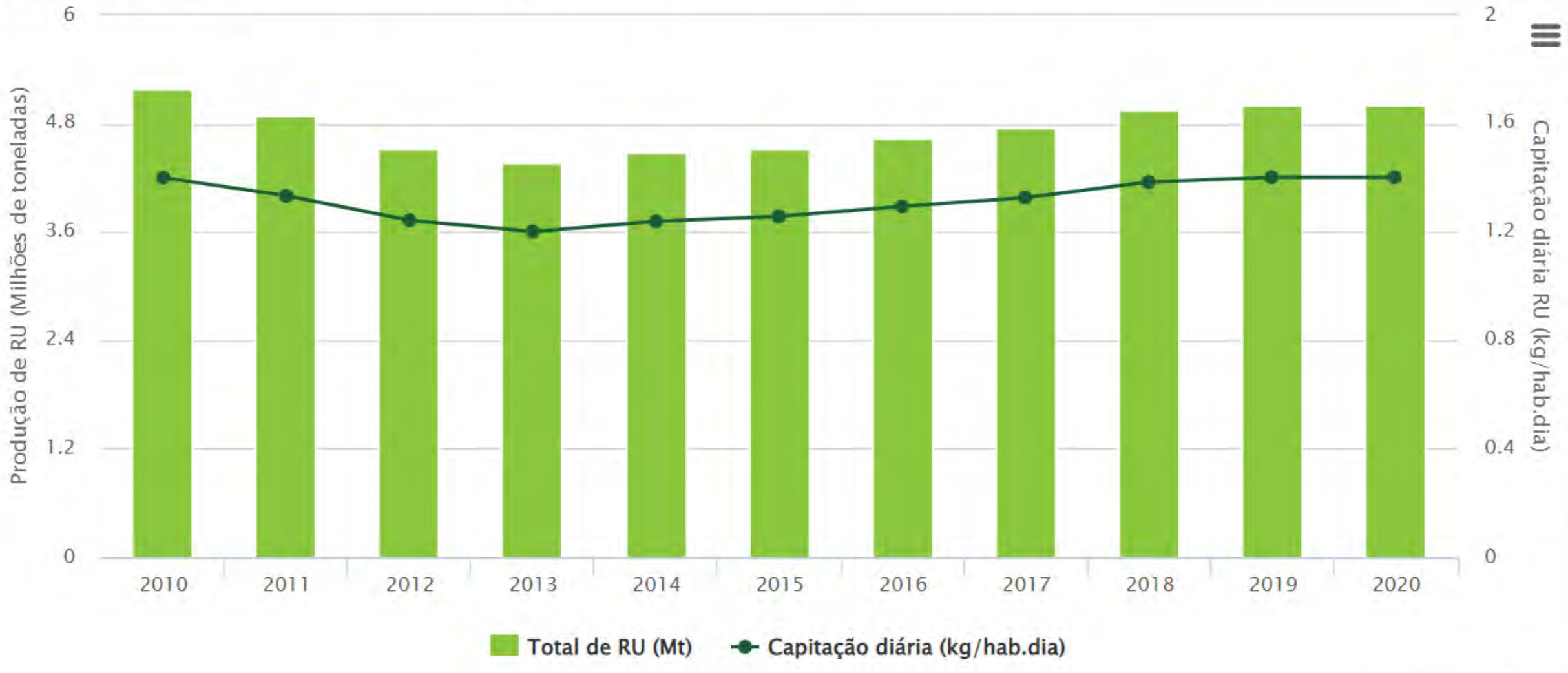


GRÁFICO INTERATIVO

Fonte: APA, 2021

Recolha de RU em Portugal continental

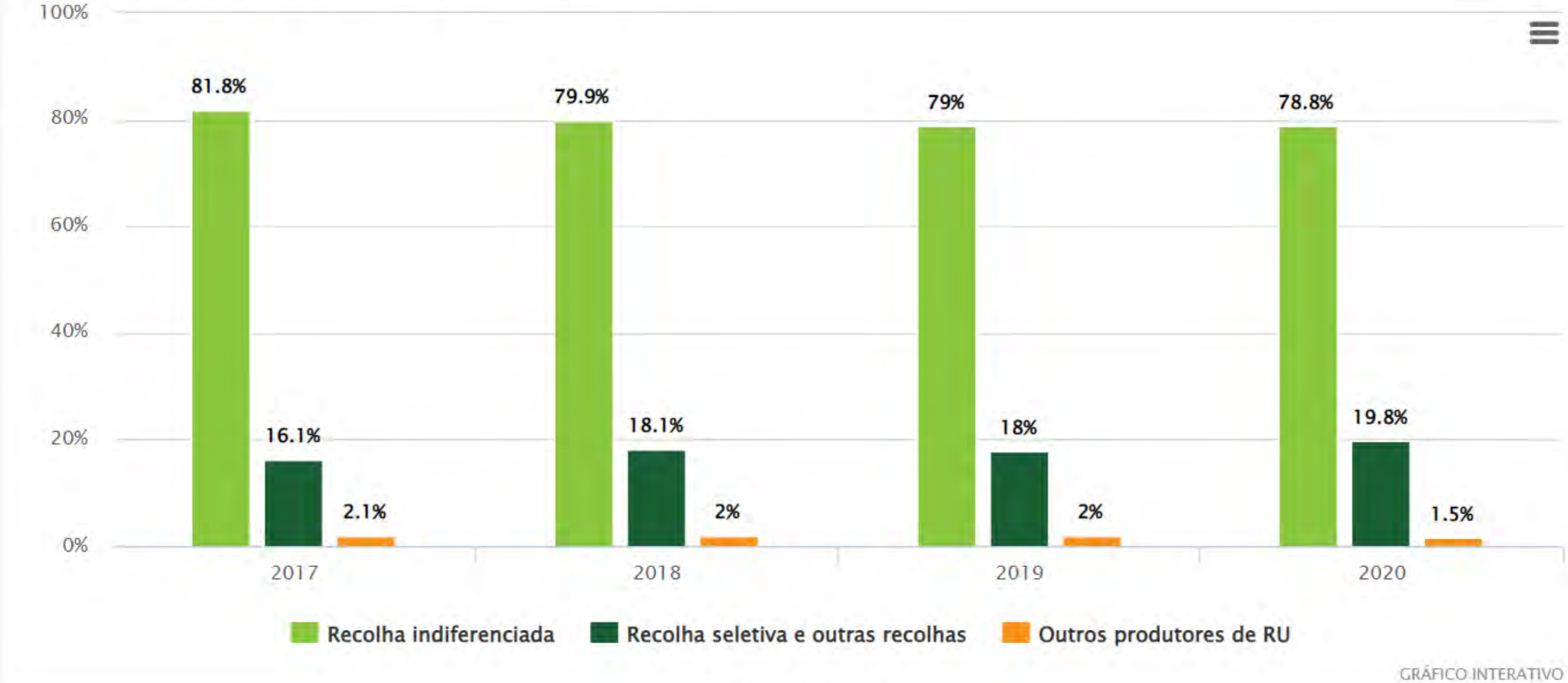


GRÁFICO INTERATIVO

Fonte: APA, 2021

RUB depositado em aterro

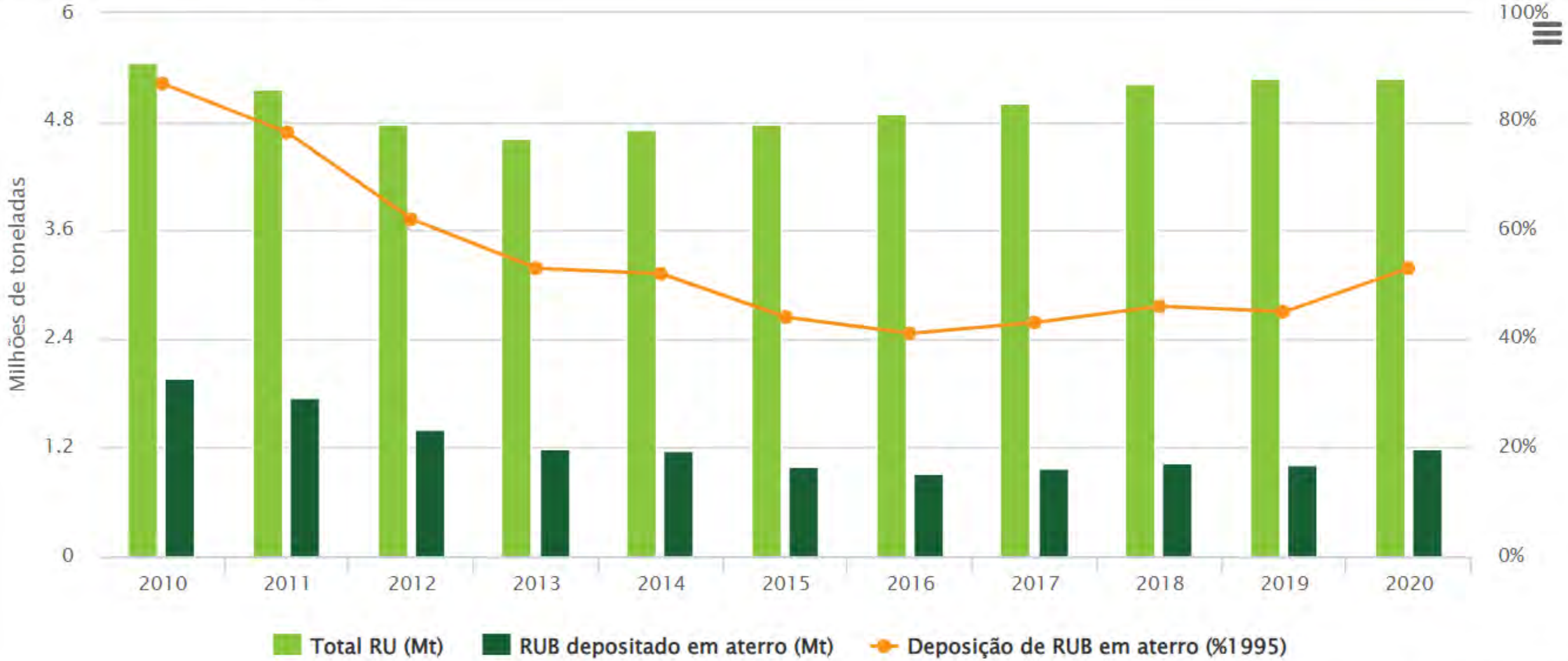


GRÁFICO INTERATIVO

Fonte: APA, 2021

RU por operação de gestão em Portugal continental, em 2020

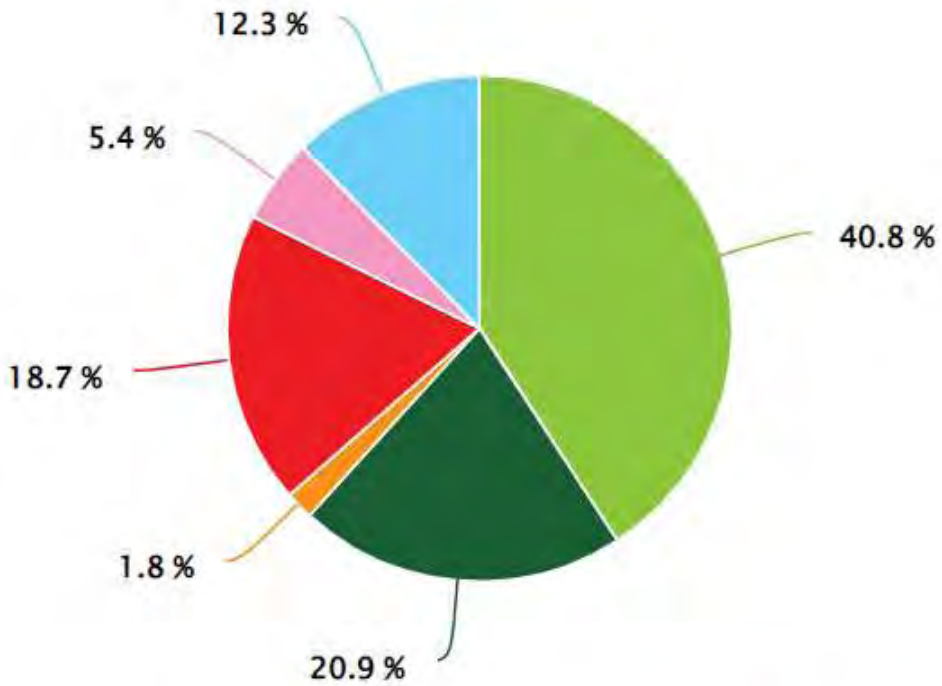


GRÁFICO INTERATIVO

Fonte: APA, 2021

E então? Isto não resulta? Porquê agora?

- Escassez de recursos naturais
- Preços elevados das matérias primas
- Maior volatilidade dos preços dos materiais
- Aumento estimado da população mundial

Antoine Laurent Lavoisier

Lei da Conservação da Massa

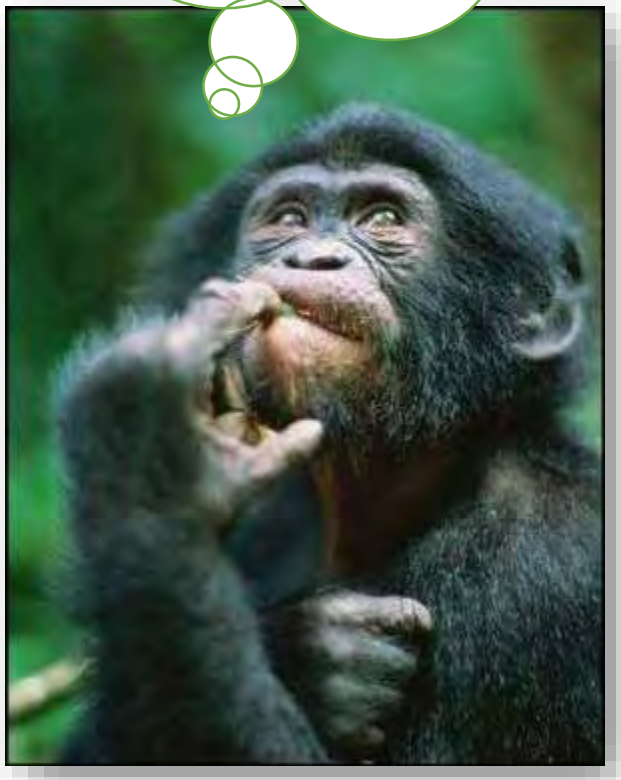
Em qualquer sistema, físico ou químico, nunca se cria nem se elimina matéria, apenas é possível transformá-la de uma forma em outra.

Portanto, não se pode criar algo do nada nem transformar algo em nada

Na natureza, nada se cria, nada se perde, tudo se transforma.

MODELO DA ECONOMIA CIRCULAR

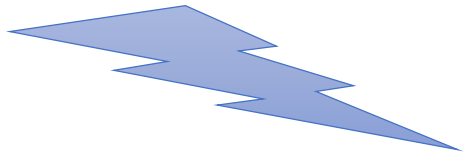
O que é que vamos fazer?



ECONOMIA CIRCULAR

Economia Circular?

Abordagem à produção e ao consumo que permite desenvolver inovação, novos produtos, serviços e novos modelos de negócio,



que contribuem para um relacionamento mais equilibrado, e criativo, entre

- ✓as empresas,
- ✓consumidores
- ✓recursos naturais

Principais desa

- Aprovação de
  legais

Entidades do setor técnico e científico na realização dos estudos e ensaios que apoiarão autoridades licenciadoras e as empresas na progressiva substituição de matérias-primas virgens por materiais obtidos a partir dos resíduos.

ação de
obtidos a partir de
resíduos.

Oportunidades na EC

Medidas como a **melhoria da conceção ecológica e a prevenção e reutilização de resíduos**

- poupanças líquidas para as empresas da UE de até **604 mil milhões de euros**
- 170.000 empregos diretos no setor da gestão de resíduos
- reduzindo ao mesmo tempo o valor total anual de emissões de gases com efeito de estufa em 2-4 %.

Oportunidades na EC

Em termos gerais, a implementação de medidas adicionais para aumentar a produtividade dos recursos em **30 % até 2030** poderá aumentar o PIB em cerca de 1 %, criando simultaneamente mais de 2 milhões de postos de trabalho

…..em comparação com um cenário de manutenção da situação atual

2030 → Aumento da produti
recursos em mais de 30%
(meta da EU. Plataforma Europeia pa

- **Promoção da Ecoeficiênci**
na ut

Os ganhos de produtividade associados à melhoria da produtividade dos recursos são significativos.

...das no
...ento de
...odutividade dos recursos em cada setor de atividade

...moção de

Potencial na redução do consumo de MP

O que se pode traduzir em

Aumento considerável do valor disponível nas empresas para o investimento

- criação de emprego
- expansão da produção
- melhorias de remuneração dos RH
- capitalização das empresas

O uso eficiente dos recursos tem uma dimensão económica e social bastante prática não se restringindo a uma perspetiva ambiental sobre a economia.

Pa ra a indústr ci nvesti ento ou despesa
se orno

A aposta na suste
como u

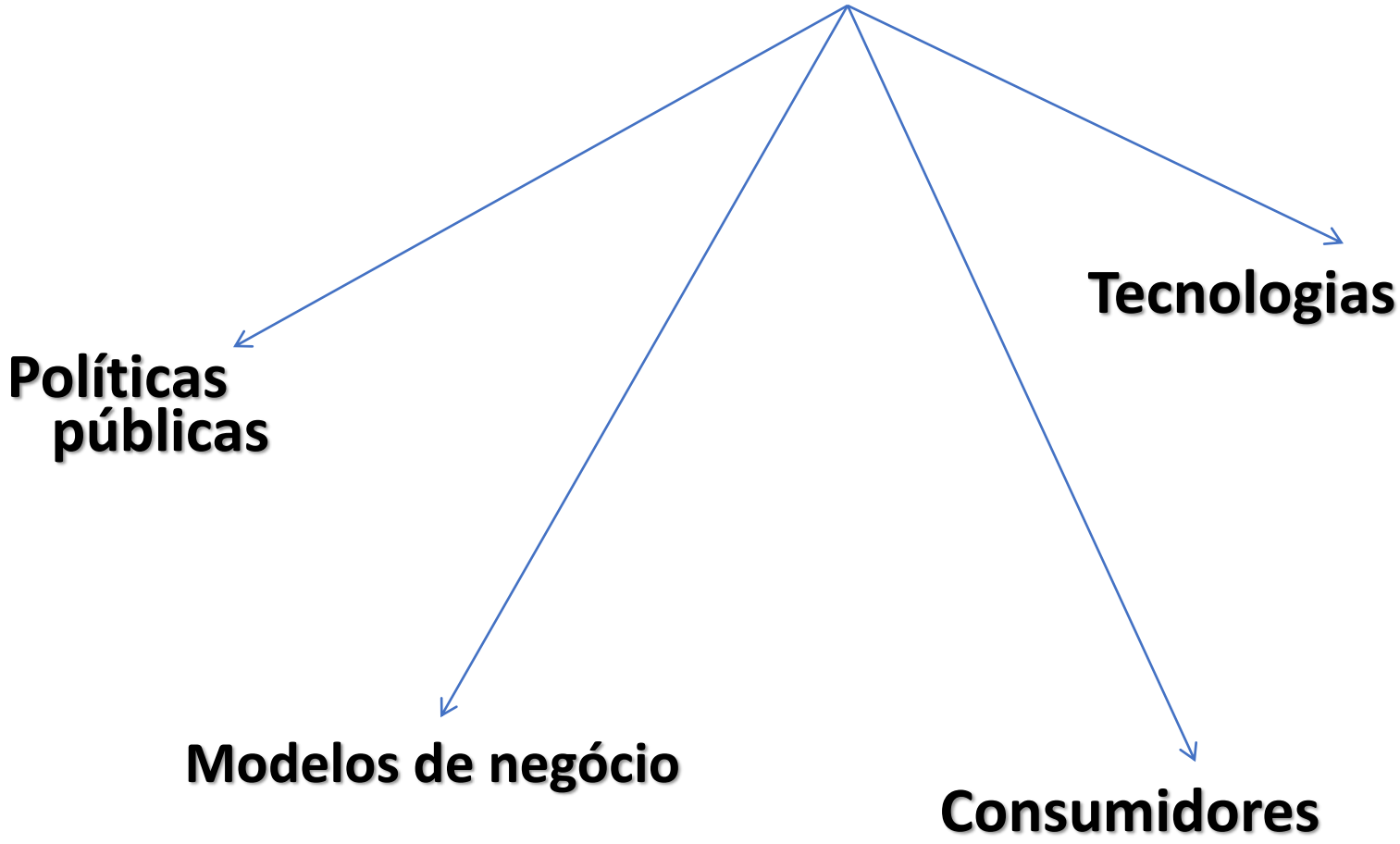
Não perde direção

Ciência e conhecimento como chave para a sustentabilidade ambiental, social e económica de Portugal.

Oportuni o e tecnológico nacional

Desenvolver p ado em termos dos seus impactes ambientais, cont par ue a nossa indústria obtenha vantagens que assegurem a sua pet vidade a nível internacional

A Economia Circular é uma mudança transformacional



REUTILIZAR O QUE FOR POSSÍVEL

SER EFICIENTE NA CADEIA DE VALOR

COMUNICAR DE FORMA INOVADORA

DESENHAR DE FORMA ECOLÓGICA

RECICLAR O QUE NÃO PODE SER REUTILIZADO

REPARAR O QUE ESTÁ AVARIADO

REMANUFACTURAR O QUE NÃO PODE SER REPARADO

É preciso ser inovador…

na produção de alimentos

É preciso ser inovador…

Aproximar a produção do consumo: agricultura urbana

- Segurança alimentar.
- Alimentação saudável.
- Redução de transporte e pegada de carbono.

É preciso ser inovador…

Transformar produtos em serviços

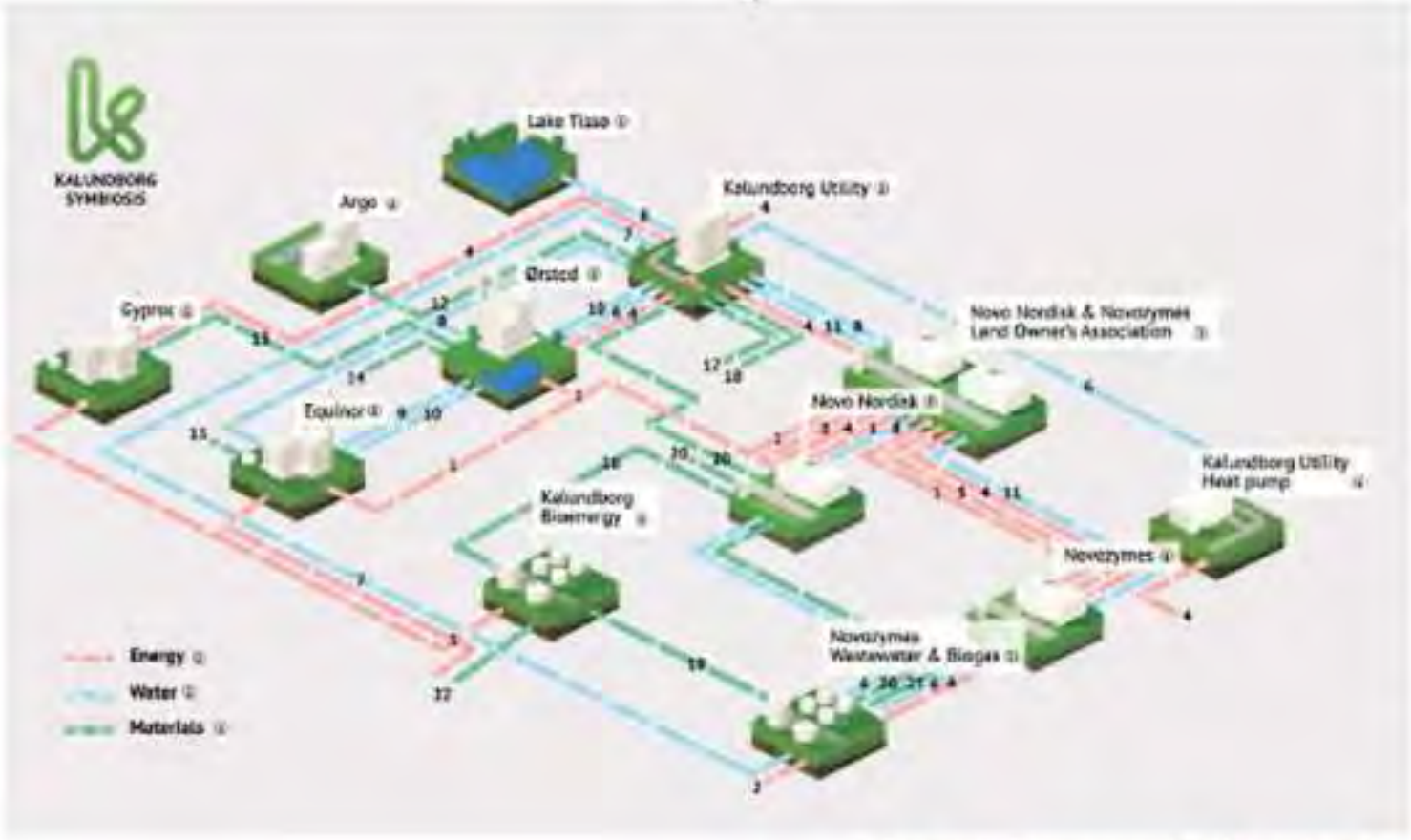
- Baixo custo de investimento.
- Partilha de custos de manutenção.
- Maior taxa de utilização.

É preciso ser inovador…

novos materiais, novas aplicações

É preciso ser inovador…

simbiose industrial



Exemplo Dinamarquês (Kalundborg)

Indústrias presentes:

- Produção de gás natural através de biogás
- Produção de energia, calor (district heating) e vapor
- Materiais de construção (gesso cartonado)
- Produtos para a Saúde (50% da produção mundial de insulina)

É preciso ser inovador…

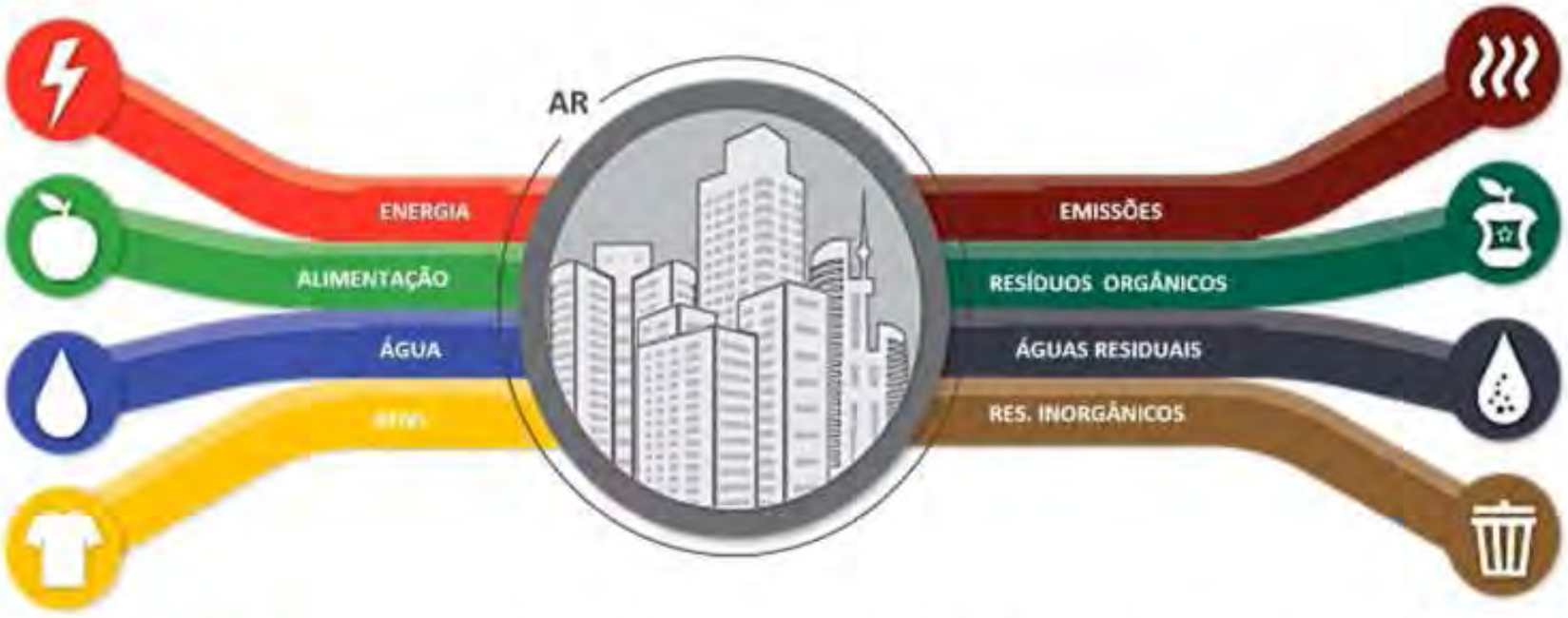
Superuse Studies – Villa Welpeloo (Roterdão) – **construir edifícios reutilizando materiais locais**

- Uma casa que alia o design à utilização de materiais reutilizados. O processo de conceção e construção de Villa Welpeloo ocorreu ao contrário do habitual.
- Numa ótica "circular" de aproveitamento e reutilização de desperdícios, começou-se por procurar e recolher materiais de fábricas e armazéns locais, para depois projetar a estrutura da casa que melhor empregaria e potenciaria a reutilização desses recursos.

Cidade e economia circular: sequestro de emissões?

- As **cidades** são a principal fonte de **poluentes atmosféricos**, dando origem à **poluição atmosférica** e às **alterações climáticas**, mas também estão ligados a vários outros processos importantes.
- Mas as **cidades** têm também uma capacidade única para **enfrentar** os **desafios** das **alterações climáticas**, tendo sido aplicadas medidas locais para lidar com **vulnerabilidades**, resultando essas soluções como **medidas de adaptação**.
- Um exemplo com sucesso são as **soluções baseadas na natureza**, também chamadas de **medidas verdes**, que fornecem **alternativas sustentáveis**, **económicas**, **flexíveis** e **multifuncionais** para vários objetivos.

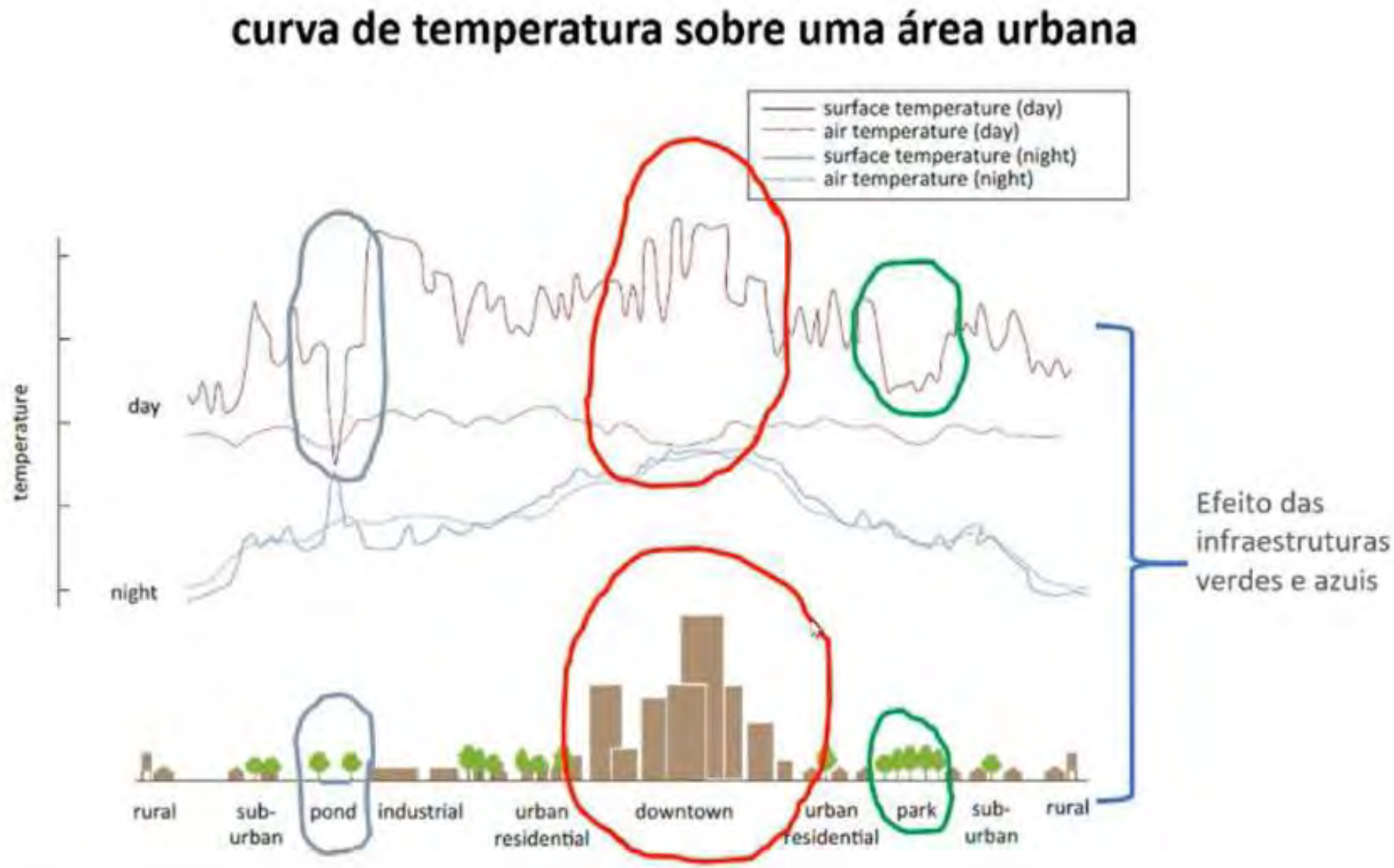
Cidade insustentável | metabolismo urbano



o modelo económico **'crescer agora, limpar mais tarde'** que domina o nosso mundo e que não contabiliza as alterações climáticas, a poluição ou a degradação do capital natural, é **insustentável**.

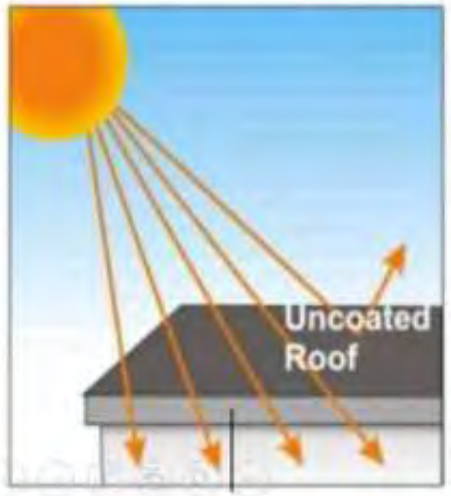
O que precisamos?

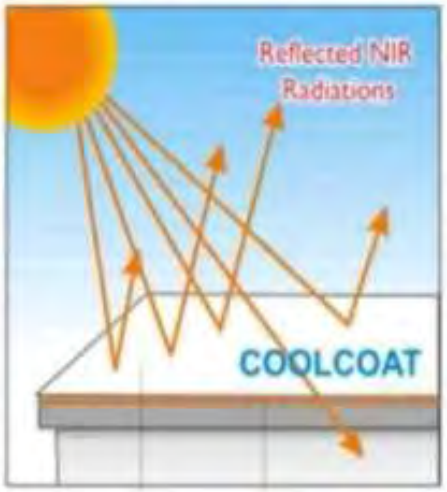
Aquecimento da cidade | ilha de calor urbana



Resiliência urbana | áreas azuis, verdes e brancas

soluções baseadas na natureza





Resiliência urbana | paredes e telhados verdes

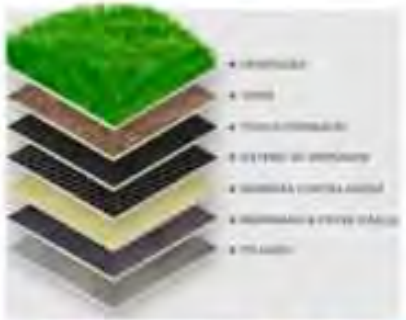
BENEFÍCIOS

- Isolamento térmico e sonoro
- Mitigação do efeito de ilha de calor
- Produção de alimentos
- Qualidade atmosférica (absorção de CO_2 e outros poluentes)
- Resistência ao fogo
- Valorização do imóvel (estética e lazer)
- Gestão de águas pluviais e redução do risco de inundações (retenção e atraso do escoamento)
- Eficiência de painéis fotovoltaicos
- Redução da poluição sonora
- Preservação da biodiversidade e habitats
- Aumento da vida útil do suporte (edifício, telhado,...)
- Criação de emprego e aumento da produtividade
- Melhoria da saúde e qualidade de vida

CUSTOS

- Instalação
- Substituição
- Manutenção
- Demolição

BS EN 13707:2013

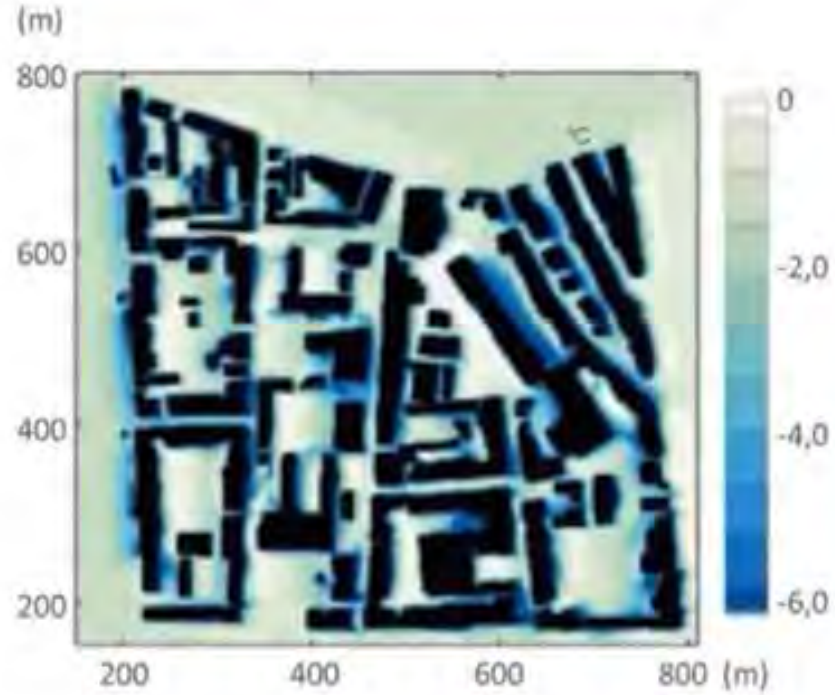


Soluções baseadas na natureza | temperatura

arrefecimento da cidade

O que se passa no **bairro da rua da Constituição** em 2050?

A aplicação de **telhados verdes** resulta em **reduções de temperatura** que variam entre **-1˚C** e **-2˚C** na maior parte do domínio, atingindo máximos de **-6˚C** (pontualmente junto aos edifícios).

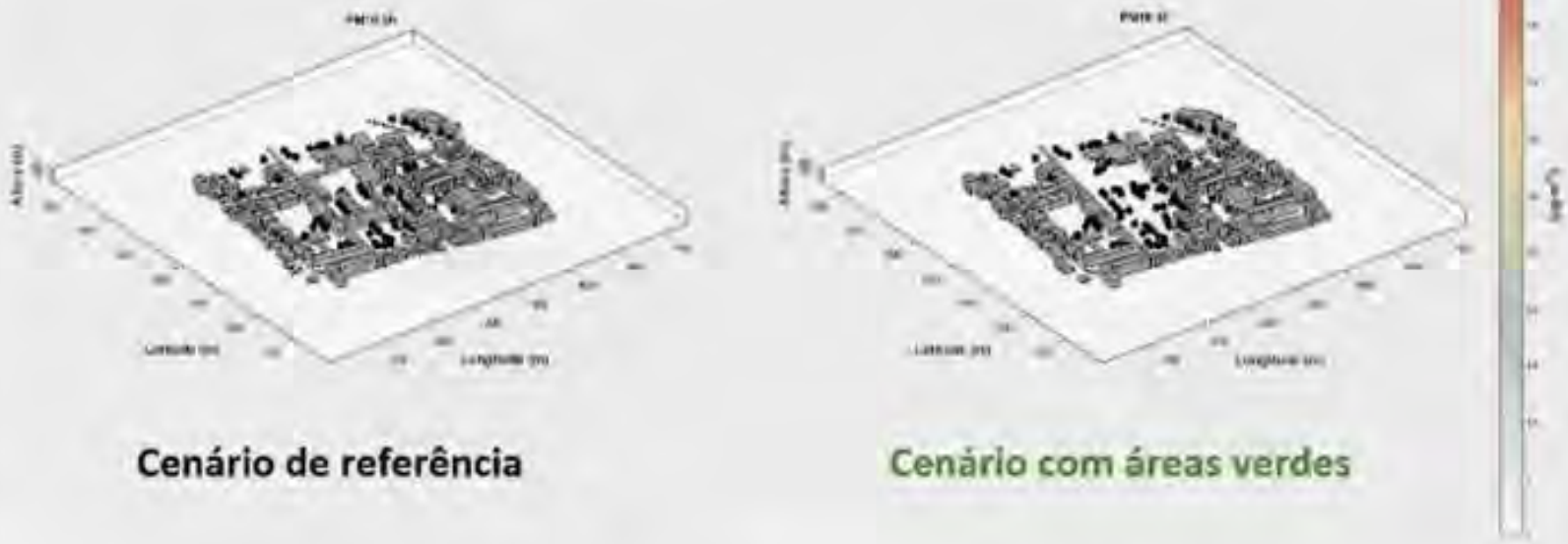


Cenário com telhados verdes - Cenário de referência

Soluções baseadas na natureza | qualidade do ar

qualidade do ar e conforto pedonal

O que se passa no **bairro da rua da Constituição** em 2050? concentrações **PM10** em 24h



Cenário de referência

Cenário com áreas verdes

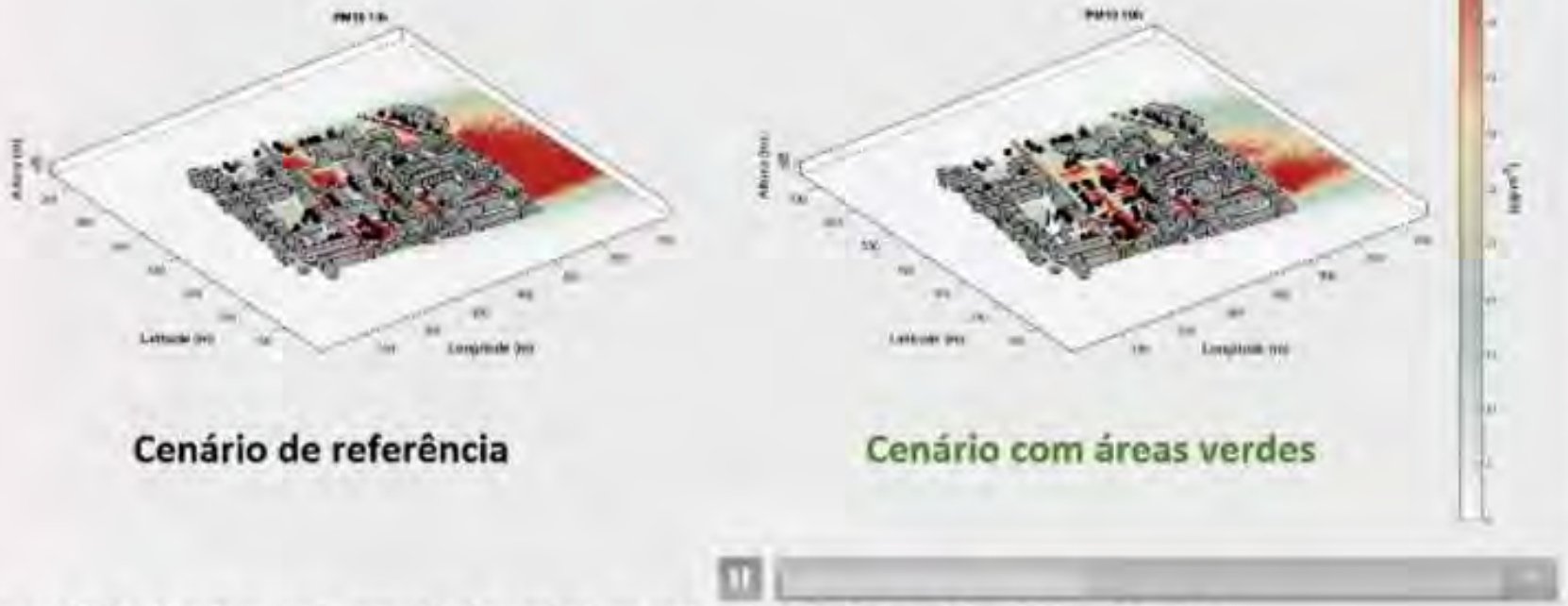
A **qualidade do ar à escala local** é particularmente dependente de:

- **morfologia urbana** e **condições climáticas locais** (direção e velocidade do vento)
- **presença de vegetação** (localização, geometria e **densidade de área foliar - LAD**)

Soluções baseadas na natureza | qualidade do ar

qualidade do ar e conforto pedonal

O que se passa no **bairro da rua da Constituição** em 2050? concentrações **PM10** em 24h



Cenário de referência

Cenário com áreas verdes

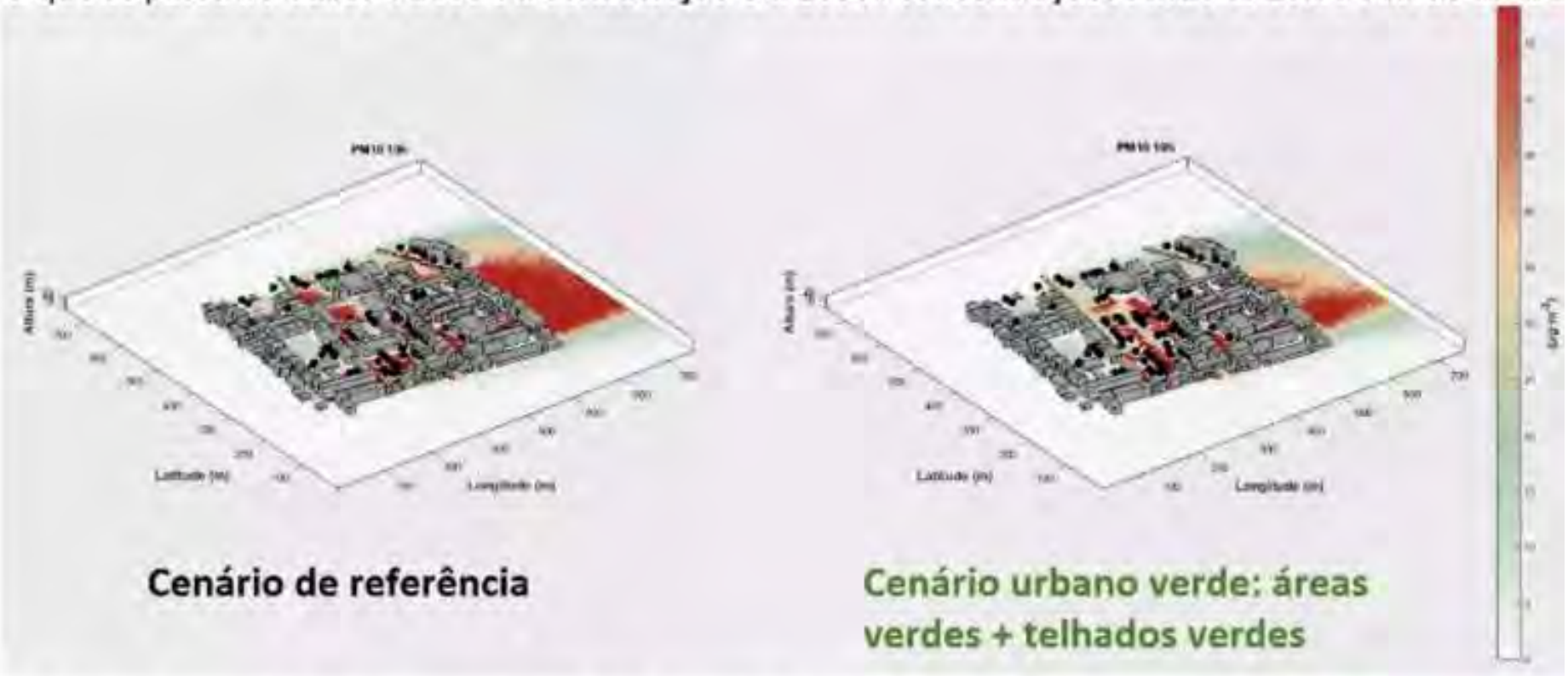
A **qualidade do ar à escala local** é particularmente dependente de:

- **morfologia urbana** e **condições climáticas locais** (direção e velocidade do vento)
- **presença de vegetação** (localização, geometria e **densidade de área foliar - LAD**)

Transição climática e soluções baseadas na natureza

qualidade do ar e conforto pedonal

O que se passa no **bairro da rua da Constituição** em 2050? concentrações **PM10** às **10h** a **3 m** de **altura**



Cenário de referência

Cenário urbano verde: áreas verdes + telhados verdes

- Redução em **20%** das **concentrações horárias de PM10** com a implementação de **áreas verdes**
- Aumento da **velocidade do vento** = Aumento da **dispersão dos poluentes atmosféricos**
- Formação de **novas áreas de recirculação,** contribuindo para a formação de ***hot-spots***

…e o novo paradigma societal

- ✓ No **pós-COVID-19** tem que se construir um novo **paradigma societal** com base em **menor uso de materiais e energia** e valorizando a **economia circular**, sem prejudicar a saúde pública.
- ✓ Não apenas devido à **pandemia**, mas para uma **vida segura**...

- ✓ Uma economia em que **"nada se perde, nada se cria, tudo se transforma"** (Antoine Lavoisier, 1789), com a **tecnologia e a sociedade** a desempenhar um papel central no nosso **bem-estar** e **prosperidade**.

A **pandemia COVID-19** e a **crise climática** são mensagens gritantes da **NATUREZA.**

Precisamos de Clima (d)e Progresso…

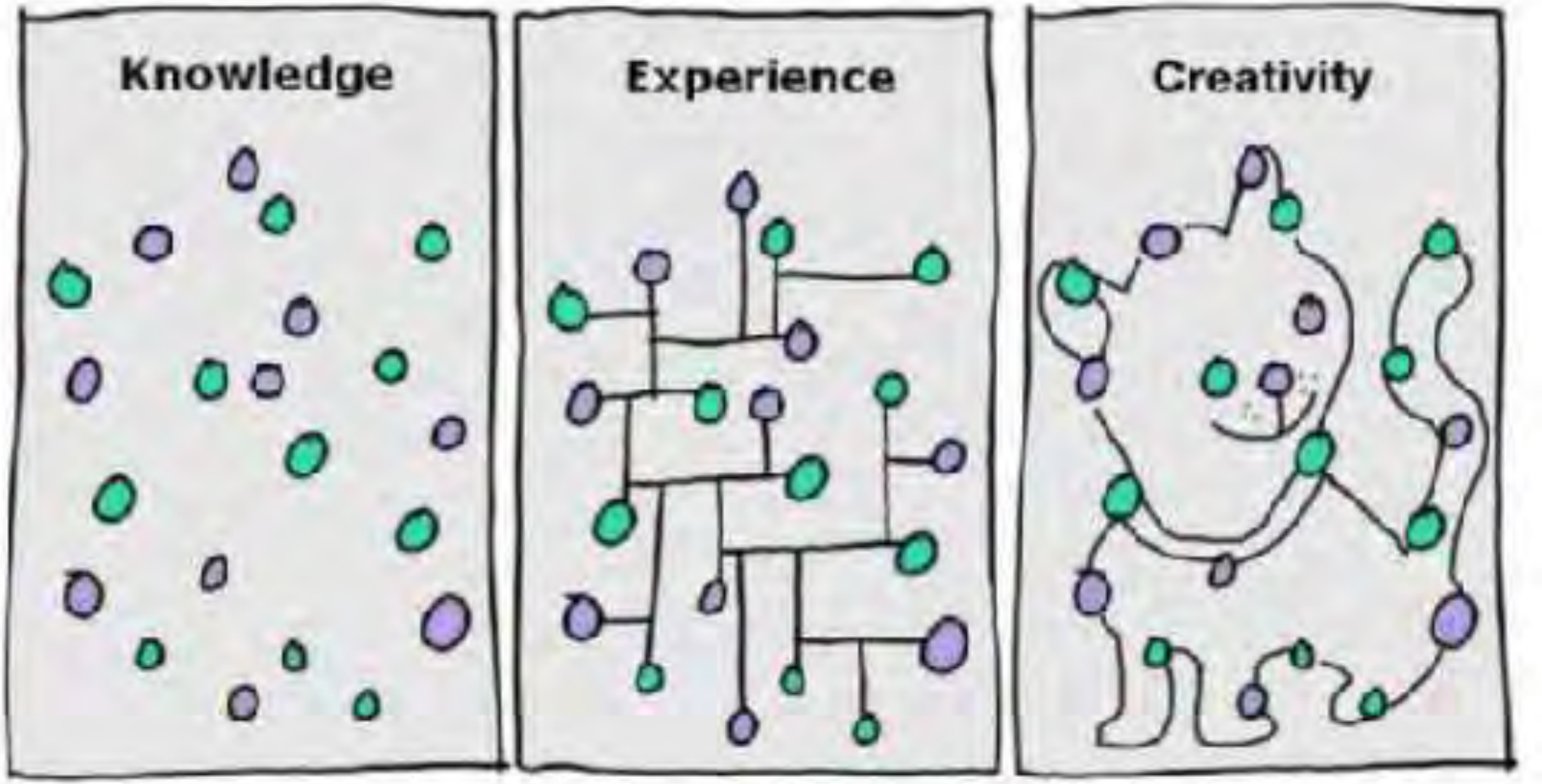

...Onde não podemos
confundir o Ser e o Parecer...

… Porque num mundo cheio de distrações…


... a grande aceleração...

…já está a acontecer!

É obrigatório unir os pontos!



Exemplos

A história da Economia Circular

- The idea of circular flow for materials and energy is not new, appearing as early as 1966 in the book by Kenneth E. Boulding, who explains that we should be in a "cyclical" system of production.

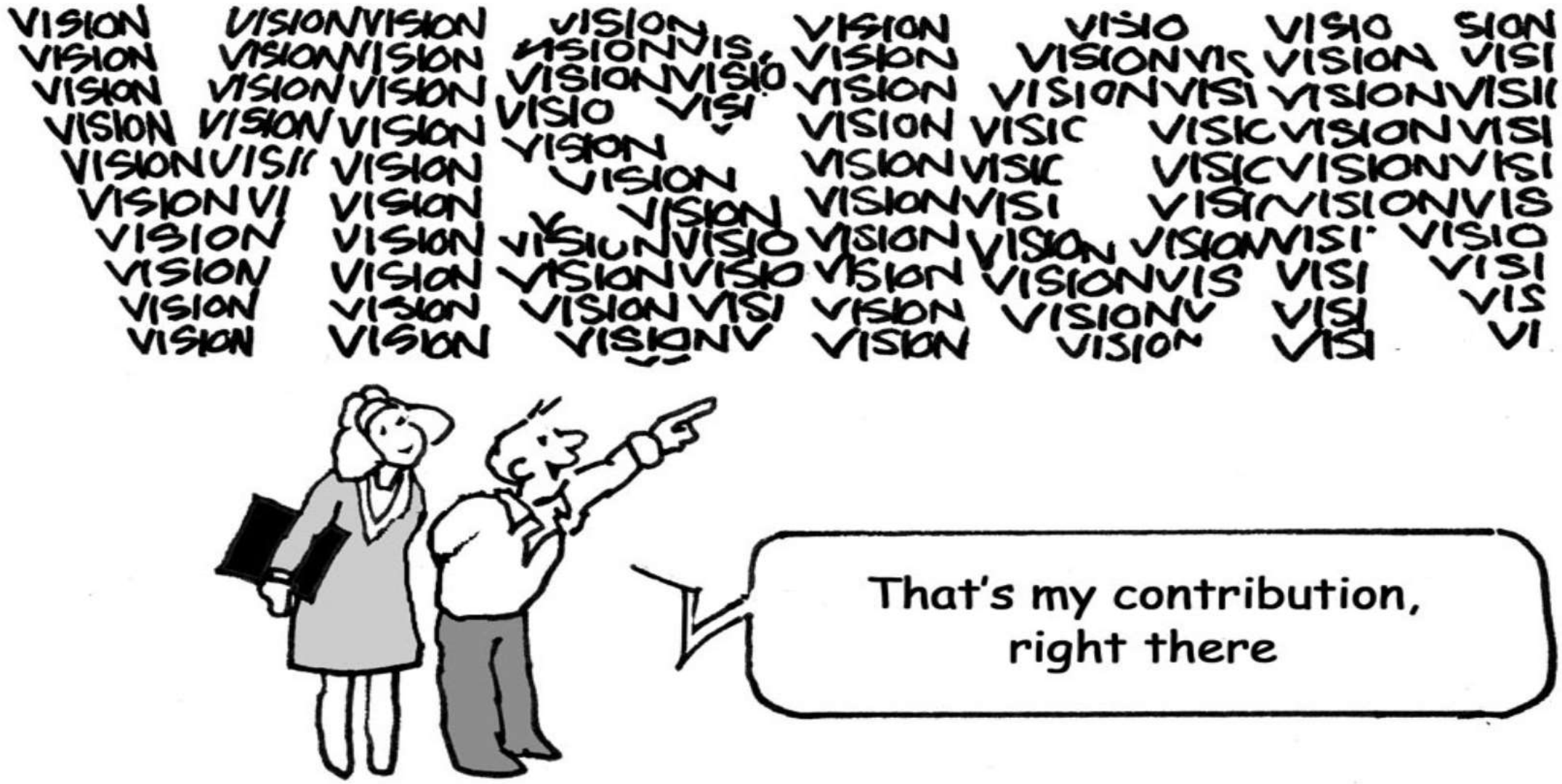
- The term "circular economy" appeared for the first time in 1988 in "*The Economics of Natural Resources*". (Kneese, Allen V. (1988). Population and Development Review. 14: 281–309.)

- The Ellen MacArthur Foundation was instrumental in the diffusion of the concept in Europe and the Americas. ("Let's build a circular economy") (https://ellenmacarthurfoundation.org/)

(Source: https://en.wikipedia.org/wiki/Circular_economy)

Be part of the international network

IMAT
INTERNATIONAL
MATERIAL FLOW MANAGEMENT

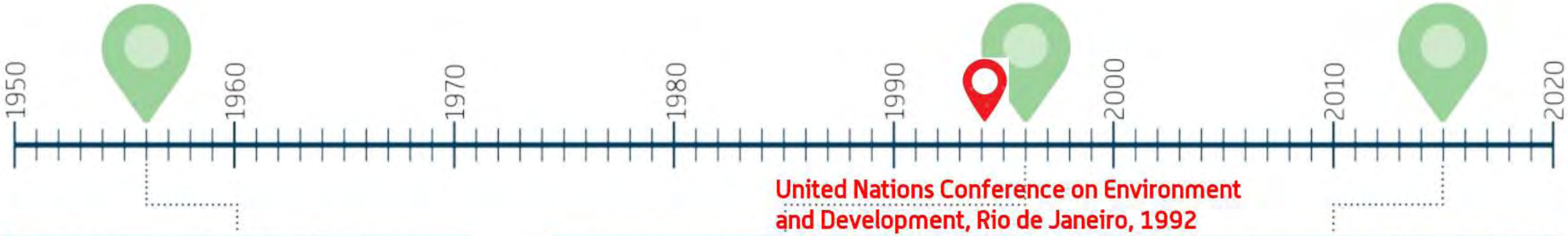


Source: http://coupleontherun.com

ECB – The Academic Village setting SDGs standards

ECB – the unique green campus idea

IMAT INTERNATIONAL MATERIAL FLOW MANAGEMENT



Up to 1994: US Military Hospital

1996: Starting the endeavour

Germany´s Greenest University Campus

ECB – NO 1 in Germany

IMAT INTERNATIONAL MATERIAL FLOW MANAGEMENT

- **Green Metric 2021**
  - NO 6 Globally and NO 1 in Germany (among 719 universities)
  - NO 1 in category „Energy and Climate Protection"
- International Sustainability Campus Network
  - World's largest sustainability forum for universities
  - NO 1 award in the category „Campus Planning and Management Systems"

Zero Emission Energy Concept

IMAT INTERNATIONAL
MATERIAL FLOW MANAGEMENT

- 100% renewable heat supply based on waste wood, biogas (co-generation) and solar thermal
- 100% renewable electricity based on cogeneration & PV
- 100% renewable cooling supply based on geothermal, biomass and solar adsorption
- 100% Energy Efficiency

7 AFFORDABLE AND CLEAN ENERGY

Eco-Industrial Park (Waste-to-Energy)

IMAT INTERNATIONAL MATERIAL FLOW MANAGEMENT

- **100%** Private investments (40 Mio. EUR CAPEX) in Public-Private-Partnership
- **100%** Regional Added Value (35 new jobs, GHG abatement, long-term affordable energy security)
- **100%** waste problems solved without second pollutions

Next CE technologies | Resource Centre instead of landfills!

- Biowaste is seen and treated as a resource!
- Industrialised (space efficient) design
- Serving as base load power plants

Biowaste to Biogas

IMAT INTERNATIONAL
MATERIAL FLOW MANAGEMENT

- Input: separately collected organic household waste [24,500 t/a]
- Biogas: 1.4 - 1.8 million m3/a
- Energy Content: 1,000,000 litre oil equivalent
- 2,700 t/a solid fertiliser
- 10,000 t/a liquid fertiliser

Powered by the Sun!

IMAT INTERNATIONAL
MATERIAL FLOW MANAGEMENT

- Own PV covers up to 50% of ECB electricity demand
- PV as an architectural design element

Charged by the sun – Sustainable Mobility

Trier University of Applied Science IfaS Institut für angewandtes Stoffstrommanagement

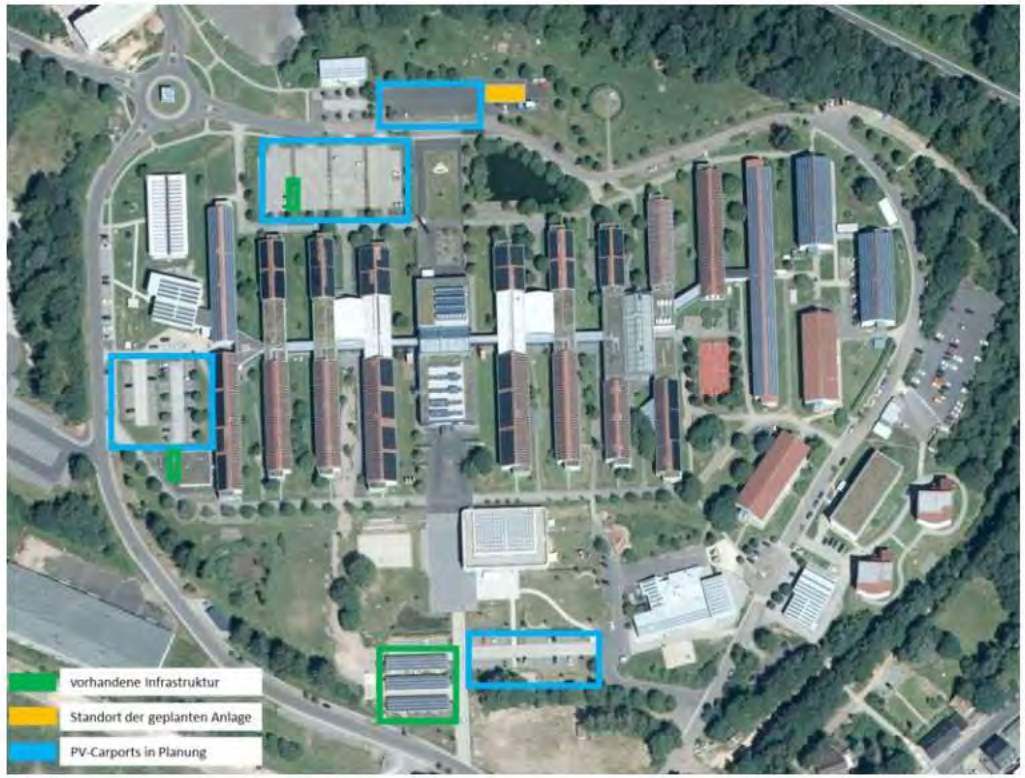
- Carport with 100kWp installed capacity
- Integrated Battery storage [80 kWh]

Zero Emission Building (Energy+ - Building)

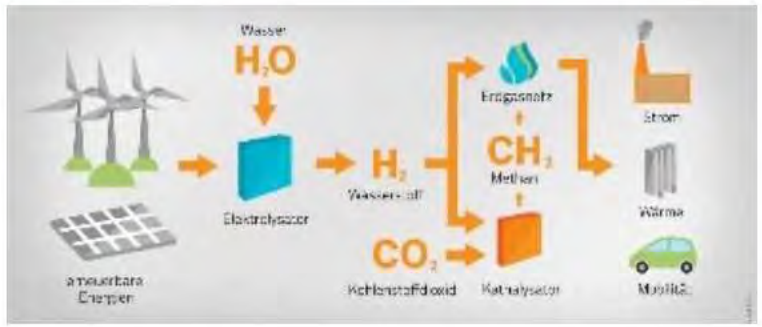
Trier Univers of Applied Scienc IfaS Institut für angewandtes Stoffstrommanagement

- PV-installation with an installed capacity of 40 kWp
- 40 cm exterior insulation and triple-glazed windows
- AHU with 80 % heat recovery and high efficient electric motors

One more thing…Hydrogen is our next coup



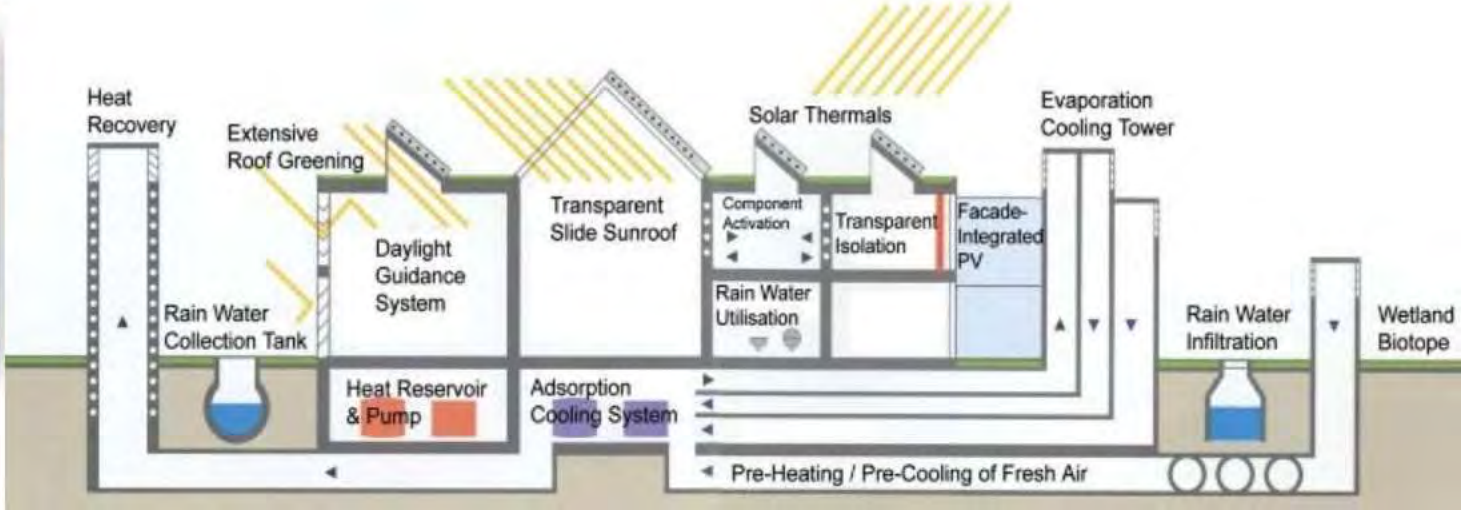
- Investment of nearly 6 Mio EUR
- Extension of PV-car parks to 850kWp and battery storage to 650kWh
- Installation of electrolyseur, fuel cell and H_2-filling station
- RE peak load saving and sustainable commuting initiative
- Hydrogen competence centre and export knowledge



Zero Emission HVAC System

IMAT INTERNATIONAL
MATERIAL FLOW MANAGEMENT

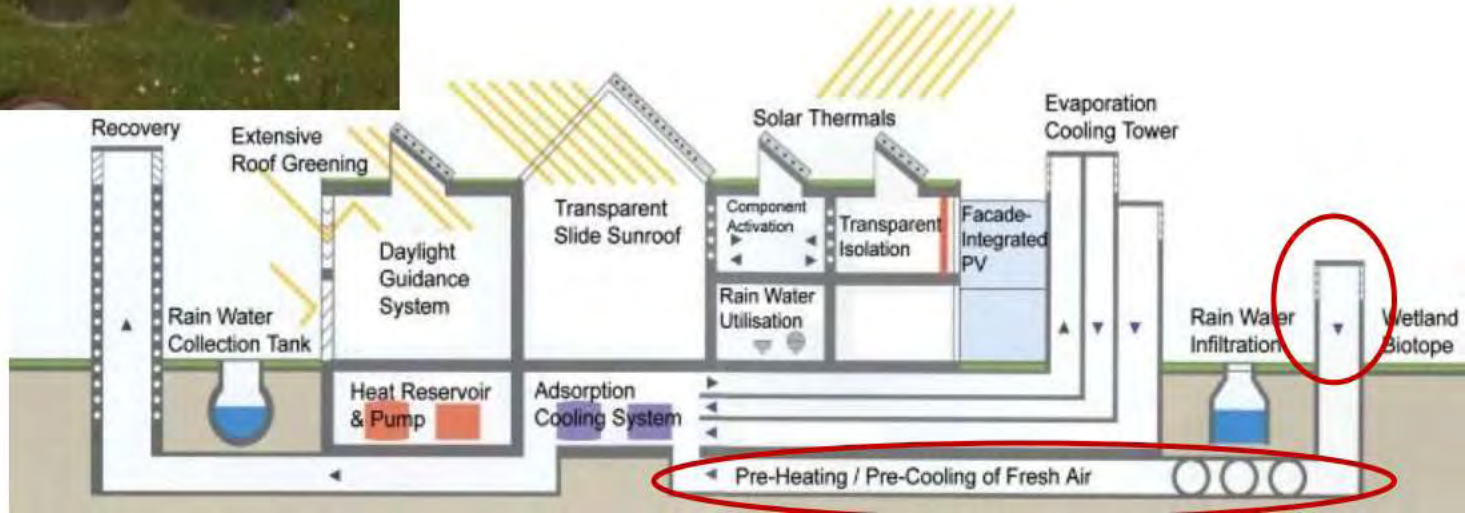
- Solar adsorption cooling
- Biomass based district heating by waste wood
- Geothermal pre-heating and cooling



Zero Emission HVAC System

IMAT INTERNATIONAL
MATERIAL FLOW MANAGEMENT

- Earth collectors and Air Inlet
- Utilising geothermal heating and cooling
- Free night cooling by AHU



Strategies & Solutions

Resilient & sustainable cities

CASE STUDY: Building a Sustainable Desert City

Terms & Definitions

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."*

Cities occupy 2% of the land yet responsible for 70% of global GDP, greenhouse gas emissions (GHG), and global waste >60% of global energy consumption

SOURCE: https://www.oecd.org/regional/resilient-cities.htm

ZE & Resilient City

First global cutting edge, self sufficient, sustainable and smart city i.e. the most INNOVATIVE property development in the World

Desert Rose 300MW SOLAR BANK

Desert Rose ECOPARK

Desert Rose housing and city center SOLAR ROOFTOP INSTALLATIONS

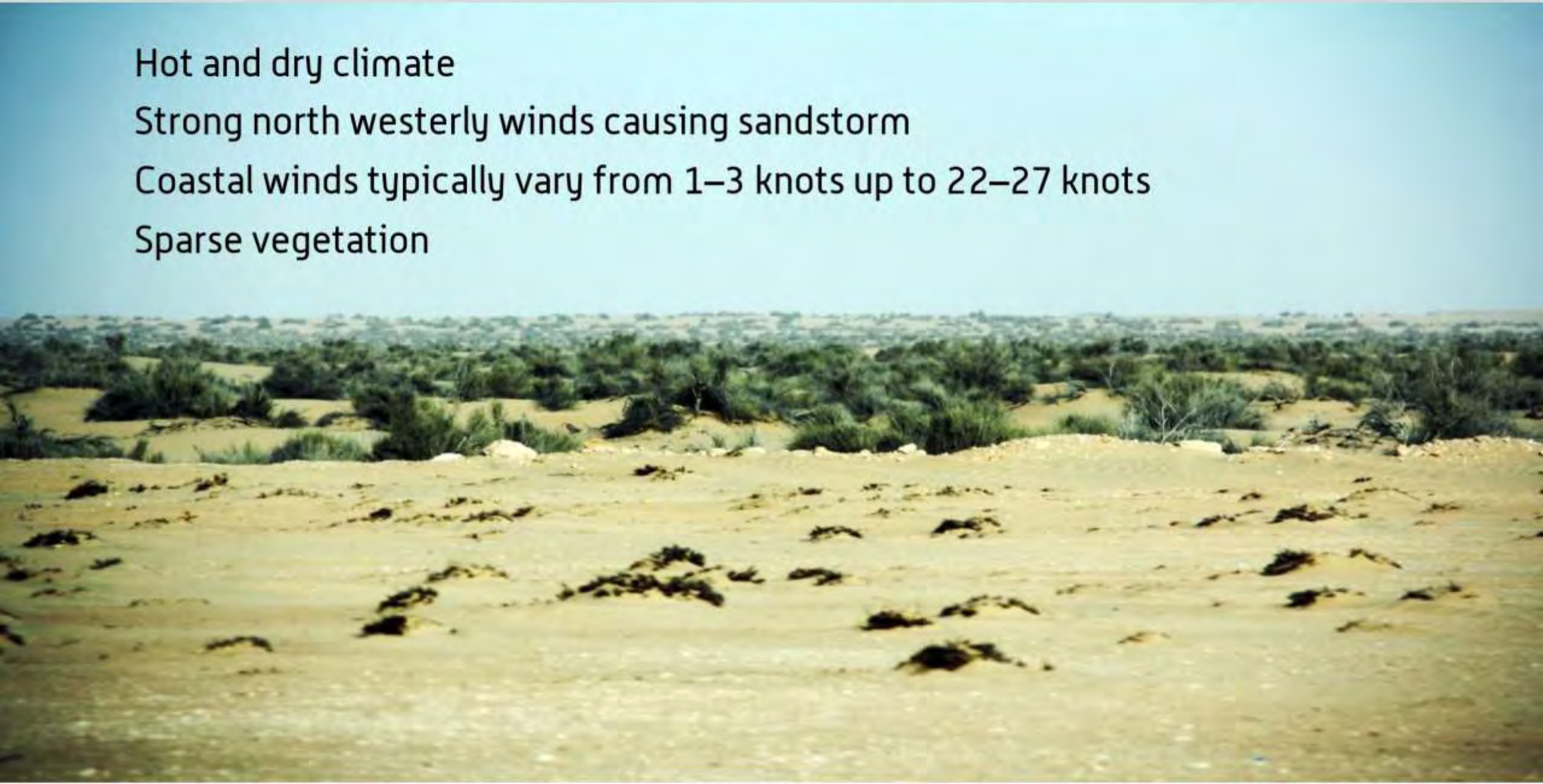
Site Survey: Climate & Natural Vegetation

Hot and dry climate

Strong north westerly winds causing sandstorm

Coastal winds typically vary from 1–3 knots up to 22–27 knots

Sparse vegetation



Site Survey: Service and Utilities

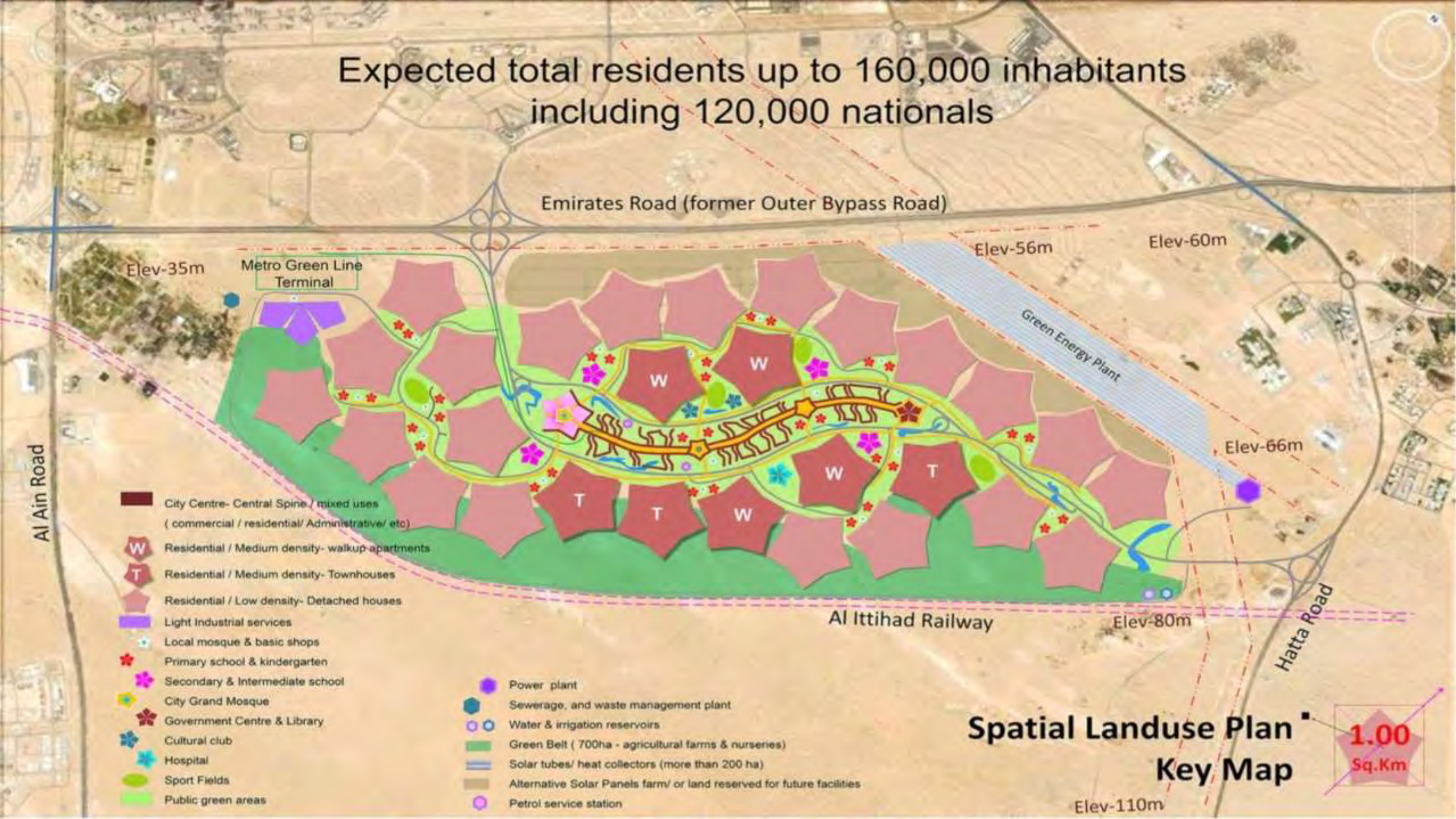
Cesspits/septic tanks, power and water supply for Falconry and other buildings on the east

High tension power lines along the northeast and north, there are no overhead power lines crossing the site

No visible evidence of groundwater wells in open areas

Water supply arrangements are through deep wells

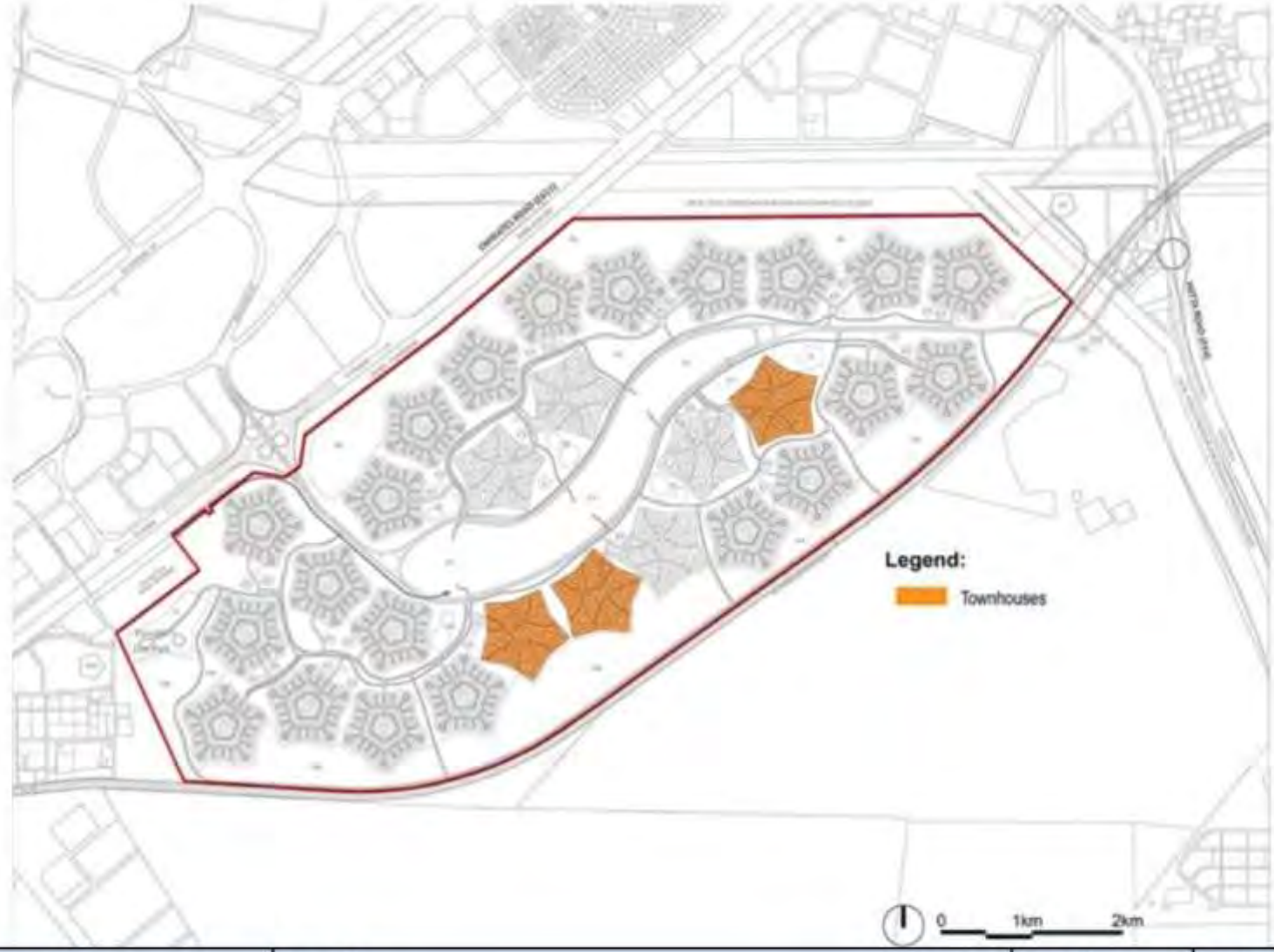
Expected total residents up to 160,000 inhabitants including 120,000 nationals



Concept Design: Resilient City

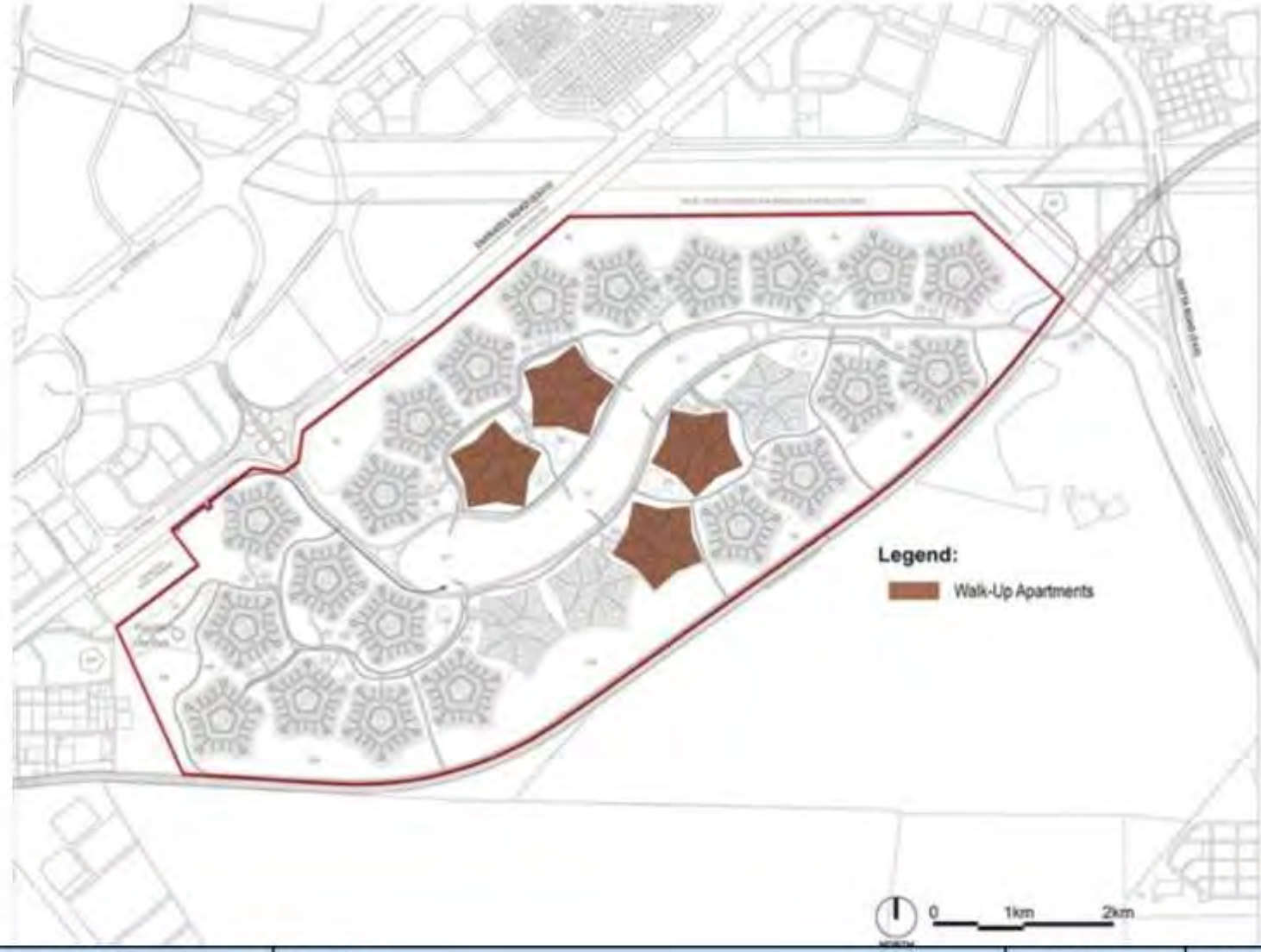
Components	Details	Height	Units/Areas*
Detached Villas	21 Neighborhoods	G+1	385 each (8,085 total)

Concept Design: Resilient City



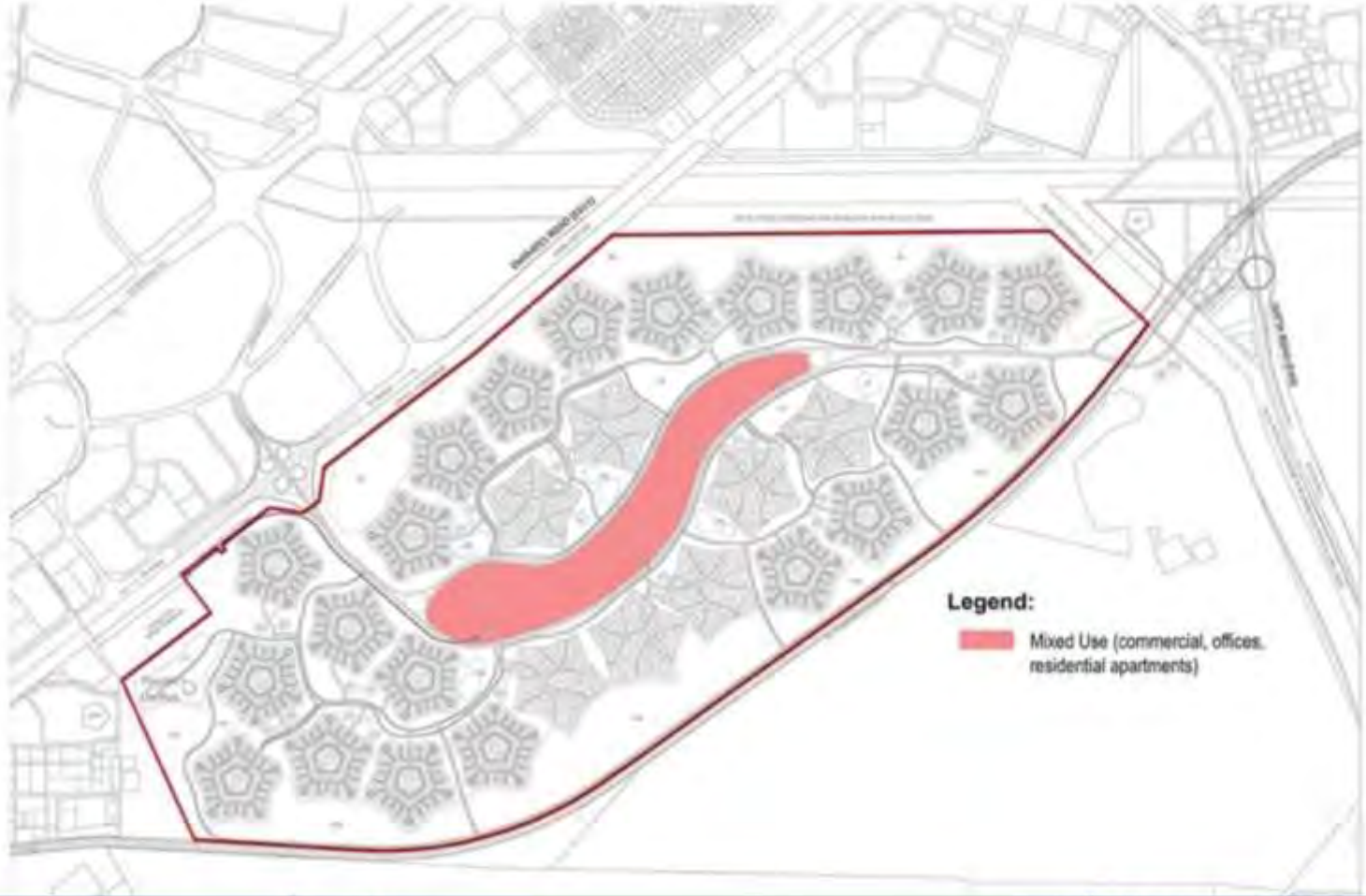
Components	Details	Height	Units/Areas*
Townhouses	3 Neighborhoods	G+1	1,088 each (3,264 total)

Concept Design: Resilient City



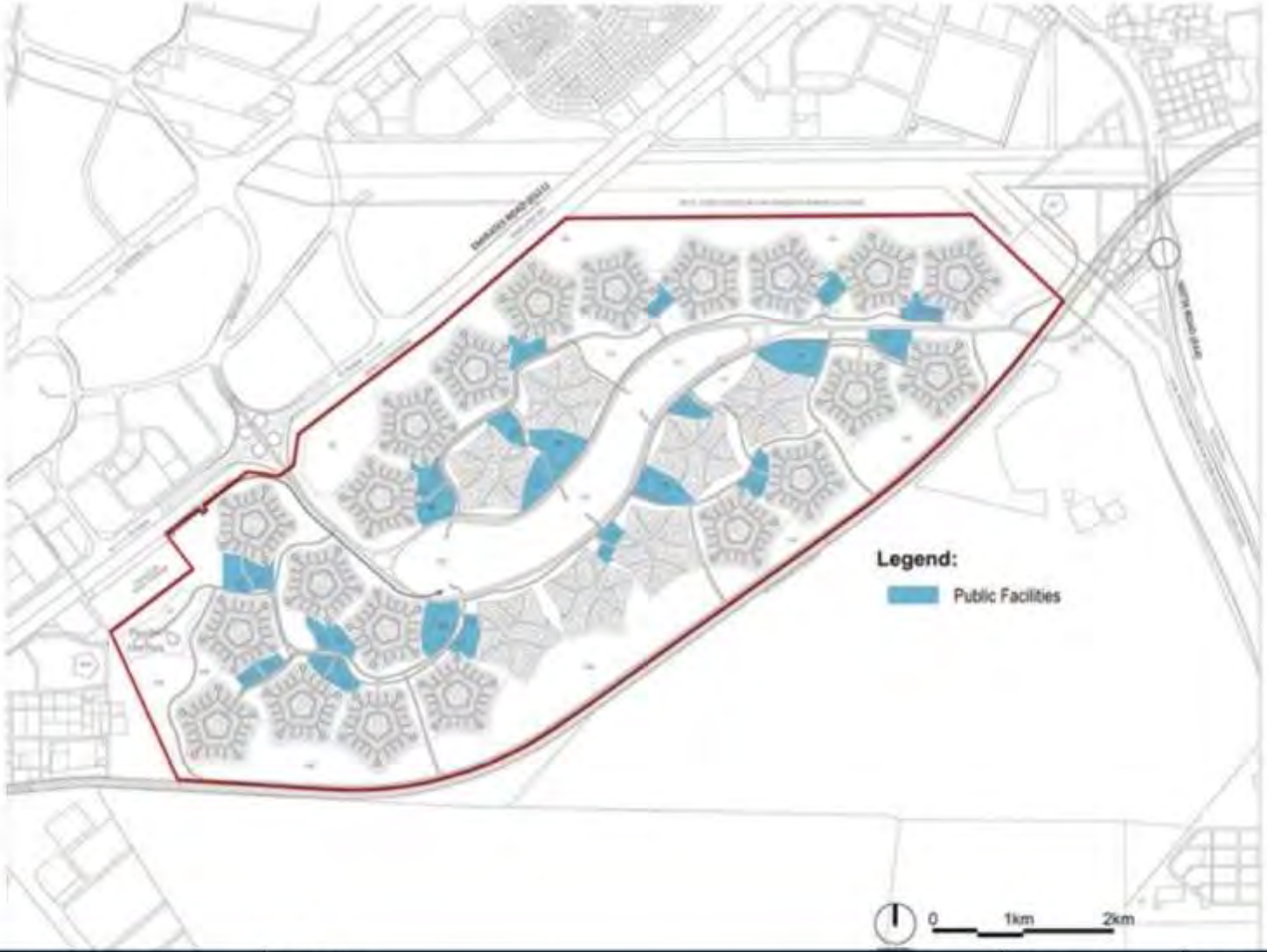
Components	Details	Height	Units/Areas*
Walk-Up Apartments	4 Neighborhoods	G+4	2,176 each (8,704 total)

Concept Design: Resilient City



Components	Details	Height	Units/Areas*
City Center	Apartment Units	5 to 8	10,000 Units
	Offices	G+2	200,000 sq.m
	Retail and Leisure		500,000 sq.m
	Hotels		230,000 sq.m
	Public Facilities		70,000 sq.m

Concept Design: Resilient City



Components	Details	Height	Units/Areas*
Public Facilities	Schools, mosques, nurseries, cultural club, hospitals, civil defense, police etc...	vary	500,000 sq.m

Concept Design: Resilient City

Components	Details	Height	Units/Areas*
Green Belt	• Agricultural Production • Partial recreational activities • Buffer from noise & sand		700 Ha

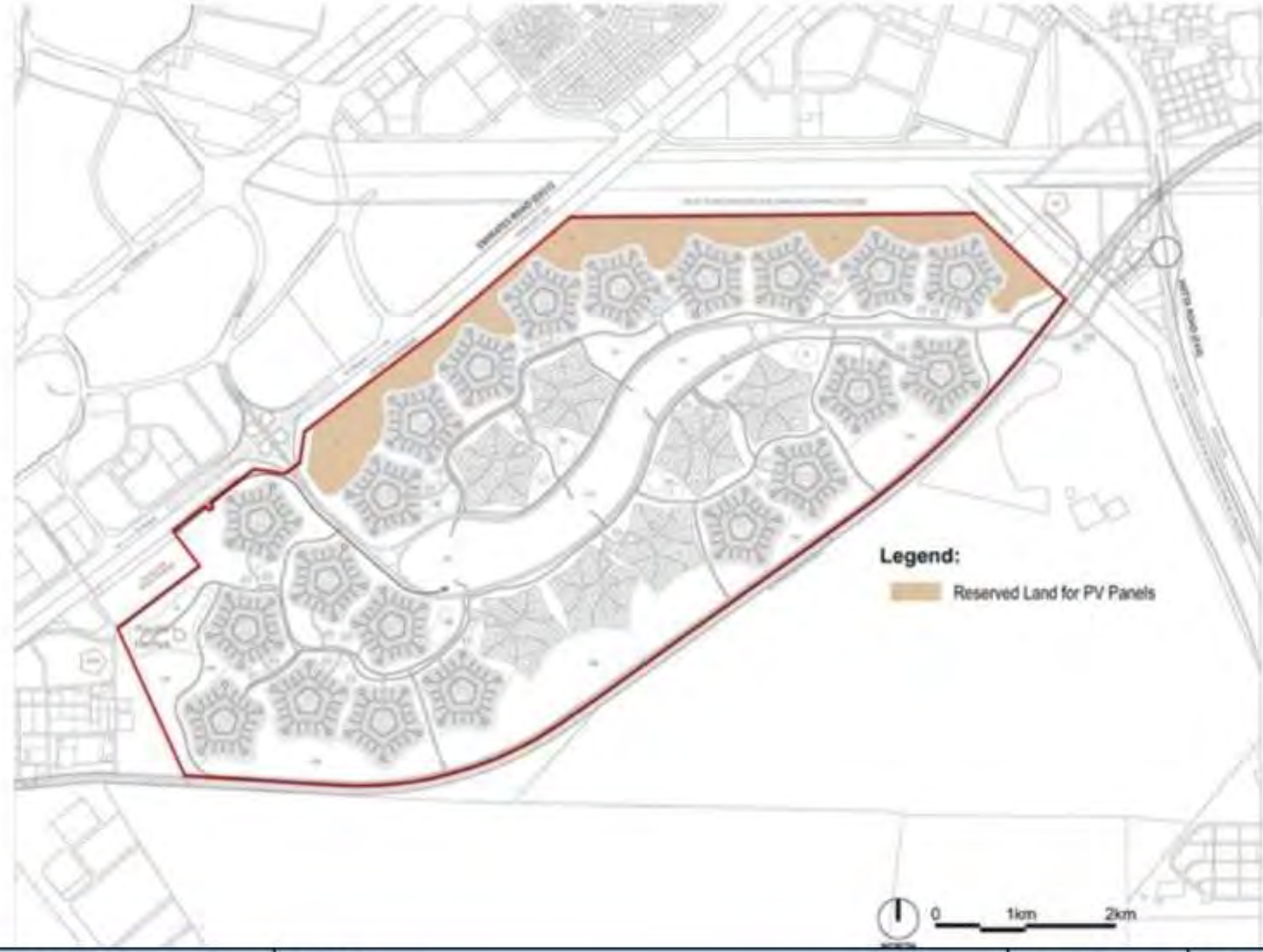
Concept Design: Resilient City

Components	Details	Height	Units/Areas*
Eco-walk	Network of pedestrian and cyclist pathways		25 Km long

Concept Design: Resilient City

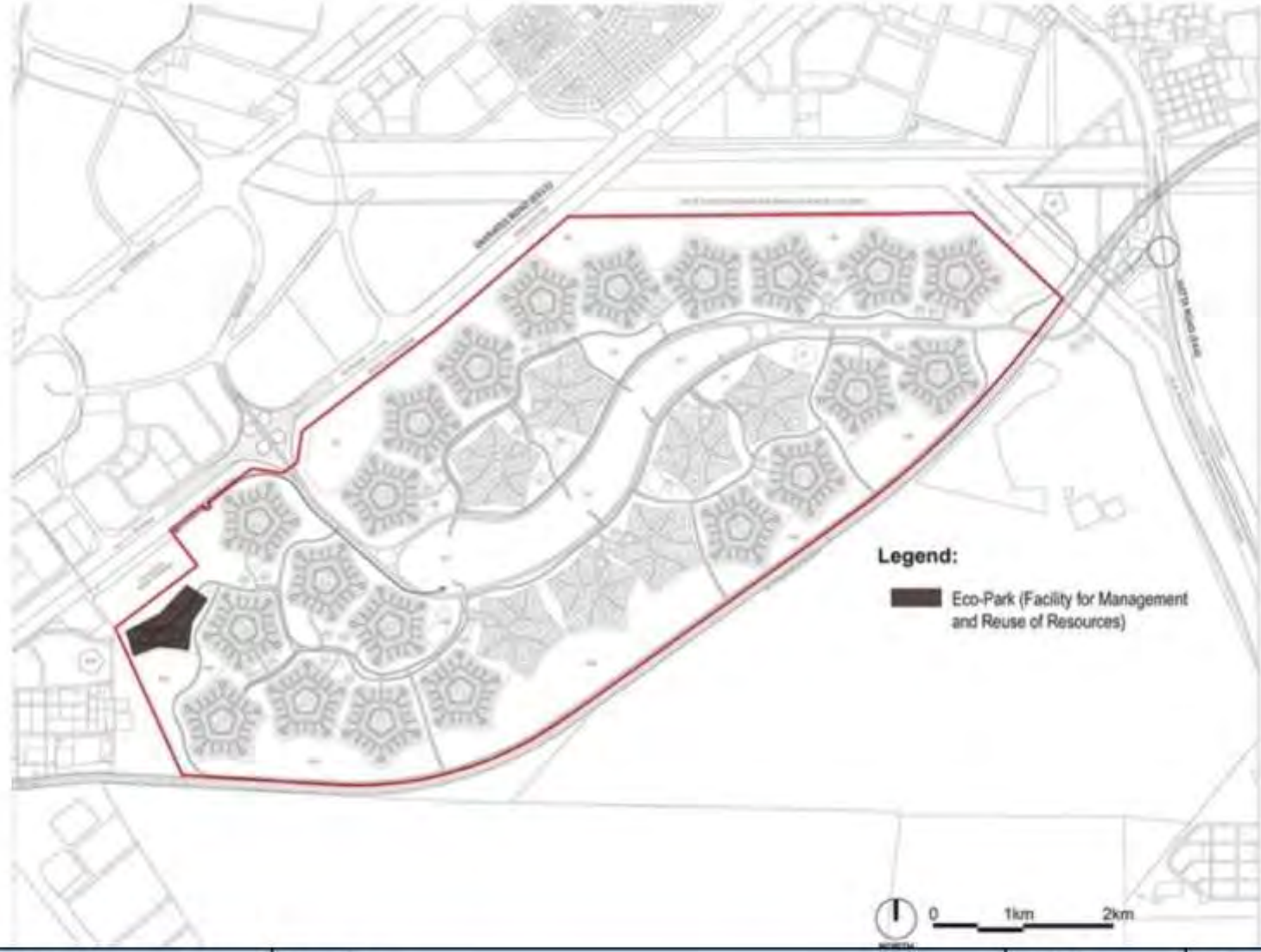
Components	Details	Height	Units/Areas*
Public Realm	Network of parks and open spaces (children play areas, BBQ facilities, community gardens, sports equipment etc...)		1000 Ha

Concept Design: Resilient City



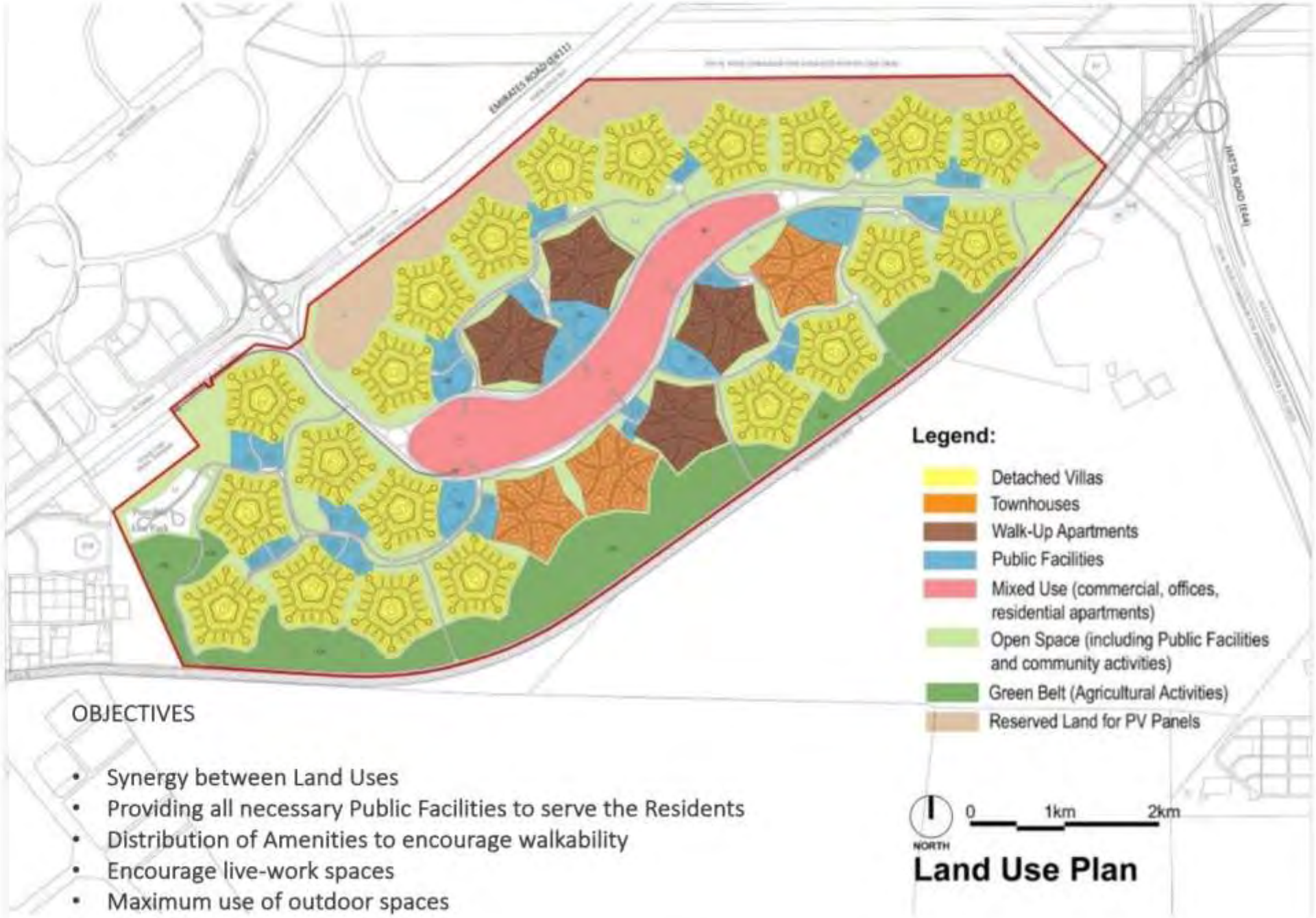
Components	Details	Height	Units/Areas*
Reserved Land	For PV Solar Panels		300 Ha

Concept Design: Resilient City



Components	Details	Height	Units/Areas*
Eco-Park	Recycling Facility and Management and reuse of Resources		

Concept Design: Resilient City



OBJECTIVES

- Synergy between Land Uses
- Providing all necessary Public Facilities to serve the Residents
- Distribution of Amenities to encourage walkability
- Encourage live-work spaces
- Maximum use of outdoor spaces

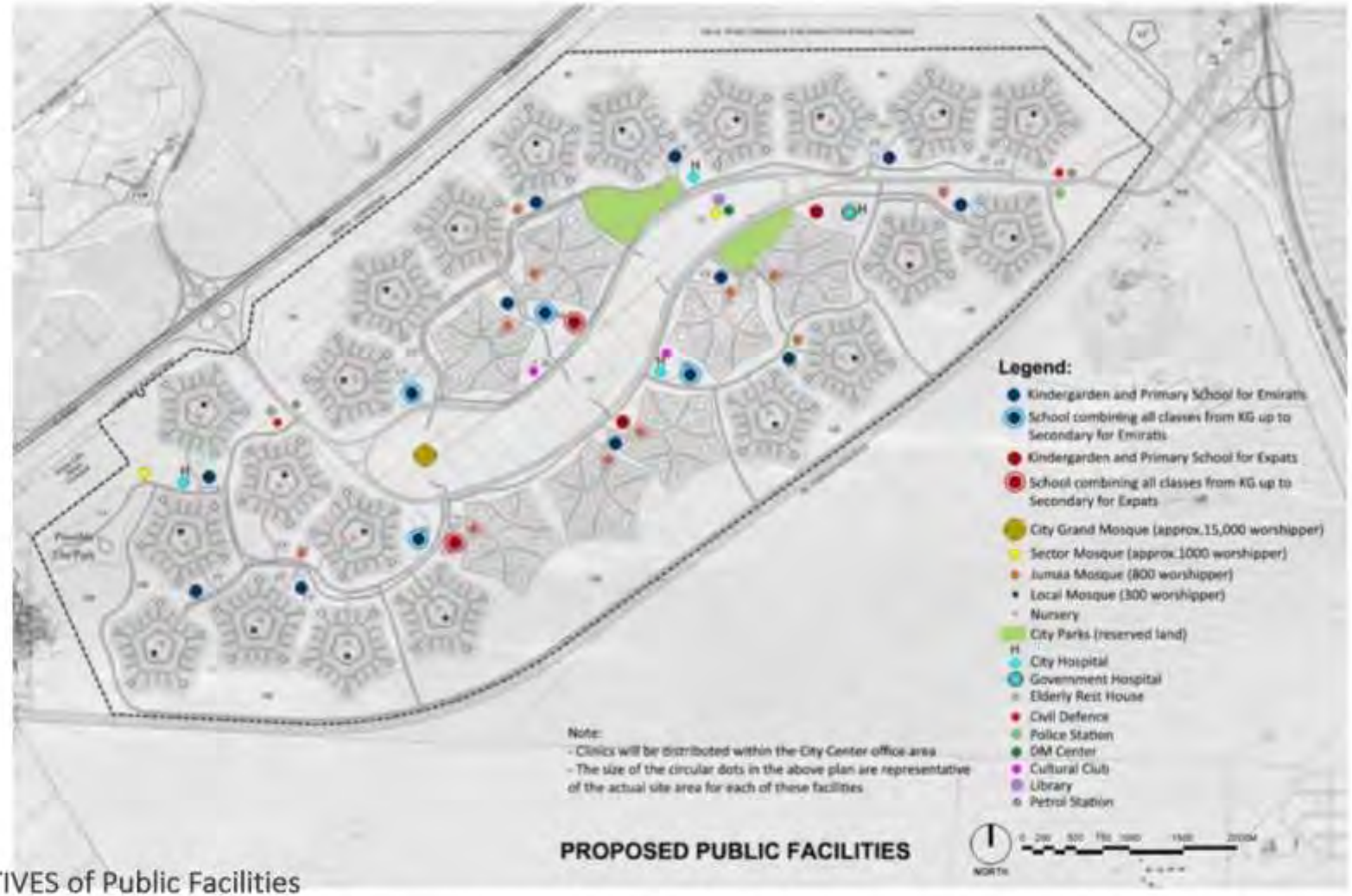
Concept Design: Resilient City

OBJECTIVES of Public Realm Design

- Recreational Opportunities
- Activities targeting all ages
- Encouraging walkability
- Providing Thermal Comfort
- Strengthening Communal relations
- Creating a Sense of Place
- Creating an Identity

Open Space Network Plan

Concept Design: Resilient City



OBJECTIVES of Public Facilities

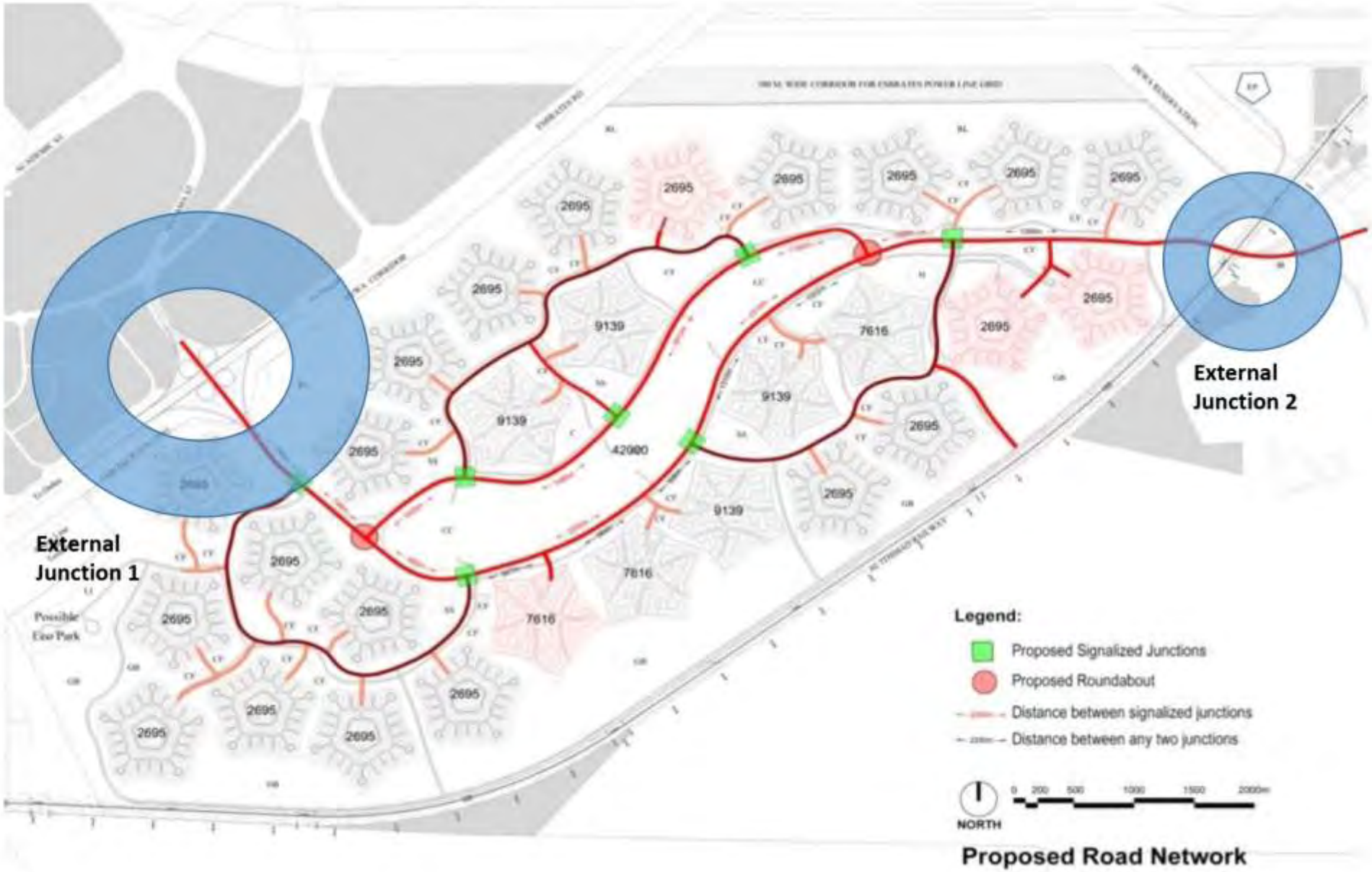
- Provide all the basic needs of the community within Desert Rose to prevent the need for residents to leave the development to access public facilities.
- Distribute Amenities within walking distance to encourage walkability
- Connect facilities with safe shaded walking and cycling pathways
- Prevent oversupply of facilities
- Efficient use of facilities during day and night

Concept Design: Resilient City

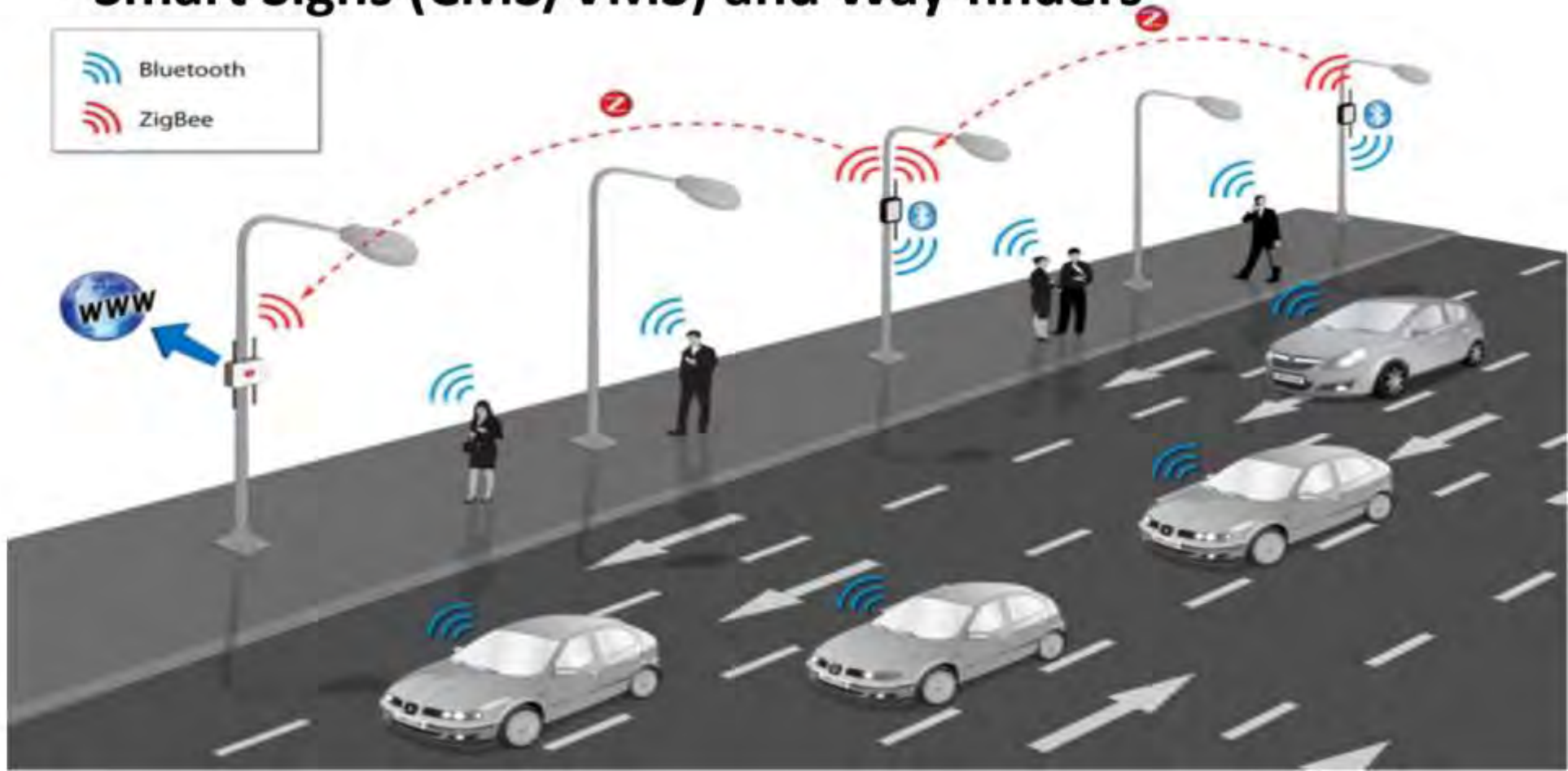
Public Facilities	Individual Plot Area	Proposed No. of Facilities	Total Plot Area	Building Height	GFA per unit (Sq.m)	Total GFA (Sq.m)	Pop Served	No. Required based on populatio	Catchment Radius	No. Required based on Catchment	Pop Capacity per unit	Total Population Capacity
Outside the City Center												
Mosques												
Local Mosques	1,800	21	37,800	G	720	15,120	2000-4000	29_58	500	28	300	6,300
Basic shops (with the mosque)	400	28	11,200	G	200	5,600	2000-4000	29_58	400	28	10	280
Jumaa Mosques	4,500	11	49,500	G+M	2,520	27,720	6000-12000	10_19	1000	9	800	8,800
Sector Mosque	6,000	1	6,000	G+M	4,000	4,000	20000-30000				1000	1,000
Schools for Locals												
Nurseries	1,858	28	52,024	G	743	20,810	6000-12000	10_19	800	13	85	2,380
Kindergadens	3,000	22	66,000	G	1,200	26,400	6000-12000	10_19	800	13	280	6,160
Primary Schools	8,000	22	176,000	G+1	6,400	140,800	6000-12000	10_19	800	13	495	10,890
Intermediate Schools	9,000	4	36,000	G+2	10,800	43,200	10000-20000	6_12	1500	2	440	1,760
Secondary School	12,000	4	48,000	G+3	19,200	76,800	20000-30000	4_6	2500	2	660	2,640
Schools for Expats												
KG and Primary schools	10,000	2	20,000	G+1	6,460	12,920	6000-12000	4	800	3	620	1,240
K12 schools	25,600	2	51,200	G+3	30080	60,160	20000-30000	2	1500-2500	1	1500	3,000
Cultural Hubs	4,000	2	8,000	G+1	2,500	5,000					80	160
City Hospital	5,000	3	15,000	G+2	7,500	22,500	35,000	9	varies		200	600
Sport Fields		0	0			0						0
Petrol Service Stations		2	0			0					10	20
Government Hospital	12,000	1	12,000	G+2	18,000	18,000	80,000	2	varies		480	480
Civil Defence	4,000	2	8,000	G+1	4,000	8,000	50,000	3	4500	1	40	80
Police Station	5,000	2	10,000	G+1	5,000	10,000	70,000	2	5000	1	120	240
Elderly Rest House	2,500	1	2,500	G	1,000	1,000	50,000	3	varies		180	180
Total (outside CC)			**609,224**			**498,030**						**46,210**
Inside the City Center												
Private General Clinic	650	10	6,500	G+1	715	7,150	6,000	26	varies		30	300
Private Specialty Clinic	650	10	6,500	G+1	715	7,150	6,000	26	varies		30	300
Private Polyclinic	650	10	6,500	G+1	715	7,150	6,000	26	varies		30	300
Post Office	2,000	5	10,000	G+1	2,000	10,000	20,000	8	1800	3	15	75
Library	6,000	1	6,000	G+1	6,000	6,000	70,000	2	5000	1	100	100
Govt Center												
DM Center	4,500	1	4,500	G+1	4,500	4,500	150,000	1	varies	1	100	100
Mosques												
Local Mosques	1,800	0	0	G	720	0	2000-4000	5_10	500	6	300	0
Sector Mosques	6,000	1	6000	G+M	4000	4,000	20000-30000	2	1,000	2	1000	1,000
City Grand Mosque/Eid Prayer	25,000	1	25000	G+2	20000	20,000	70000-120000	2	varies	1	15000	15,000
Nurseries	1,858	5	9,290	G	743	3,716	6000-12000	3_7	800	3	85	425
Total (inside CC)			**80,290**			**69,666**						**17,600**
GRAND TOTAL PROJECT						9,144,670						259,660

Concept Design:
Resilient City

Traffic Control –External Junctions



- **Smart Design,**
- **Smart Monitoring and Communication,**
- **Smart Signs (CMS/VMS) and Way-finders**



Concept Design: Resilient City

Zero Emission – Sustainability


Landscape Studies:
Recreation & Agriculture

Concept Design:
Resilient City

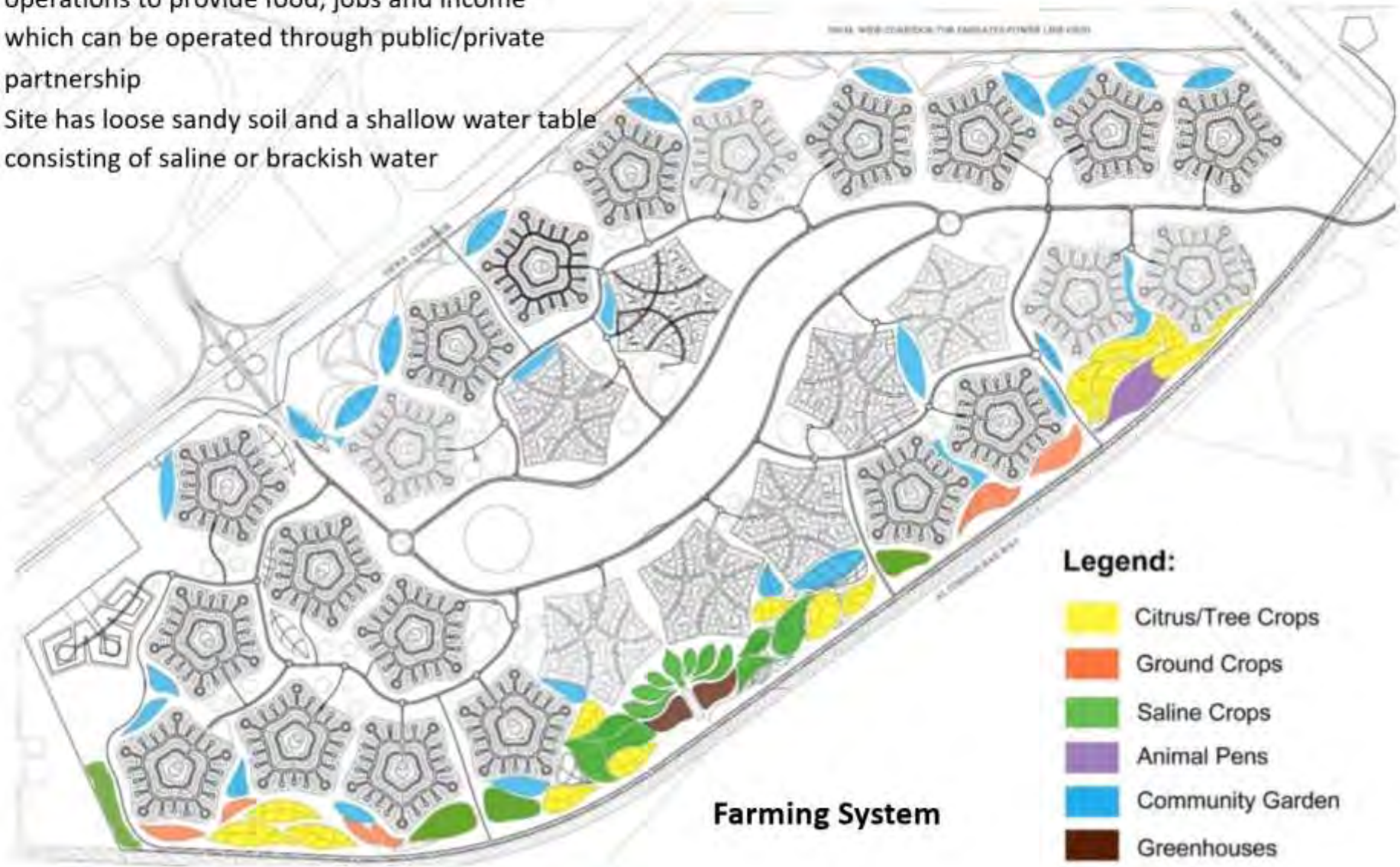
Green Belt and Farms

Greenbelt

— 700 hectares along the eastern boundary

— **Role:** provide and integrate sustainable farming operations to provide food, jobs and income which can be operated through public/private partnership

— Site has loose sandy soil and a shallow water table consisting of saline or brackish water



Farming System

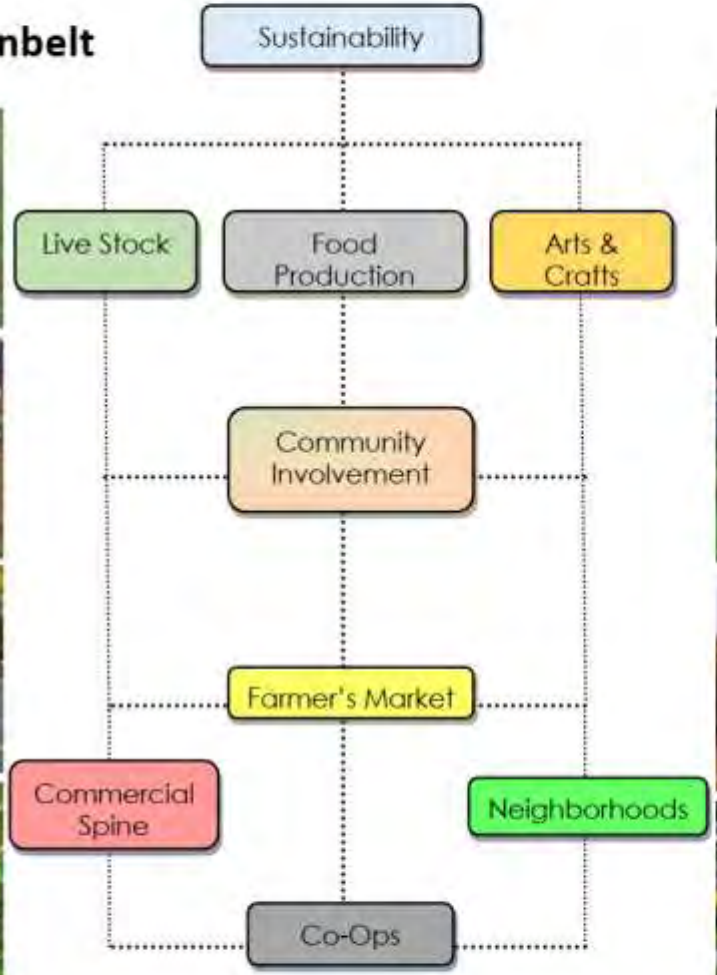
Concept Design: Resilient City

Green Belt and Farms

Farming Hierarchy

Role of Sustainable Farming in the Greenbelt

- Diversify farm products
- Supplement income
- Reduce soil erosion from wind and water
- Improve Soil
- Create and provide wildlife habitats
- Light competition
- Root competition
- Allelopathy



Sustainable Farming

— The Greenbelt has numerous environmental assets to achieve the sustainable label.
— The forested bands and understory plantings will incorporate stormwater runoff facilities or ponds and swales which will filter out unwanted nutrients and protect downstream crops and reclaimed water.
— The use of organic fertilizers, herbicides and pesticides will assist in the prevention of unwanted nutrients within the Greenbelt system.

Sustainable Source and Sink

— The greenbelt will act as a sustainability source providing energy services for the overall renewable energy balance (source) and additional biomass material for biochar and Terra Preta production
— The "BioEnergy and Resource Centre" provides fertilizer by turning organic waste flows into high value and quality fertilizer with highest hygienic standards and necessary irrigation water for the greenbelt operation

Concept Design: Resilient City

Crops

Sustainable Farming

Organic fertilizers, herbicides and pesticides
Smart irrigation practices
Protection of public health
Zero carbon footprint
Flood prevention
Solar powered machinery
Polyculture

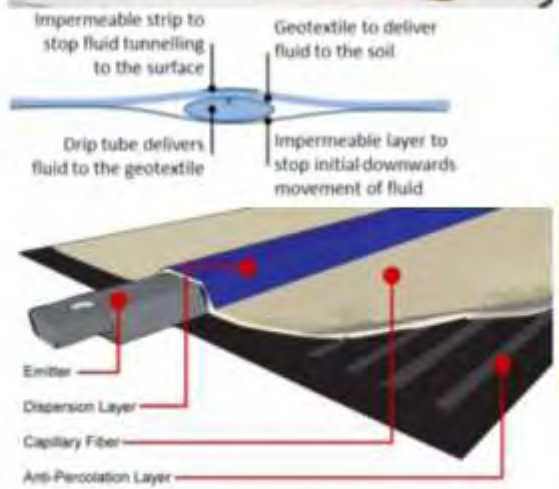
Crop and Animal rotations
Environmental preservation
Upholding animal welfare
Composting
Wind breaks
Biodiversity
Cooperative food production

Citrus and other fruiting tree orchards are proposed that consist of orange, lemon, lime, grapefruit, mango, coconut, fig, date and nuts which will be harvested for human consumption and prevent desertification.

Concept Design:
Resilient City

Wind Breaks

New Irrigation Technology

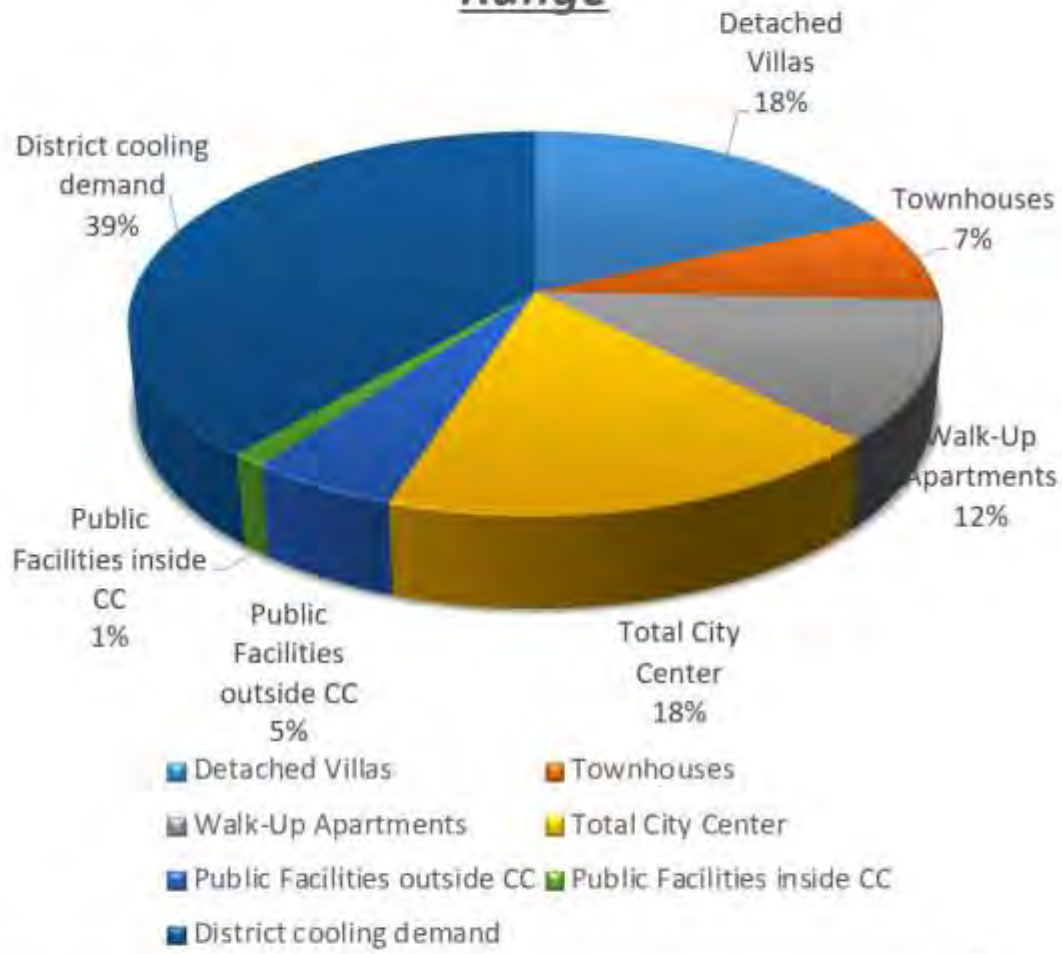


Reserved Area Solar Fields

Parks and Recreation

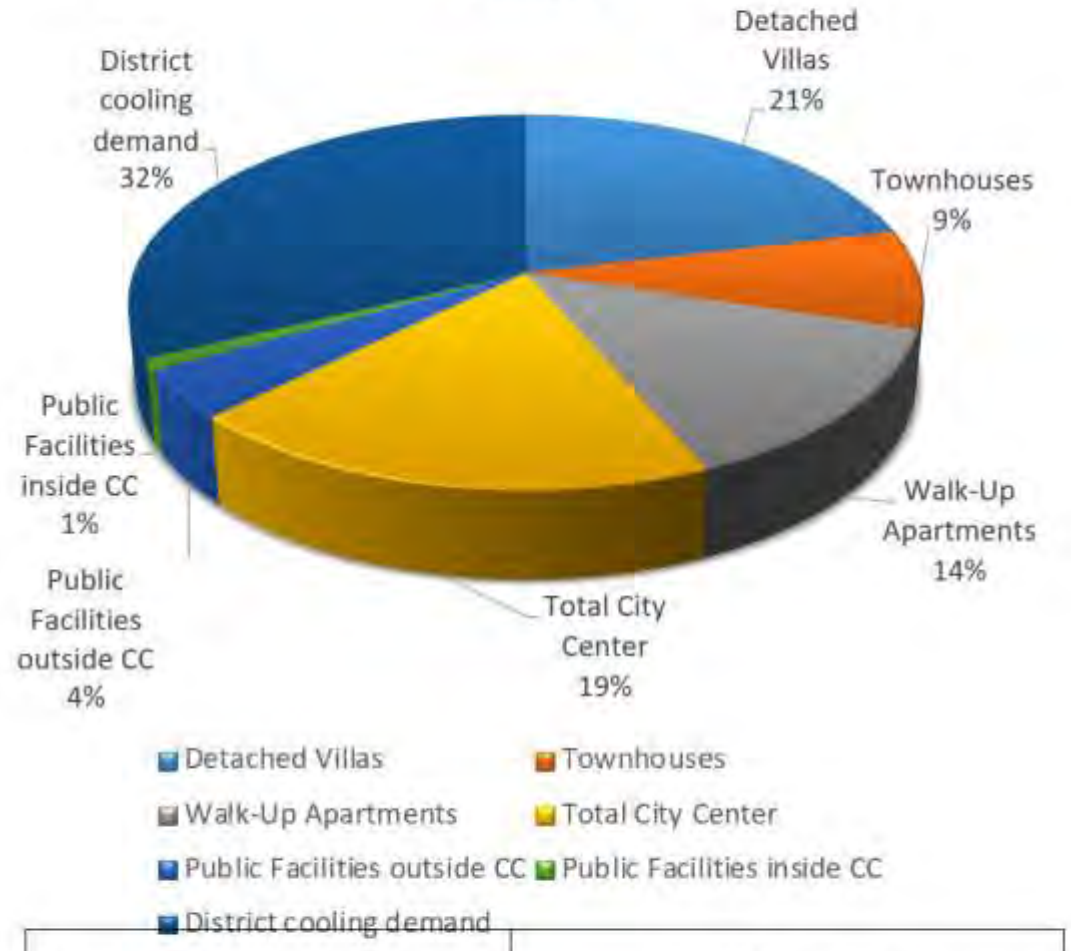
The public park network is designed to include the Dubai Municipality Parks hierarchy of park types. The park system in Desert Rose is unique where all public parks are physically linked creating one large recreation network.

Demand Details for Minimum Range



Domestic Demand	75,875 m3/day
District cooling demand	36,000 m3/day
Total	***111,875 m3/day***

Demand Details for Maximum Range

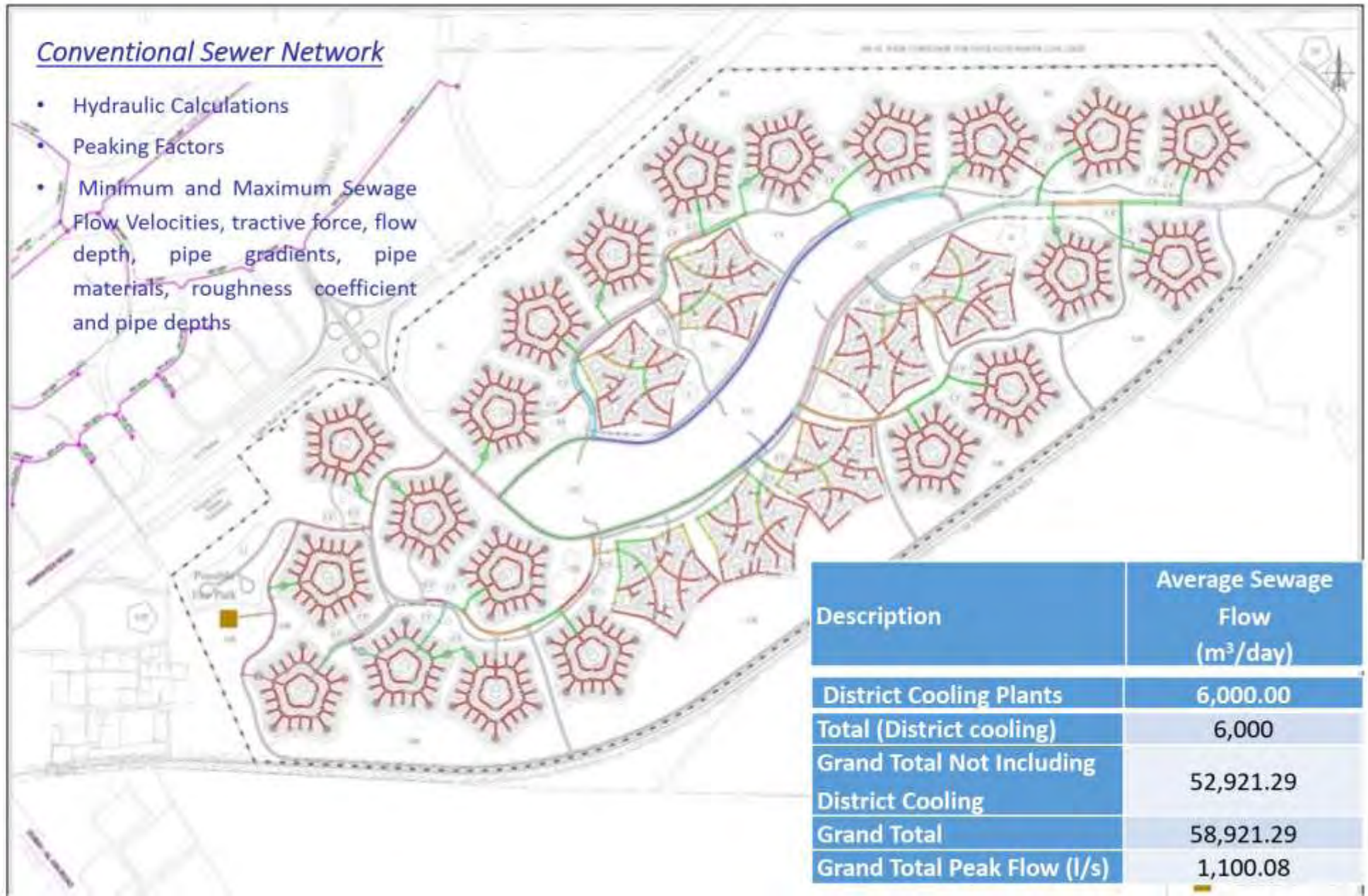


Domestic Demand	56,915 m3/day
District cooling demand	36,000 m3/day
Total	***92,915 m3/day***

Waste Water Network

Conventional Sewer Network

- Hydraulic Calculations
- Peaking Factors
- Minimum and Maximum Sewage Flow Velocities, tractive force, flow depth, pipe gradients, pipe materials, roughness coefficient and pipe depths



Description	Average Sewage Flow (m^3/day)
District Cooling Plants	6,000.00
Total (District cooling)	6,000
Grand Total Not Including District Cooling	52,921.29
Grand Total	58,921.29
Grand Total Peak Flow (l/s)	1,100.08

ZE & Resilient City

Options for STP

1. Centralized STP 46,000 m3/day treating all waste water (black and grey)
2. Two options for centralized Treatment units (MBR- AE)
3. Third Option Centralized Grey water and Black water treatment
4. Sustainable option of STP upgrade to BERC (Bio Energy Research Center) for renewables generations

Selection Item	Importance %
Foot print	12
Environmental impact	20
Power consumption	10
O&M	11
Capital Cost	8
Environmental Sustainability	15
Effluent quality	9
Health &Safety	15

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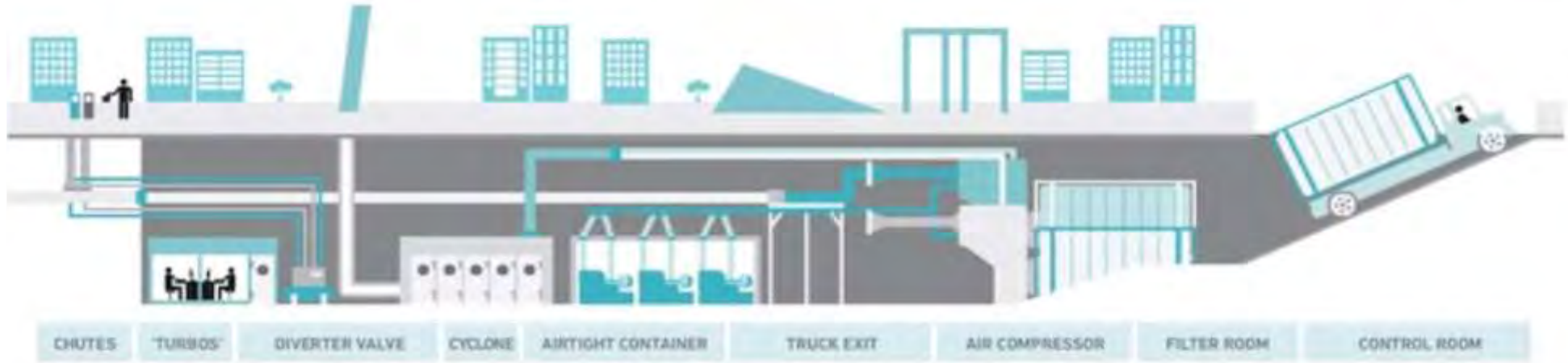
Solid Waste System



1.Modern Systems:

- Solid Waste Vacuum Collection System

2.Traditional:

- Door to door collection system

Advantages of Automated Solid Waste Vacuum System

1. Totally covered.
2. Invisible system to the unhygienic, aesthetically undesirable traditional handling system.
3. The waste ends up in one central collection station.
4. The system also saves valuable usable space that would have otherwise been specialized solely for the truck circulation purposes.
5. The system is completely automatic.
6. Waste never remains for long before being transported away from the buildings.
7. The system is environmentally friendly, completely in favour of recycling and may allow selective collection of different waste fractions

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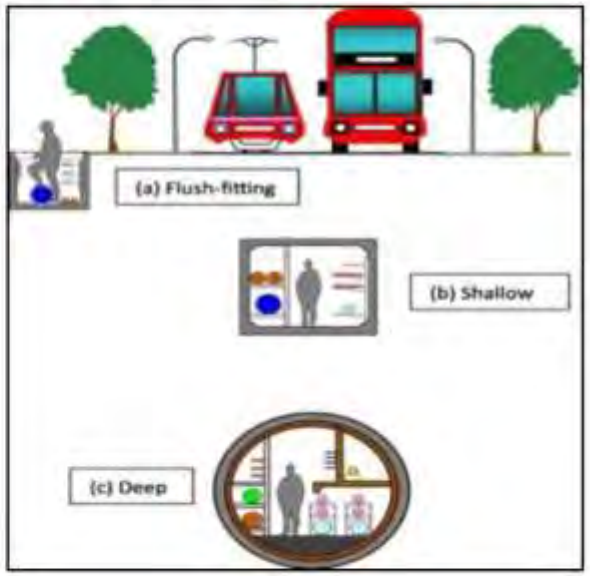
Multi-Utility Tunnel

- Utility tunnel is a passage built underground or aboveground to carry utility lines such as electricity, water, sewer pipes, Communications utilities, etc.
- Sustainable Solution for housing all utilities in one location
- Alternative solution in large scale sites where large scale infrastructure is required



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Core Infrastructure: Multi-utility channel

- Accessible and intelligent integration of all infrastructure
  - Supplied utility service units: (waste) water supply, MSW, IT, district cooling, gas & electricity
  - Real-time monitoring and low-effort inspection of infrastructure
  - Easy system maintenance and upgrade without traffic interference
  - Total investment of 4,700 Mio. AED with immediate savings, e.g. vacuum-based sewer system for 650 Mio. AED compared to 800 Mio. AED for gravity sewer system

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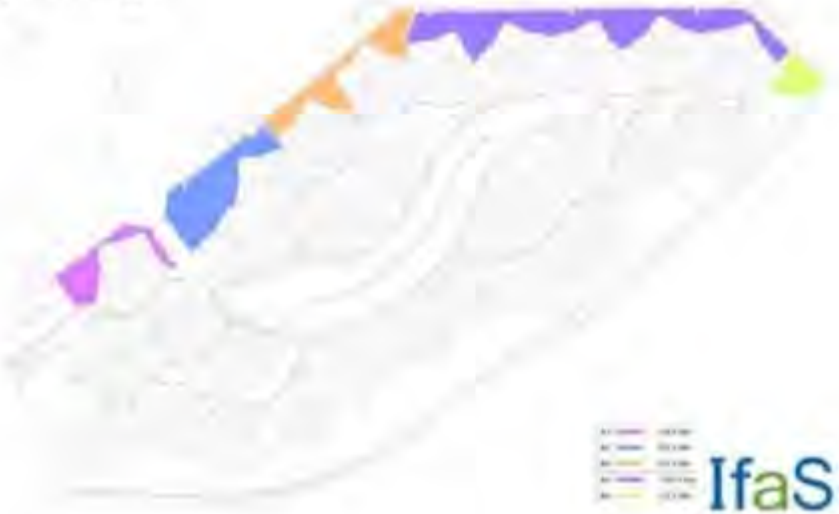
Sustainability Impacts of Solar Energy

- **Environmental Sustainability**
  - Current renewable energy coverage of 37%
    - Solar RE production of **1,037GWh/a** with GHG abatement of **620,000t CO_{2e}**
  - 100% RE coverage possible with strengthening of building codes
- **Economic Sustainability**
  - Total solar energy investment opportunity (612MWp) of 3,000 Mio. AED
  - Competitive LCOE of 250 AED/MWh
    - Exploitable investment options in energy efficiency existing



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Zero Energy Strategy

- **Zero Energy is possible with a) strengthening of Green building code and b) overall energy efficiency strategies**
  - LED based lighting with 80% energy saving potential
  - Energy efficient appliances
  - District cooling systems (COP of 3.92) for neighbourhoods with 50% saving potential
- City wide application of battery storage would be innovative
  - Zero energy on a physical level rather on balance

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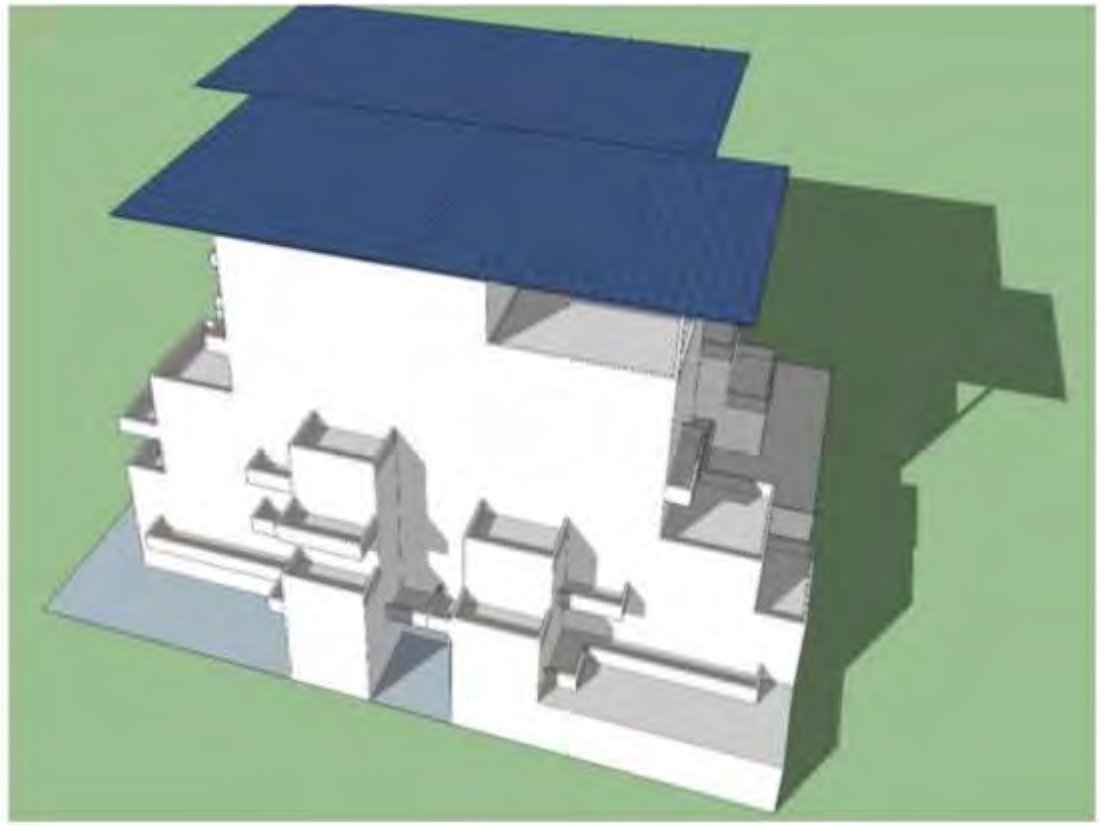
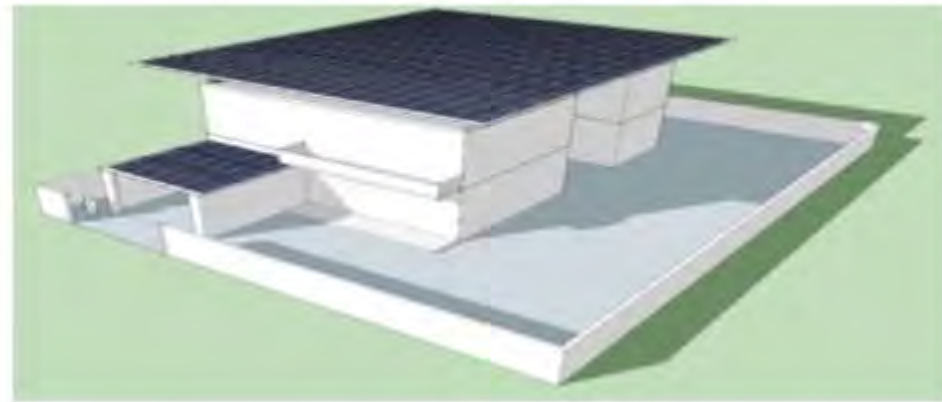
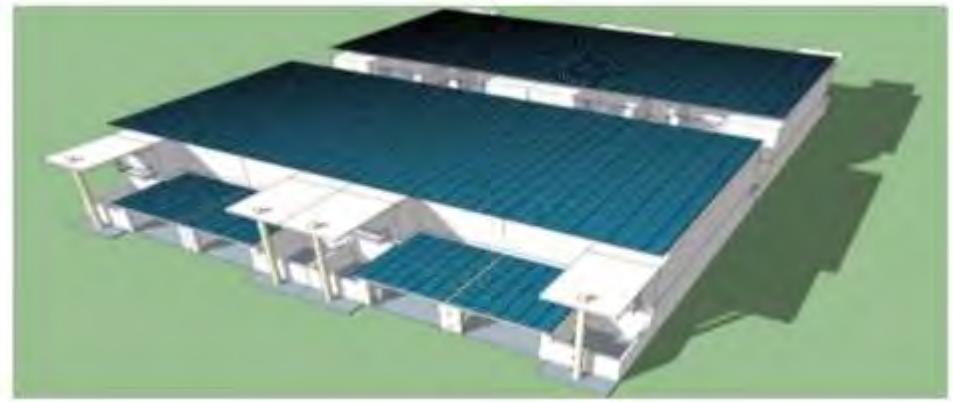
Desert Rose will have green building design…

- Decrease cooling energy demand
- Maximize solar energy use







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Desert Rose 300MW Solar Bank

Desert Rose Biological Energy Recycling Centre BERC

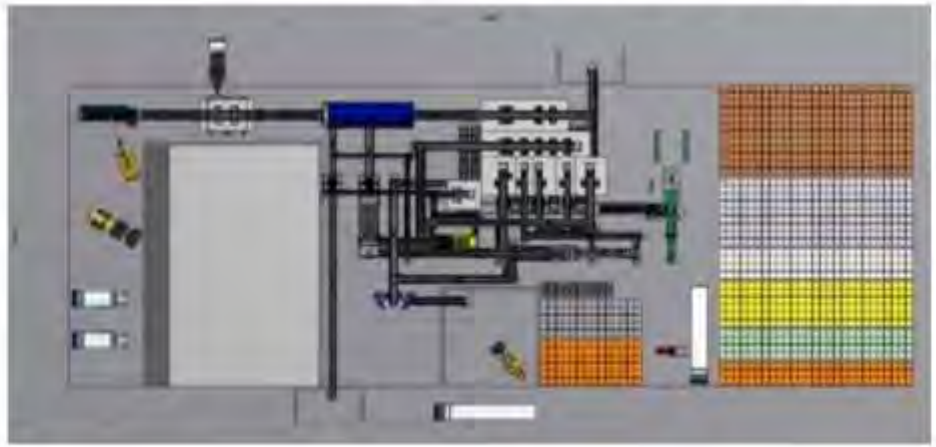
Desert Rose TSE and stormwater storage and recreation Lake

Desert Rose Hydroponic Visitor Centre for innovative food production and Aquaculture Center

0 500m
scale

Sustainability Impacts of BERC - MSW

- **Environmental Sustainability**
  - Maximised (dry waste) recycling and energy recovery ratio of **over 90%**
  - Complete utilisation of wet waste for production of 10.000.000m³/a of biogas
  - GHG abatement fossil fuel switch of **47,500t CO_{2e}** and avoided LFG emissions of **49,200t CO_{2e}**
- **Economic Sustainability**
  - Investment of 90 Mio. AED in anaerobic digestion
    - Biogas of 0.52 AED/m³ or 0.25 AED/kWh_{elec} or sludge treatment of 65 AED/t or 10.5 AED/t of wet waste
  - Highly profitable dry waste recycling facility with 60 Mio. AED investment **and** net contribution margin of 200 AED per ton of recyclables



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Sustainability Impacts of BERC - WW

- **Environmental Sustainability**
  - Recovery of 21 Mio. m^3 of irrigation water suitable to irrigate entire greenbelt (700ha) plus addition 1.000ha of landscape
  - GHG abatement of **80,000t CO_{2e}** by avoided desalination (**85,000MWh/a**)
  - GHG abatement of **138,000t CO_{2e}** by secondary fuel (HTC) production (**146,000MWh/a**)
  - Comprehensive space demand is 78,250m^2 (including the sorting facility for the dry MSW fraction).

- **Economic Sustainability**
  - Investment of 116 Mio. AED results in production of 7.7 Mio. m^3 of irrigation water (spray quality) at LCOS 1.10 AED per m^3 (Cost of black water treatment)
  - Investment of 158 Mio. AED results in production of 13.2 Mio. m^3 of irrigation water (drip quality) at LCOS 0.70 AED per m^3 (Cost of grey water treatment)
  - 200 Mio. AED investment for vacuum WW transportation results to 0.89 AED/m^3

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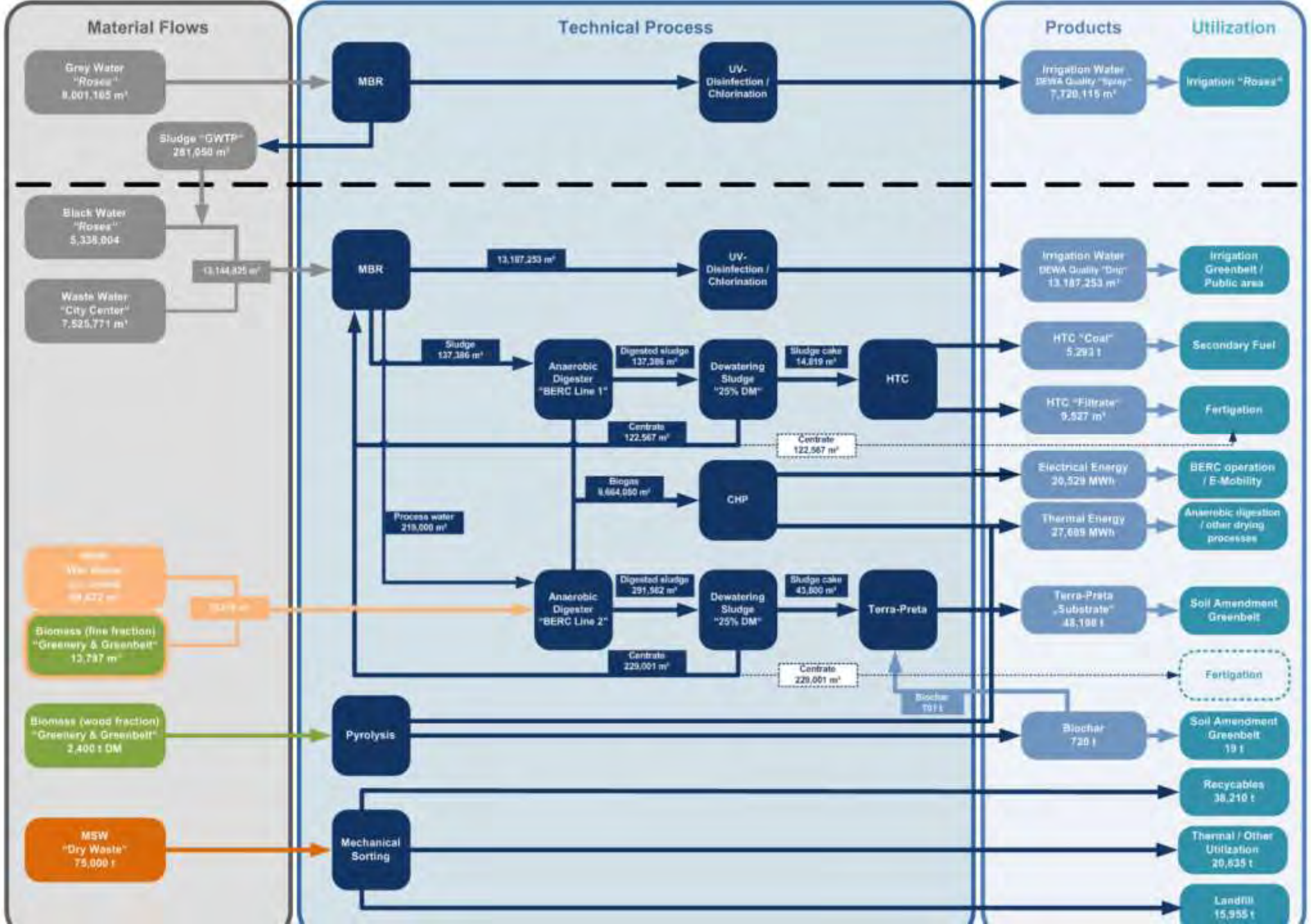
Sustainability Impacts of BERC

- **Environmental Sustainability**
  - Production of 5,293t of HTC coal and 9,527m³ of nutrient-rich centrate for fertigation.
  - Production of 48,198 tons of high valuable "Terra Preta"
  - GHG abatement of **138,000t CO_{2e}** by secondary fuel (HTC) production (**146,000MWh/a**)
  - GHG abatement of **12,500t CO_{2e}** by avoided soil imports and **10,700t CO_{2e}** by avoided mineral fertilizer
- **Economic Sustainability**
  - Investment of 11.7 Mio. AED results in production of 48,180 m³ of Terra Preta at LCOS 65 AED/m³ with a estimated profit of 1,000 AED per m³
  - Investment of 12.8 Mio. AED results in production of 6,000t of HTC coal at LCOS 198 AED/t per m


Material Flows
Technical Process
Products
Utilization
Grey Water "Roses" 8,001,165 m³
Sludge "GWTP" 281,050 m³
Black Water "Roses" 5,338,004
13,144,835 m³
Waste Water "City Center" 7,525,771 m³
Biomass (fine fraction) "Greenery & Greenbelt" 13,787 m³
Biomass (wood fraction) "Greenery & Greenbelt" 2,400 t DM
MSW "Dry Waste" 75,000 t
MBR
UV-Disinfection / Chlorination
MBR
13,187,253 m³
UV-Disinfection / Chlorination
Sludge 137,386 m³
Anaerobic Digester "BERC Line 1"
Digested sludge 137,386 m³
Dewatering Sludge "25% DM"
Sludge cake 14,819 m³
HTC
Centrate 122,567 m³
Centrate 122,567 m³
Biogas 9,664,050 m³
CHP
Process water 219,000 m³
Anaerobic Digester "BERC Line 2"
Digested sludge 291,562 m³
Dewatering Sludge "25% DM"
Sludge cake 43,800 m³
Terra-Preta
Centrate 229,001 m³
Centrate 229,001 m³
Biochar 721 t
Pyrolysis
Mechanical Sorting
Irrigation Water DEWA Quality "Spray" 7,720,115 m³
Irrigation "Roses"
Irrigation Water DEWA Quality "Drip" 13,187,253 m³
Irrigation Greenbelt / Public area
HTC "Coal" 5,293 t
Secondary Fuel
HTC "Filtrate" 9,527 m³
Fertigation
Electrical Energy 20,529 MWh
BERC operation / E-Mobility
Thermal Energy 27,689 MWh
Anaerobic digestion / other drying processes
Terra-Preta „Substrate" 48,100 t
Soil Amendment Greenbelt
Fertigation
Biochar 720 t
Soil Amendment Greenbelt 19 t
Recycables 38,210 t
Thermal / Other Utilization 20,835 t
Landfill 15,955 t

Greywater

8 million m3
From Roses

Membrane Bioreactor

UV Disinfection + Chlorination

7.7 million m3 DEWA quality spray irrigation for Roses

Greywater sludge

Blackwater

&

Wastewater

5.3 million m3
From Roses
87.5million m3
From City Centre

Membrane Bioreactor

UV Disinfection + Chlorination

13.1 million m3 DEWA quality spray irrigation for Greenbelt and landscape

Greywater sludge

Anaerobic
Digester BERC
Line 1

Digested
Sludge

Dewatering Sludge

Sludge
Cake

H.T.C.Coal 5.3 tonnes

Fuel

From Anaerobic
Digester BERC Line 2

Biogas

Thermal Energy
28,000 MWh

Biogas

Electrical Energy
20,000 MWh

MSW
Wet Waste
60,000 m3

Biomass
from
Open space
and Green
belt
13,800m3

Anaerobic
Digester BERC
Line 1

Digested
Sludge
290,000m3

Sludge Cake

Soil and
Biochar

Wood Biomass
from
Open space
and Green
Belt
2400t

Terra pyrolisis

Biochar

Soil Additives and Amendments in Landscape
59,000t

MSW
Dry Waste
75,000t

Mechanical Sorting

Sorted

Recyclables

Thermal/
Other uses 37,000t

MFA Results

- Assumption: Source separated (dry & wet fraction) MSW collection per vacuum (ENVAC)
  - Input: 175t/d dry MSW for sorting and recycling
  - Input: 175t/d wet MSW + 40t/d greenery residues for anaerobic digestion

K&A Planning Parameter for MSW	t/day	t/a
Desert Rose - Residential Parts	233,3	85.158
Desert Rose - City Centre - excl. Residential	68,8	25.113
Public Facility	44,1	16.097
Total (Based on ENVAC)	346,21	126.368
Planning Parameter BERC	**350,00**	**127.750**
Organic Residue from green belt and landscape gardening	40,00	14.600

MSW - Composition - Planning Parameter BERC			
Desert Rose - Combined	350	t/d	Waste components
Type of material	t/d	t/a	
Organic matter (excl. Agricultural Residues from Greenbelt)	175,00	63.875	50,0%
Wood	1,75	639	0,5%
Plastic	73,50	26.828	21,0%
Metals	14,00	5.110	4,0%
Glass	14,00	5.110	4,0%
Textile	7,00	2.555	2,0%
Paper / Cardboard	59,50	21.718	17,0%
Sand / stones	1,75	639	0,5%
Others	3,50	1.278	1,0%
Sum	350	127.750	100%

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MFA Results – MSW Dry Fraction

Levelised Cost of Service (sorting and recycling) of 156 AED/t (<u>without revenues</u>)

Average income of 365AED/t and **<u>positive contribution margin of 209AED/t.</u>**

Capital Expenditure - CAPEX

Position		Amount/Piece	Price/Piece	Sum	
			€	€	AED
A	**Sub-Total CAPEX**			**14.318.346 €**	**58.234.861 AED**
A.1	Preliminaries/Planing			642.892 €	2.614.738 AED
A.2	Contingencies			143.183 €	582.347 AED
B	**Total CAPEX**			**15.104.421 €**	**61.431.946 AED**

Operational Expenditure - OPEX

Position		Amount	Price/unit	Sum	
			€	€	AED
1	**Consumabels**				
	Electricity	6.090.727 kWh	0,09 €	569.066 €	2.314.476 AED
	Gas	22.759 kWh	0,098 €	2.230 €	9.071 AED
	Operating materials			138.000 €	561.267 AED
	Machine costs (fuel for wheel loader, etc.)			161.600 €	657.251 AED
	Disposal costs	15.955 t	18,00 €	287.200 €	1.168.085 AED
2	**Maintenance**				
	Services and Spare Parts			408.300 €	1.660.617 AED
	Insurance			72.900 €	296.495 AED
3	**Labor**				
	Manager	0,5	146.000 €	73.000 €	296.902 AED
	Administration, scale/secretary	2	44.000 €	88.000 €	357.909 AED
	Plant manager	1	44.000 €	44.000 €	178.955 AED
	Mechanic	2	44.000 €	88.000 €	357.909 AED
	Shift manager/Electric	2	44.000 €	88.000 €	357.909 AED
	Manager machinery/Mechanic	2	44.000 €	88.000 €	357.909 AED
	Sorting staff	24	15.000 €	360.000 €	1.464.174 AED
	Loader driver	2	25.000 €	50.000 €	203.358 AED
	Truck driver	2	25.000 €	50.000 €	203.358 AED
C	**Total OPEX**			**2.568.296 €**	**10.445.646 AED**
D	**Total OPEX - 50 year intervall**			**128.414.813 €**	**522.282.305 AED**
E	**TOTEX - 50 year intervall**			**143.519.234 €**	**583.714.251 AED**
F	**Levelised Cost**				
F.1	LC of treated waste per t			**38,27 €**	**155,66 AED**
G	**Revenues - Secondary Raw Materials**				
G.1	Annual Revenues	58.950 t		**5.289.000 €**	21.511.156 AED
G.2	Revenues - 50 year intervall	2.947.500 t		**264.450.000 €**	**1.075.557.818 AED**

MFA Results – Dual Pipe Vacuum Collection

- Pre-requiste for water, nutrient and material re-utilisation
- Levelised Cost of WW Transportation of 0.89 AED/m³ (including comprehensive real-time monitoring)
- System congruent to MSW collection system and energy efficient

Capital Expenditure - CAPEX

Position		Amount/Piece	Price/Piece	Sum	
			€	€	AED
A	**Sub-Total CAPEX**			**42,650,000 €**	**173,463,948 AED**
A.1	Preliminaries/Planing (0% of Sub-Total CAPEX)	0%		- €	- AED
A.2	Contingencies (15% of Sub-Total CAPEX)	15%		6,397,500 €	26,019,592 AED
B	**Total CAPEX**			**49,047,500 €**	**199,483,540 AED**

Operational Expenditure - OPEX

Position		Amount	Price/unit	Sum	
			€	€	AED
1	**Consumabels**				
	Electricity	6,514,494 kWh	0.09 €	608,659 €	2,475,508 AED
2	**Maintenance**				
	Services and Spare parts (3% of the Sub-Total Capex)	3%	42,650,000 €	1,279,500 €	5,203,918 AED
3	**Labor**				
	Manager	0.25	146,000 €	36,500 €	148,451 AED
	Technicians	0.25	44,000 €	11,000 €	44,739 AED
	Operators	0.25	44,000 €	11,000 €	44,739 AED
	Workers unskilled	0.25	15,000 €	3,750 €	15,252 AED
C	**Total OPEX**			**1,950,409 €**	**7,932,606 AED**
D	**Total OPEX - 50 year intervall**			**97,520,453 €**	**396,630,312 AED**
E	**TOTEX - 50 year intervall**			**146,567,953 €**	**596,113,851 AED**
F	**Levelised Cost - 50 year intervall**				
F.1	LC of pumped water per m^3			**0.22 €**	**0.89 AED**

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MFA Results – Grey Water

- Grey Water **treatment and re-utilisation**
  - 14 decentralised GWTP close to MSW vacuum stations with low CAPEX (excluding civil work)
  - Levelised cost of Treatment at 1.06AED/m³ or levelised costs of 1,10AED/m³ for TSE (DEWA Spray).

Capital Expenditure - CAPEX

Position		Amount/Piece	Price/Piece	Sum	
			€	€	AED
A	**Sub-Total CAPEX**			**25,000,000 €**	**101,678,750 AED**
A.1	Preliminaries/Planing (0% of Sub-Total CAPEX)	0%			- AED
A.2	Contingencies (15% of Sub-Total CAPEX)	15%		3,750,000 €	15,251,813 AED
B	**Total CAPEX**			**28,750,000 €**	**116,930,563 AED**

Operational Expenditure - OPEX

Position		Amount	Price/unit	Sum	
			€	€	AED
1	**Consumabels**				
	Electricity	5,108,283 kWh	0.09 €	477,275 €	1,941,148 AED
	Operating material (Chlorine, NaOCl, Citric acid)			226,667 €	921,887 AED
2	**Maintenance**				
	Services and Spare parts (3% of the Sub-Total Capex)	3%	25,000,000	750,000 €	3,050,363 AED
3	**Labor**				
	Manager	0.25	146,000 €	36,500 €	148,451 AED
	Technicians	0.25	44,000 €	11,000 €	44,739 AED
	Operators	0.25	44,000 €	11,000 €	44,739 AED
	Workers unskilled	0.25	15,000 €	3,750 €	15,252 AED
C	**Total OPEX**			**1,516,191 €**	**6,166,577 AED**
D	**Total OPEX - 50 year intervall**			**75,809,565 €**	**308,328,873 AED**
E	**TOTEX - 50 year intervall**			**104,559,565 €**	**425,259,436 AED**
F	**Levelised Cost - 50 year intervall**				
F.1	LC of treated grey water per m^3			**0.26 €**	**1.06 AED**
F.2	LC of irrigation water per m^3 (Quality "Spray)			**0.27 €**	**1.10 AED**

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MFA Results – MSW Wet Fraction

2 Anaerobic Digestion Line – Heart of BERC – Energy provider for energy autarky

- Levelised cost of sludge treatment of 64.50 AED/m³ **or**
- Levelised costs of biogas of 0,52 AED/m³ **or**
- Levelised costs of electricity of 0.25 AED/kWh

Capital Expenditure - CAPEX

Component		Amount/Piece	Price/Piece	Sum	
			€	€	AED
A	**Sub-Total CAPEX**			**19,100,000 €**	**77,682,565 AED**
A.1	Preliminaries/Planing (0% of Sub-Total CAPEX)				- AED
A.2	Contingencies (15% of Sub-Total CAPEX)			2,865,000 €	11,652,385 AED
B	**Total CAPEX**			**21,965,000 €**	**89,334,950 AED**

Operational Expenditure - OPEX

Component		Amount	Price/unit	Sum	
			€	€	AED
1	**Consumabels**				
	Operating material (Polymer etc.)			170,000 €	691,416 AED
2	**Maintenance**				
	Services and Spare parts	3%	19,100,000	573,000 €	2,330,477 AED
3	**Labor**				
	Manager	0.25	146,000 €	36,500 €	148,451 AED
	Technicians	0.25	44,000 €	11,000 €	44,739 AED
	Operators	0.25	44,000 €	11,000 €	44,739 AED
	Workers unskilled	0.25	15,000 €	3,750 €	15,252 AED
C	**Total OPEX**			**805,250 €**	**3,275,073 AED**
D	**Total OPEX - 50 year intervall**			**40,262,500 €**	**163,753,627 AED**
E	**TOTEX - 50 year intervall**			**62,227,500 €**	**253,088,577 AED**
F	**Levelised Cost - 50 year intervall**				
F.1	LC of treated sludge and biowaste per m³			**15.86 €**	**64.50 AED**
F.2	LC of produced biogas per m³			**0.13 €**	**0.52 AED**
F.3	LC of produced electricity per kWh			**0.06 €**	**0.25 AED**
F.4	LC of produced heat per kWh			**0.05 €**	**0.19 AED**

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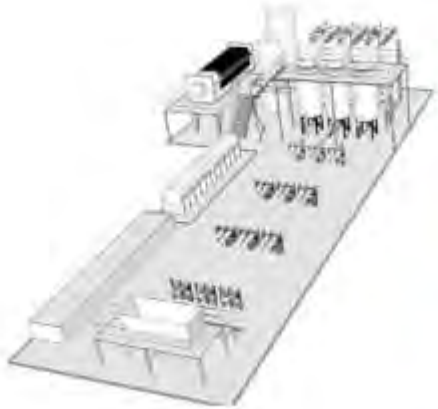
MFA Results – MSW Wet Fraction

Hydro Thermal Carbonization (HTC Technology)

- HTC process suitable to stabilize, sterilize and utilize (potentially contaminated) digestate
  - Acceleration of **natural coal generation** within 2 hours in closed reactor at 200°C and >20 bar pressure
  - HTC filtrate is suitable as low pollutant, liquid fertilizer according to the German fertilizer law.
  - The produced HTC-coal (capsuled the contaminations from waste water sludge), with a calorific value of around 11MJ/kg, can be marketed as secondary fuel, e.g. in cement industry.
  - Example based on TerraNova® HTC reactor with an annual treatment capacity of 40.000 t of sewage sludge (25% DM) applied for planning.
  - Total area demand of the HTC plant within the BERC sums up to 1,000 m².

HTC (sludge from line 1)		Input HTC	HTC coal	HTC filtrate	Input HTC	HTC coal	HTC filtrate
		per day			per year		
Sludge cake (25% DM) / HTC products	t or m³	41	15	26	14,819	5,293	9,527
Thermal energy demand	kWh	3,248			1,185,520		
Electrical energy demand	kWh	568			207,466		
Heat value	kWh		44,309			16,172,822	



Economic Pre-Evaluation - HTC Technology

Levelised cost of HTC coal production of 198 AED/t (LC of Sludge Disposal)

Levelised cost HTC filtrate amount to 114 AED/m³

Capital Expenditure - CAPEX

Position		Amount/Piece	Price/Piece	Sum	
			€	€	AED
A	**Sub-Total CAPEX**			**2,640,000 €**	**10,737,276 AED**
A.1	Preliminaries/Planing (0% of Sub-Total CAPEX)			- €	- AED
A.2	Contingencies (15% of Sub-Total CAPEX)			396,000 €	1,610,591 AED
B	**Total CAPEX**			**3,036,000 €**	**12,347,867 AED**

Operational Expenditure - OPEX

Position		Amount	Price/unit	Sum	
			€	€	AED
1	**Consumabels**				
	Operating material (catalyst)			25,000 €	101,679 AED
2	**Maintenance**				
	Services	5%	2,640,000	132,000 €	536,864 AED
	Spare parts	1%	2,640,000	26,400 €	107,373 AED
3	**Labor**				
	Operators	0.5	44,000	22,000 €	89,477 AED
C	**Total OPEX**			**205,400 €**	**835,393 AED**
D	**Total OPEX - 50 year intervall**			**10,270,000 €**	**41,769,631 AED**
E	**TOTEX - 50 year intervall**			**13,306,000 €**	**54,117,498 AED**
F	**Levelised Cost 50 year intervall**				
F.1	LC of HTC Coal per ton			**49 €**	**198 AED**
F.2	LC of HTC Filtrate per m³			**28 €**	**114 AED**

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MFA Results – MSW Wet Fraction

Terra Preta Production

Terra-Preta process is processing and refining of the digestate from BERC line 2

- TP used for the improvement and fertilization of soils and long-term humus accumulation in greenbelt.
- Annual generation of 50,000 m^3 TP humus substrate likely to improve soil humus content by 1% (annually) for approx. 600 ha (long-term soil improvement) and support CO_2 sequestration
- The required area for the TP-Plant within BERC is approximately 4,500 m^2.

Capital Expenditure - CAPEX

Position		Amount/Piece	Price/Piece €	Sum €	Sum AED
A	**Sub-Total CAPEX**			**2,308,886 €**	**9,390,586 AED**
A.1	Preliminaries/Planing (10% of Sub-Total CAPEX)			230,889 €	939,059 AED
A.2	Contingencies (15% of Sub-Total CAPEX)			346,333 €	1,408,588 AED
B	**Total CAPEX**			**2,886,108 €**	**11,738,232 AED**

Operational Expenditure - OPEX

Position		Amount	Price/unit €	Sum €	Sum AED
1	**Consumabels**				
	Operating materials (Microorganisms and fermentation bacteria, minerals, etc.)	1,100 m^3	75 €	82,500 €	335,540 AED
	Machine costs per operating time in hours (wheel loader, screening plant, etc.)	1,500 h	15.00 €	22,500 €	91,511 AED
2	**Maintenance**				
	Services (5,5% of the Sub-Total Capex)	5.5%	2,308,886 €	126,989 €	516,482 AED
	Spare Parts (1% of the Sub-Total Capex)	1%	2,308,886 €	23,089 €	93,906 AED
	License fees for Palaterra-Initial (lump sum)			193,600 €	787,400 AED
3	**Labor**				
	Manager	1	146,000 €	146,000 €	593,804 AED
	Operators	2	44,000 €	88,000 €	357,909 AED
	Workers unskilled	2	15,000 €	30,000 €	122,015 AED
C	**Total OPEX**			**712,678 €**	**2,898,567 AED**
D	**Total OPEX - 50 year intervall**			**35,633,880 €**	**144,928,333 AED**
E	**TOTEX - 50 year intervall**			**38,519,987 €**	**156,666,565 AED**
F	**Levelised Cost**				
F.1	LC of Terra-Preta per m^3			**15.99 €**	**65.03 AED**

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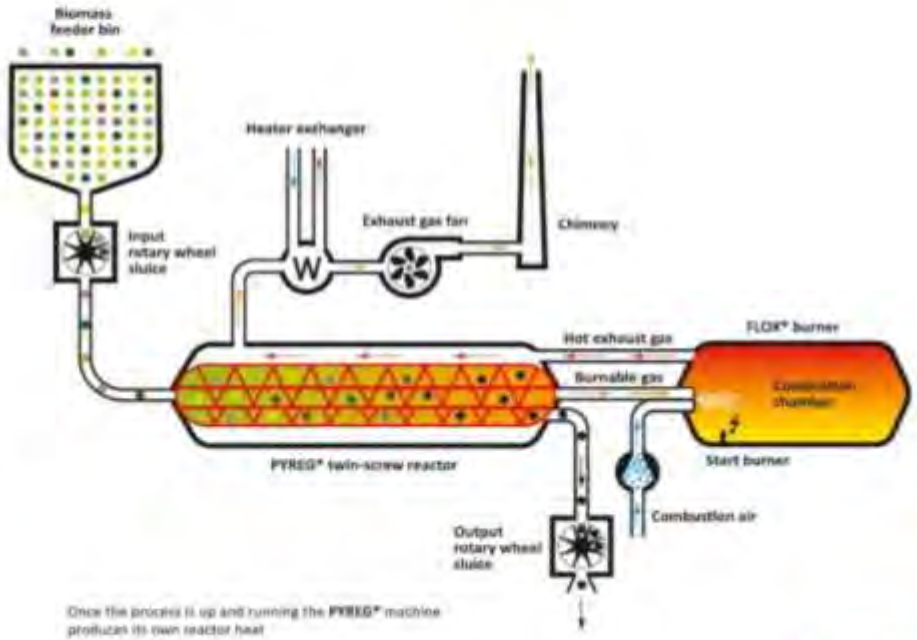
MFA Results – Biochar

Biochar Production

- Biochar production vital for Terra Preta and utilisation of ligneous residue from greenbelt
  - Pyrolysis process with excess heat (support heat demand for sludge dewatering)
  - Plug-Play solutions with low space and maintenance demand
  - Biochar is multi-use: soil amendment (TP), food additive for lifestock, etc
  - Biochar as a long term carbon sequestration strategy for INDC/NAMA
  - Example based on PYREG Technology



Economic Pre-Evaluation - Biochar Production

Levelised cost of biochar of 613 AED/t

Market sales (certified) up to 4,000AED/t

Capital Expenditure - CAPEX

Position		Amount/Piece	Price/Piece	Sum	
			€	€	AED
A	**Sub-Total CAPEX**			**874,182 €**	**3,555,428.58 AED**
A.1	Preliminaries/Planing (10% of Sub-Total CAPEX)			87,418 €	355,542.86 AED
A.2	Contingencies (15% of Sub-Total CAPEX)			131,127 €	533,314.29 AED
B	**Total CAPEX**			**1,092,727 €**	**4,444,285.73 AED**

Operational Expenditure - OPEX

Position		Amount	Price/unit	Sum	
			€	€	AED
1	**Consumabels**				
	Machine costs per operating time in hours (gasoline for wheel loader, etc.)	1,500 h	15.00 €	22,500.00 €	91,510.88 AED
2	**Maintenance**				
	Services (4% of the Sub-Total Capex)	4%	874,181.82 €	34,967.27 €	142,217.14 AED
	Spare parts (1% of the Sub-Total Capex)	1%	874,181.82 €	8,741.82 €	35,554.29 AED
3	**Labor**				
	Operators	0.5	44,000	22,000.00 €	89,477.30 AED
C	**Total OPEX**			**88,209.09 €**	**358,759.60 AED**
D	**Total OPEX - 50 year intervall**			**4,410,454.55 €**	**17,937,980.20 AED**
E	**TOTEX - 50 year intervall**			**5,503,181.82 €**	**22,382,265.93 AED**
F	**Levelised Cost - 50 year intervall**				
F.1	LC of Biochar per ton			**150.77 €**	**613.21 AED**

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ZE Results – BERC

Environmental Indicators

Solid Resource Management (MSW)	Total Amount of MSW treated	142.350 t/a
	Amount of organic residues treated by anaerobic digestion	74.825 t/a
	Utilisation ratio of organic residues	100%
	Amount of dry MSW treated	75.000 t/a
	Production of Secondary Raw Material from dry MSW fraction	32.810 t/a
	Production of Secondary Fuel from dry MSW fraction	20.835 t/a
	Amount of MSW to be disposed (excl. Contingency Reserve)	11.313 t/a
	Utilisation ratio of dry MSW fraction (including Contingency Reserve)	85%
Integrated Water Resource Management	Total Amount of Waste Water treated	20.907.368 m^3/a
	Production amount of irrigation water in the quality: "spray"	7.720.115 m^3/a
	Production amount of irrigation water in the quality: "drip"	13.187.253 m^3/a
	Total Amount of Sewage Sludge Treated in Anaerobic Digestion	418.436 m^3/a
	Total Utilisation ratio of Sewage Sludge	100%
	Current Utilisation rate of N (excl. Terra-Preta) - 52%	732 t/a
	Current Utilisation rate of N (excl. Terra-Preta) - 69%	245 t/a
Total energy recovery	Biogas	9.664.080 m^3/a
	Electrical Energy	20.529 MWh/a
	Thermal Energy	27.689 MWh/a
	Secondary Fuel	120.348 MWh/a
Total energy demand	Electrical Energy	29.022 MWh/a
	Thermal Energy	32.957 MWh/a
Space Demand BERC		78.750 m^2
Space Demand GWTPs (incl. Vacuum Stations)		14.000 m^2

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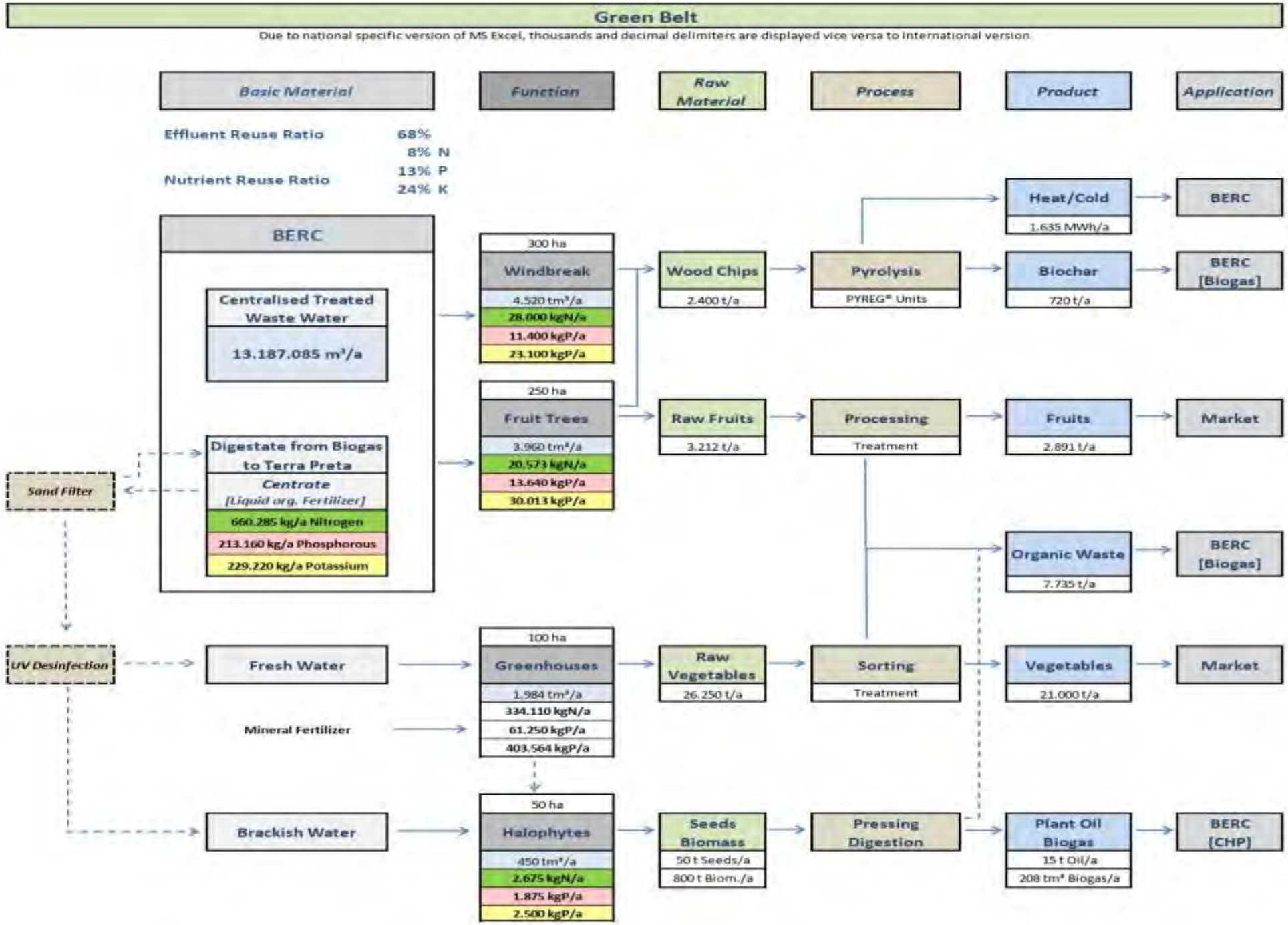
ZE Results – BERC

Economic Indicators	Position	Value
Total CAPEX		653.801.503 AED
Total OPEX/a		38.133.666 AED
Total Revenues/a		45.446.475 AED
Revenues / Economic value of secondary products per year	Recycables	20.677.635 AED
	RDF	848.595 AED
	HTC-Coal	215.425 AED
	Biochar	730.000 AED
	Terra-Preta	9.636.000 AED
	Electrical Energy	7.801.020 AED
	Thermal Energy	5.537.800 AED
Levelised Cost of BERC Services	LCOS Vacuum WW Transportation per m^3	0,89 AED
	LCOS Grey Water Treatment per m^3	1,06 AED
	LCOS Irrigation Water per m^3 (Quality "Spray)	1,10 AED
	LCOS Black Water Treatment per m^3	0,71 AED
	LCOS Irrigation Water per m^3 (Quality "Drip")	0,71 AED
	LCOS Sewage Sludge/Organic Residue Treatment per m^3	65 AED
	LCOS Biogas Production per m^3	0,52 AED
	LCOS Electricity Production per kWh	0,25 AED
	LCOS Heat Production per kWh	0,19 AED
	LCOS HTC Coal Production per ton	198 AED
	LCOS HTC Filtrate production per m^3	114 AED
	LCOS Terra-Preta Production per m^3	65 AED
	LCOS Biochar Production per ton	613 AED
	LCOS Treatment of Dry MSW Fraction per t	156 AED

MFA Results – Greenbelt



- Greenbelt: Ecological and Economical Self-Sustaining

		Treated Waste Water Reuse					Treated Waste Water Reuse							Fresh Water *(Treated Grey Water)*					Treated Brackish Ground Water			SUM
Item	Unit	Windbreak				Σ	Fruit trees						Σ	Greenhouses				Σ	Halophytes		Σ	
	Species	Mimosa	Date Palm	Tamarix	Eucalyptus		Olive	Mango	Fig	Pomegranate	Avocado	Citrus		Lettuce	Cucumber	Pepper	Tomato		Salicornia Bigelovii	Euphorbia Tiruccali		
Cropland	ha	100	40	80	80	300	50	50	30	20	20	80	250	25	25	25	25	100	25	25	50	700
Ø Water demand	m^3/ha/a	14.000	18.000	14.000	16.000		12.000	16.000	16.000	18.000	14.000	18.000		18.250	20.650	18.250	22.200		10.000	8.000		
Ø Water demand	tm^3/a	1.400	720	1.120	1.280	4.520	600	800	480	360	280	1.440	3.960	456	516	456	555	1.984	250	200	450	10.914
Ø Nitrogen demand	kg_N/ha/a	100	110	90	80		138	38	44	135	192	49		3.723	2.808	2.606	4.227		45	62		
Ø Nitrogen demand	kg_N/a	10.000	4.400	7.200	6.400	28.000	6.900	1.900	1.320	2.700	3.833	3.920	20.573	93.075	70.210	65.153	105.672	334.110	1.125	1.550	2.675	385.358
Ø Phosphorous demand	kg_P/ha/a	38	38	38	38		115	16	9	66	175	25		698	527	659	566		42	33		
Ø Phosphorous demand	kg_P/a	3.800	1.520	3.040	3.040	11.400	5.750	800	270	1.320	3.500	2.000	13.640	17.452	13.164	16.482	14.153	61.250	1.050	825	1.875	88.165
Ø Potassium demand	kg_K/ha/a	77	77	77	77		325	33	22	135	242	49		2.963	4.739	3.723	4.718		46	52		
Ø Potassium demand	kg_K/a	7.700	3.080	6.160	6.160	23.100	16.250	1.650	660	2.700	4.833	3.920	30.013	74.072	118.479	93.075	117.938	403.564	1.200	1.300	2.500	459.177
Ø Yield (Prunings/Wood)	t_{DM}/ha/a	8	1,5	6,5	7		0,8	1,3	0,8	1,2	1,5	1,5		0	0	0	0		0	0		
Ø Yield (Prunings/Wood)	t_{DM}/a	800	60	520	560	1.940	40	65	24	24	30	120	303	0	0	0	0	0	0	0	0	2.243
Ø Yield (Fruits/Crops)	t_{FM}/ha/a	0	6	0	0		9,7	8,5	11	8,9	9,7	20		150	350	150	400		0	0		
Ø Yield (Fruits/Crops)	t/a	0	240	0	0	240	485	425	330	178	194	1600	3.212	3.750	8.750	3.750	10.000	26.250		0	0	29.702
CAPEX	EUR	1.222.917	690.667	1.133.333	1.257.333	4.304.250	675.938	722.813	417.188	307.500	293.750	1.147.500	3.564.688	49.177.125	49.177.125	49.177.125	49.177.125	196.708.500	472.250	516.500	988.750	205.566.188
OPEX	EUR/a	400.291	164.349	321.614	326.188	1.212.441	438.300	444.054	267.576	180.605	178.730	715.673	2.224.938	4.428.673	4.494.131	4.580.755	4.503.526	18.007.085	495.090	485.063	980.153	22.424.617
OPEX (50 years)	EUR	20.014.540	8.217.440	16.080.678	16.309.384	60.622.042	21.914.984	22.202.694	13.378.810	9.030.258	8.936.483	35.783.665	111.246.893	221.433.673	224.706.530	229.037.736	225.176.307	900.354.246	24.754.505	24.253.153	49.007.658	1.121.230.838
Ø Turnover	EUR/a					0	488.480	473.155	299.088	233.488	216.010	890.440	2.600.661	6.375.000	7.000.000	9.375.000	6.200.000	28.950.000	3.300	83.200	86.500	31.637.161
Ø Turnover (50 years)	EUR	0	0	0	0	0	24.424.000	23.657.750	14.954.400	11.674.400	10.800.500	44.522.000	130.033.050	318.750.000	350.000.000	468.750.000	310.000.000	1.447.500.000	165.000	4.160.000	4.325.000	1.581.858.050
Profit/Loss Carryforward	EUR/a	-424.749	-178.162	-344.280	-351.334	-1.298.526	36.662	14.645	23.168	46.733	31.405	151.817	304.429	962.784	1.522.327	3.810.703	712.931	7.008.745	-501.235	-412.193	-913.428	5.101.220
Profit/Loss Carryforward	EUR/ha/a	-4.247	-4.454	-4.304	-4.392	-17.397	733	293	772	2.337	1.570	1.898	7.603	38.511	60.893	152.428	28.517	280.350	-20.049	-16.488	-36.537	234.019

ZE & Resilient
City

Desert Rose Hydroponic Visitor Center

- Growing plants in a water based, nutrient rich solution
- Plants mature up to 25% faster and produce up to 30% more than the same plants grown in soil
- Use less water than soil based plants because the system is enclosed

ZE & Resilient City

Land Utilisation *(Allocation of land)* [in ha]				
Waste Water Reuse		(Desalted) Brackish Water		
Windbreak	Fruit trees	Greenhouses	Halophytes	Total Area
300	250	100	50	700

Green Belt	50%	50%
	Food Production Area	Production of Raw Materials

ZE & Resilient City

Sustainability impact

- Total GHG Abatement estimate of 1,400,000 tons CO_{2e}
  - From solar energy of 620,000 tons CO_{2e}
  - Sustainable resource management of 75,000 tons CO_{2e}
  - Integrated water resource mgt of 80,000 tons CO_{2e}
  - Combined BERC and greenbelt of 208,700 tons CO_{2e}
  - Sustainable transport of 404,500 tons CO_{2e}
  - Sustainable landscape design of 11,880 tons CO_{2e}

- Reduction potential per capita - 8.75 tons of CO_{2e}/a or 43% reduction of current UAE capita (20 tons) GHG footprint

ZE & Resilient City

Annual cost-benefit impact

- Total annual cost-benefits of 334,690,000 AED
  - Arbitrage income from solar energy of 155,550,000 AED *(LCOE of solar 250AED/MWh compared to estimated 400 AED/MWh for fossil fuel based)*
  - Sustainable marketing of recyclables of 13,000,000 AED *(65,000tons/a with cross margin of 200AED/t)*
  - Avoided landfilling of organic residues of 16,500,000 AED *(103,000t/a (sludge and organic waste) with LCOS of 65AED/t compared to 225 AED/t landfill cost)*
  - Complete re-use of irrigation water of 73,500,000 AED *(21 Mio. m3 with LCOS of 0.70 AED/m3 and a 6x higher desalinated water cost)*
  - Market valuation of Terra Preta of 48,140,000 AED *(48.140 m3 with a profit of 1,000 AED/m^3)*
  - Cross-subsidized profit of greenbelt operation of 28,000,000 AED

SEMINÁRIO TÉCNICO ECONOMIA CIRCULAR

6 - 7 OUTUBRO

Muito obrigada!

☺

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UNIVERSIDADE LUSÓFONA

Faculdade de engenharia

AÇORES 2020

GOVERNO DOS AÇORES

PORTUGAL 2020

UNIÃO EUROPEIA