Technology Management & Innovation in the regional energy supply

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ECB – The Zero Emission Campus

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Energy und Agriculture

- **Energy use** for planting, irrigation, growing, harvesting, processing, storing, transport, sales and disposal

- **Energy potentials** through MFM in:
  Energy Efficiency
  Renewable Energy sources
  Waste ton Energy and Waste Water to energy
  Embedded Energy (fertilizer, agrochemicals, buildings)

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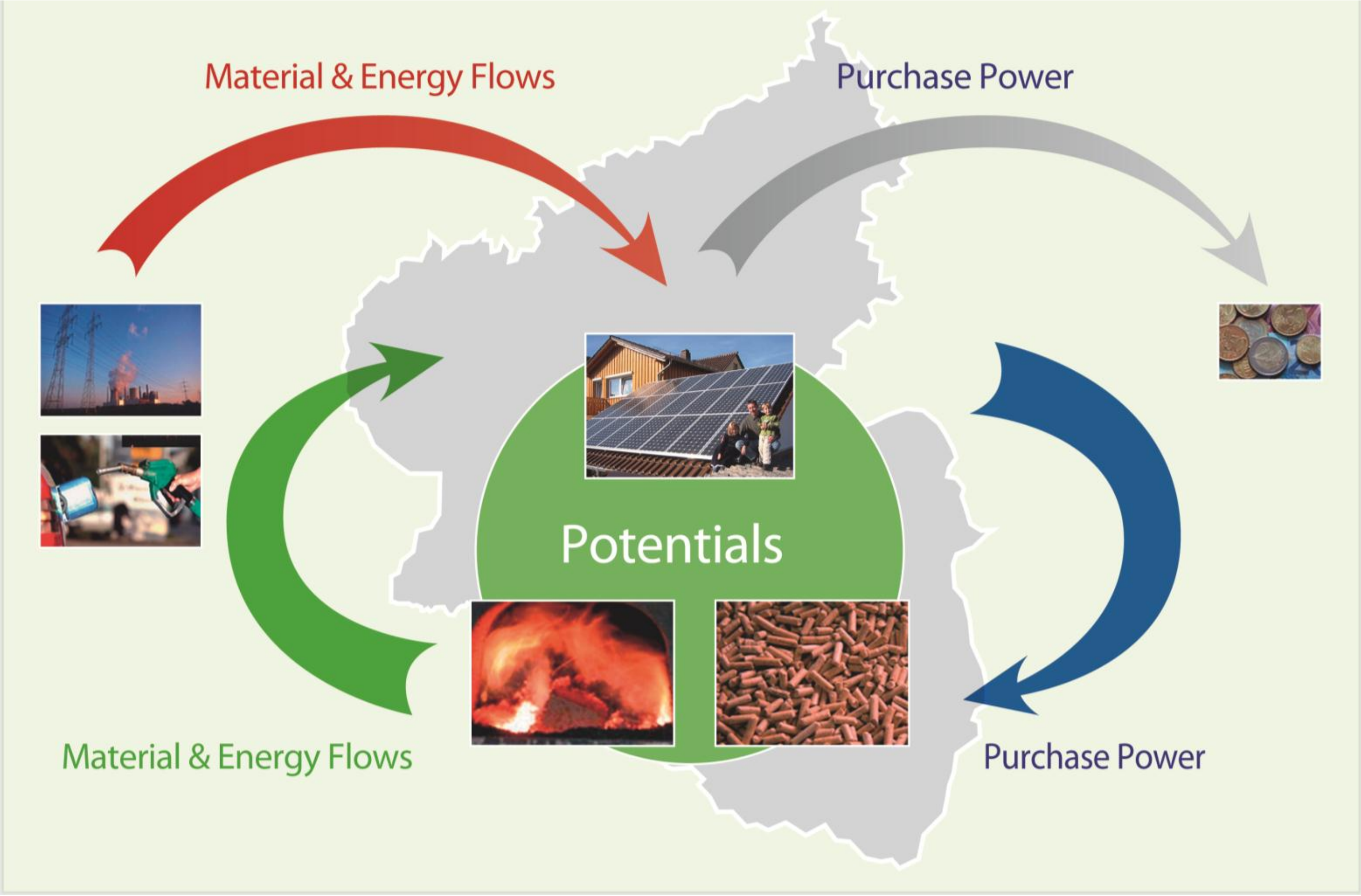
"Circular Economy" with MFM approach



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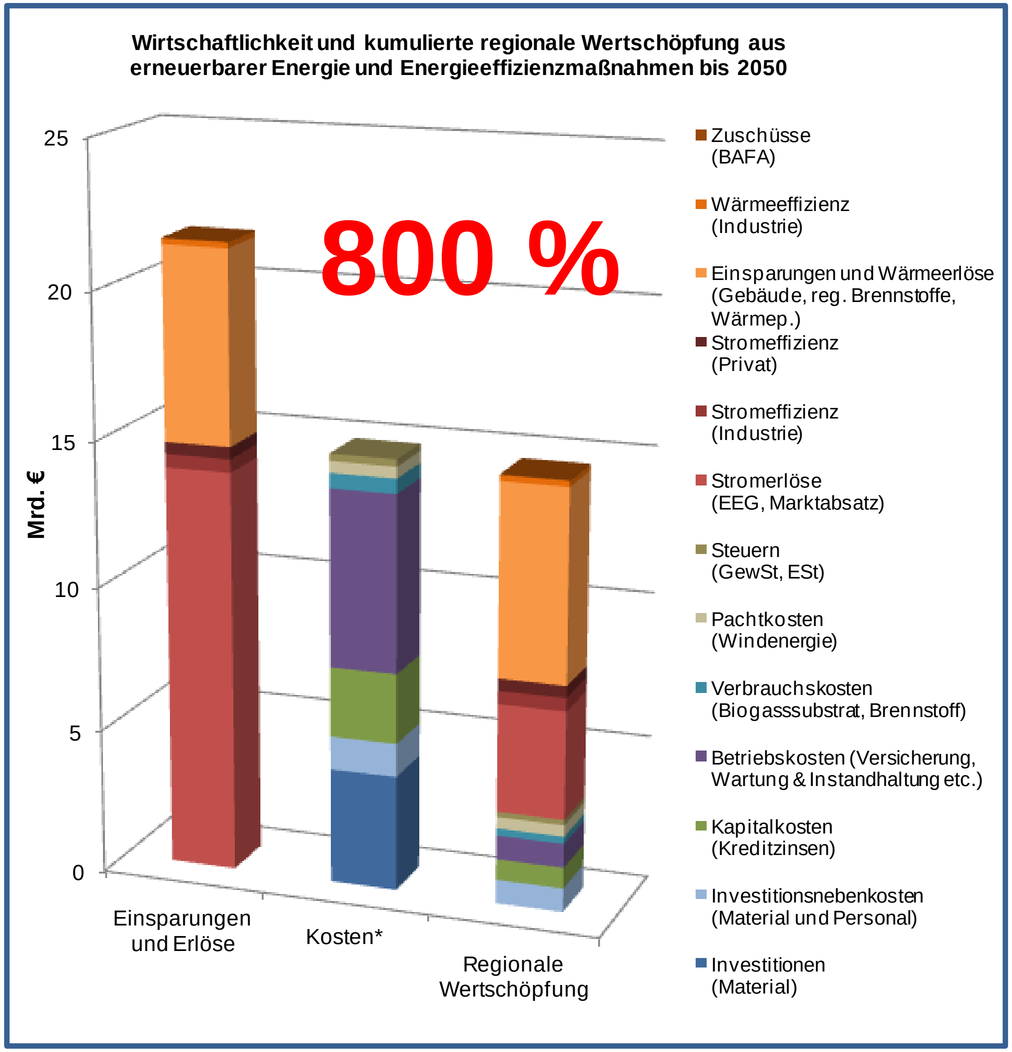
Monetary Flows of ZE Scenario (Electricity & Heat) until 2050 (Case Study Rhein-Hunsrück County)

Ausbau regenerativer Strom und Wärme 2050	Einsparungen und Erlöse	Kosten*	Regionale Wertschöpfung
Summe Umsätze	**21,60 Mrd. €**		
Summe Invest		**5,14 Mrd. €**	
Summe operative Kosten		**9,70 Mrd. €**	
Summe Kosten		**14,84 Mrd. €**	
Summe RWS			**14,64 Mrd. €**

*Kosten für industrielle Effizienzmaßnahmen nicht enthalten
Bei den privaten Stromeffizienzmaßnahmen nur Kosten für Umwälzpumpen aufgeführt

Regional Added Value until 2050:

Wind:	3,28 Mrd. €
Photovoltaik:	2,16 Mrd. €
Solar Thermal:	1,43 Mrd. €
Biomass:	2,11 Mrd. €
Geothermal:	0,18 Mrd. €
Optimised Buildings:	4,41 Mrd. €
Energy Efficiency:	1,07 Mrd. €



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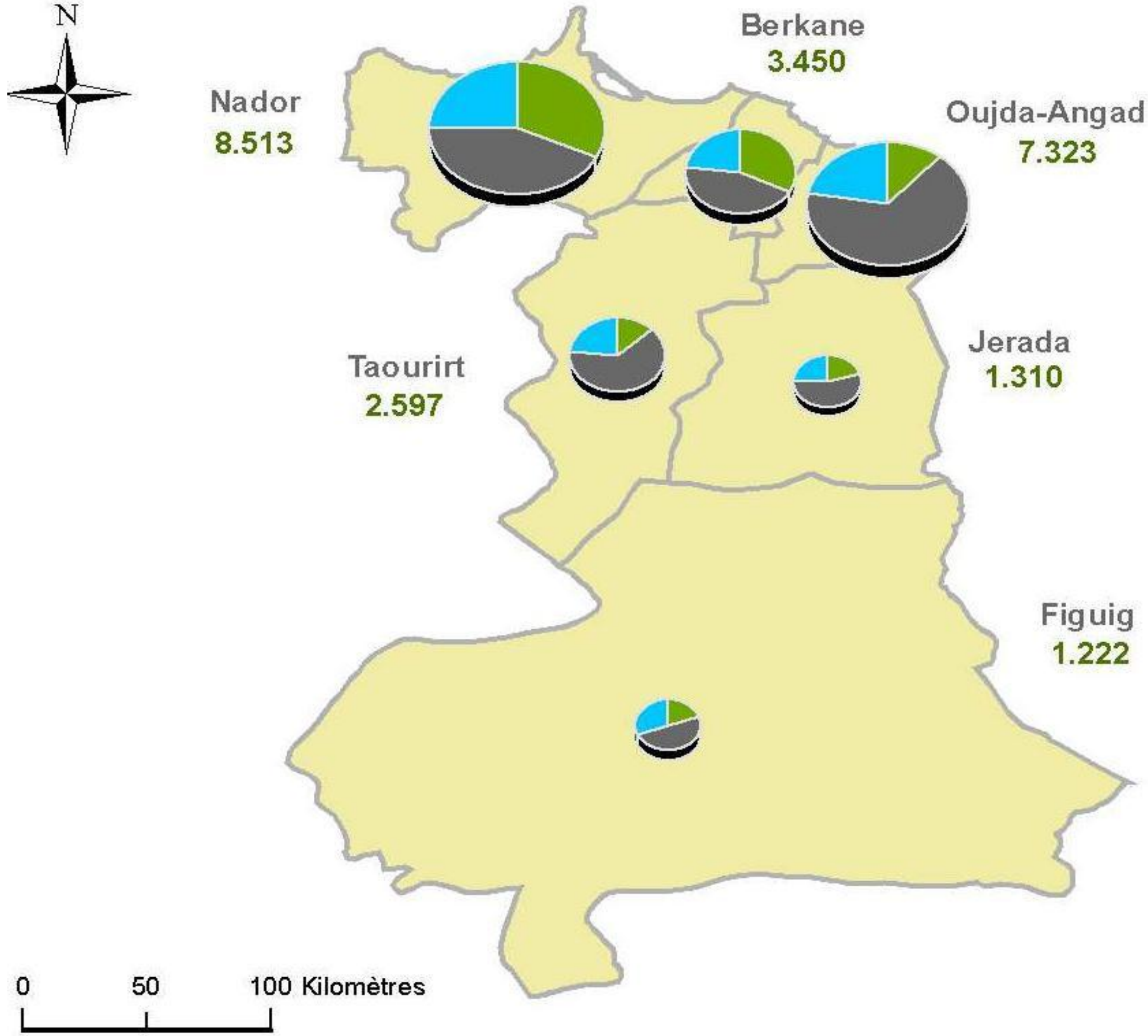

Potentiel énergétique issu de la biomasse [tep/a]

- Agriculture
- Déchets
- Eaux usées
- Provinces/préfectures
- 4.711 Potentiel énergétique total

Case studies energy and material recovery

- Examples from:
- **Cape Verde**

  100% RE with Water (desalination) and Energy Storage (freezer)

- **Morocco**

  Lowering production costs through biogas and fertilizer from process waste and manure

- **Sri Lanka**

  Biochar from Coconut Industry and Fertilizer from Sewage Sludge

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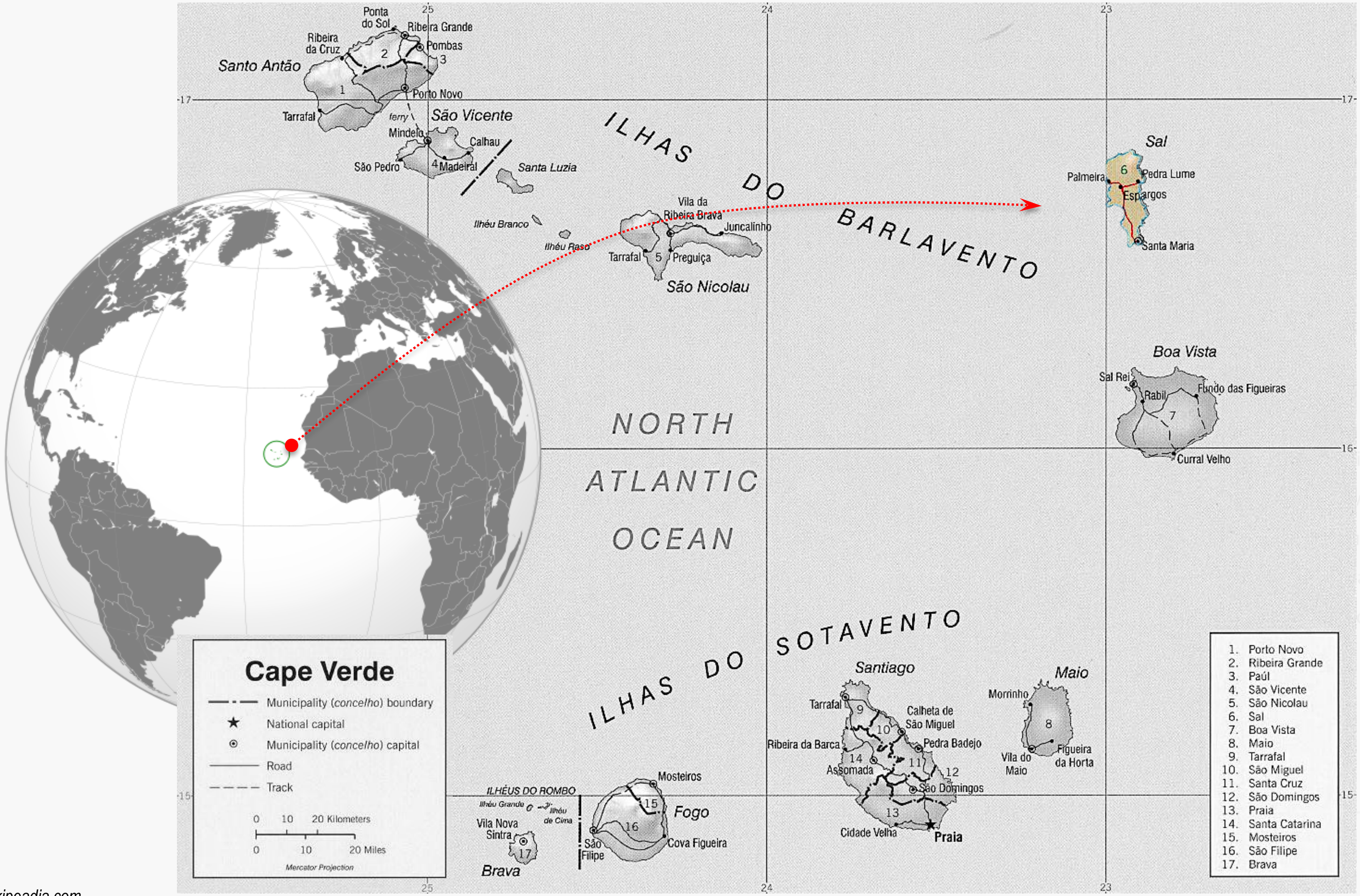
Case study: Sal, Cape Verde



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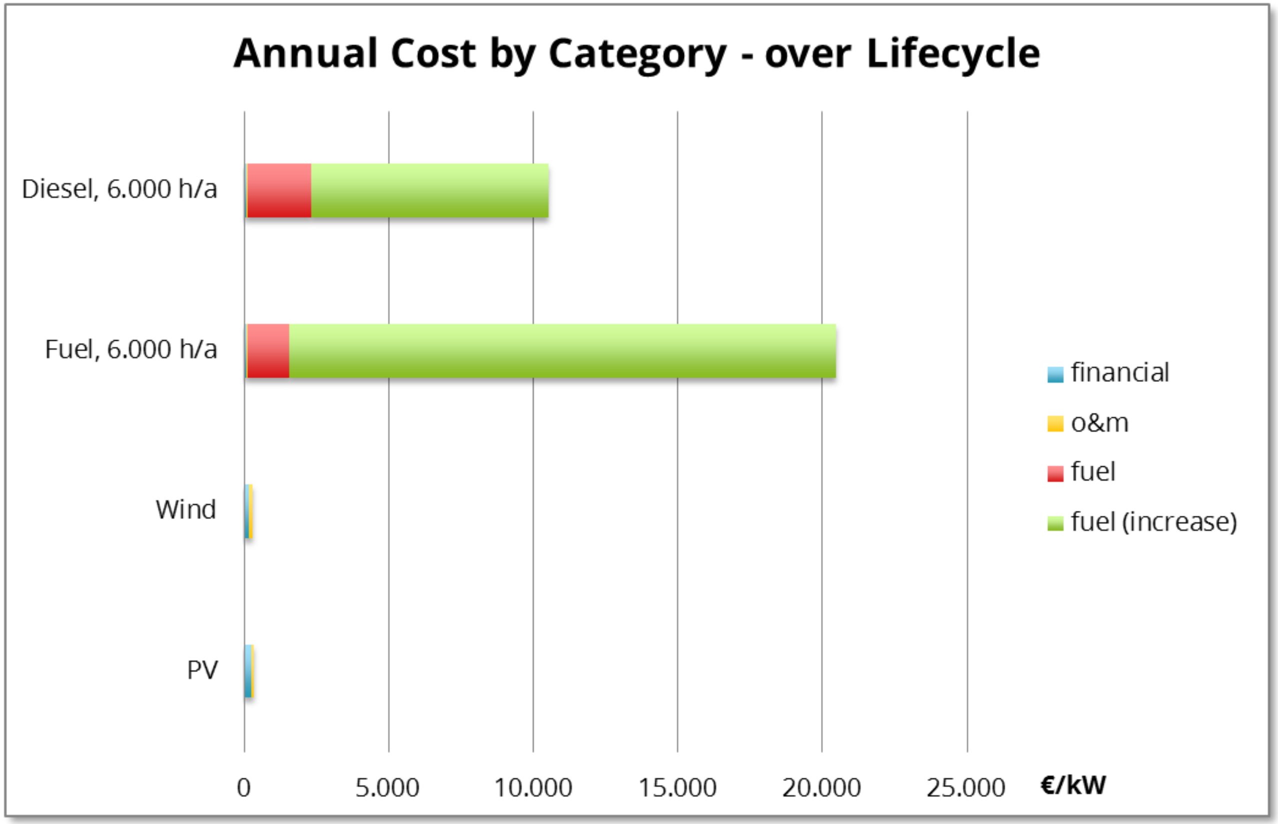
Investment Plan

- lifecycle cost is dominated by fuel cost and its increase



Assumptions

PV	3.400 €/kW
Wind	2.200 €/kW
Thermal Group	1.000 €/kW
Efficiency	30 %
Fuel Cost (act.)	0,71 €/l
Diesel Cost	1,09 €/l
Increase rate	15 %/a
	8,5 %/a
Service Time	6.000 h/a
Life Cycle	20 a

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Cabo Verde: RE as an option for the future

2500 MW = 600 %

- Saving 100 % on imported fuel in the long run by using a small part of the RE potentials
- Building an high efficiency agriculture based on water turned RE!
- Building a modern cooling logistics for fishery and vegetables based on RE
- Building a modern engineering and training society based on RE

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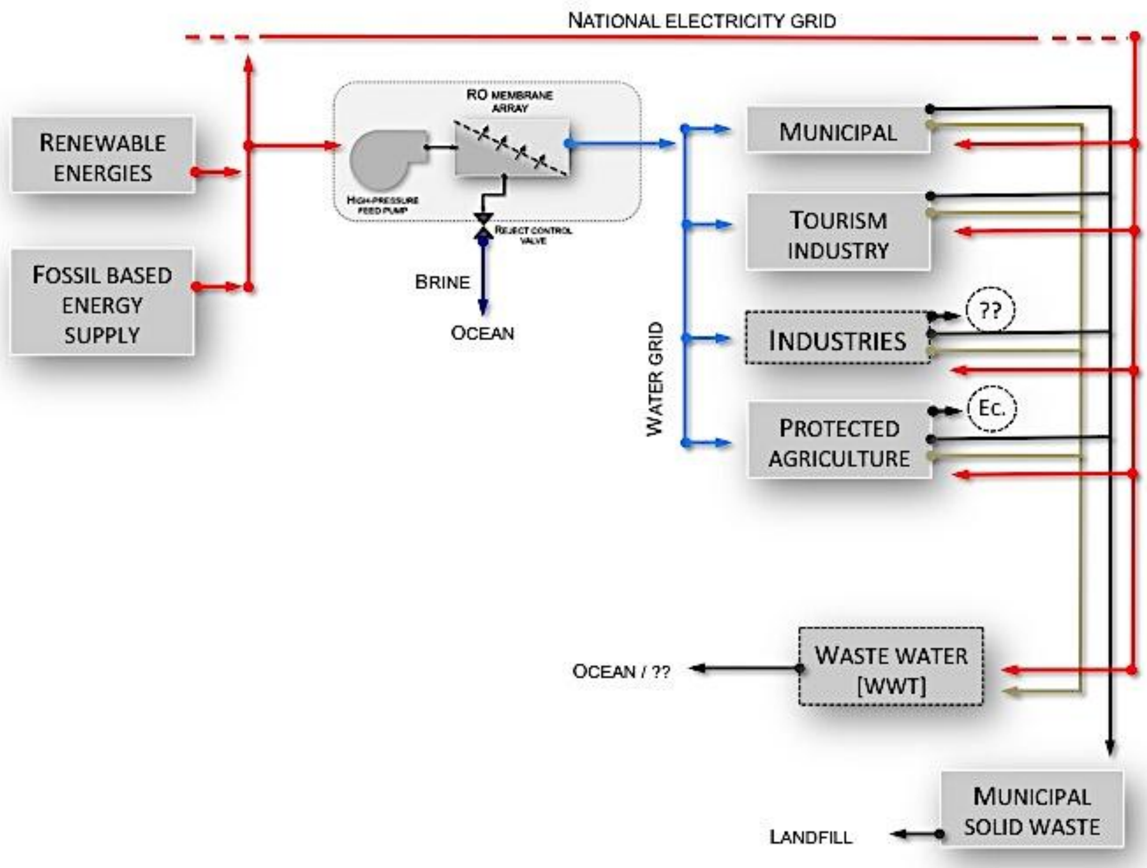
Case study: Sal, Cape Verde

- Status quo system



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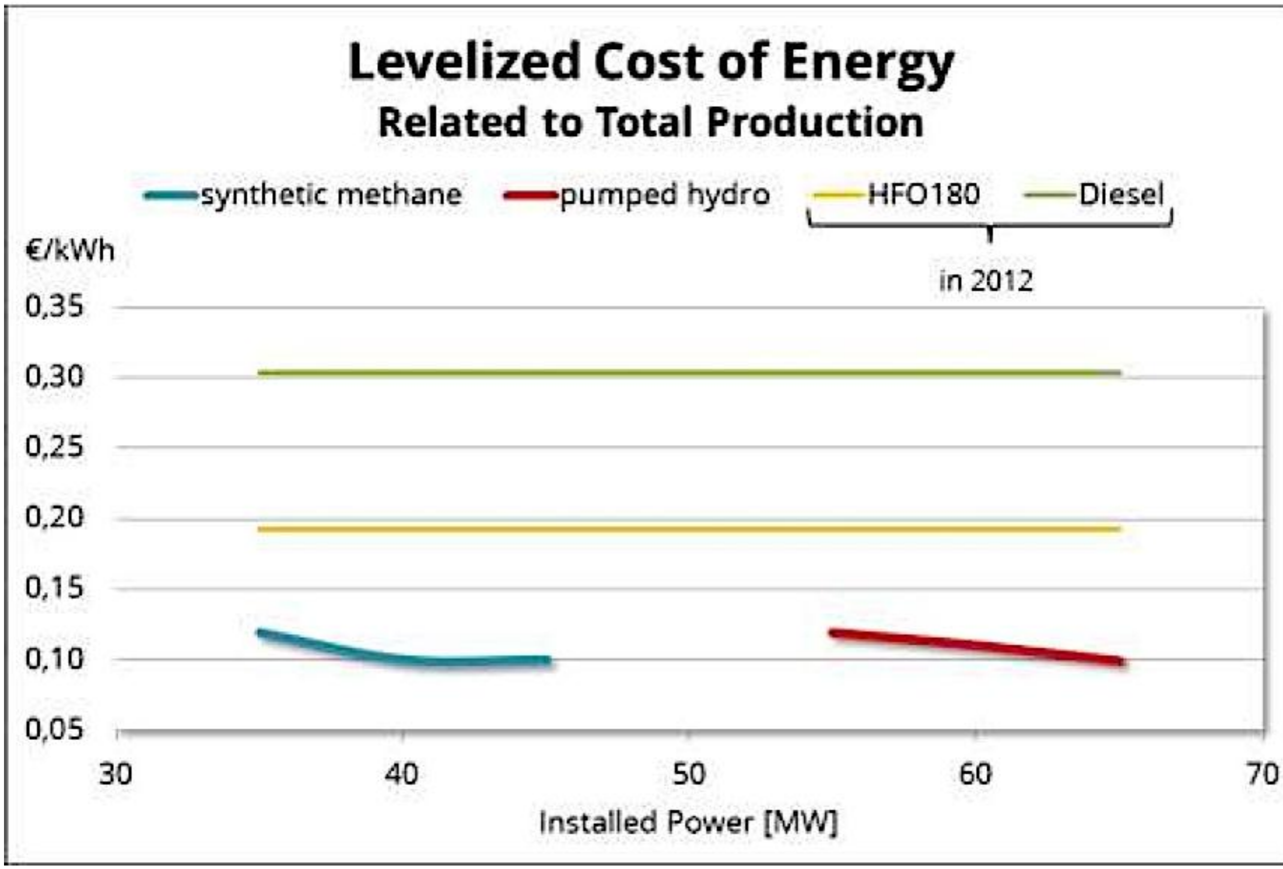
Case study: Sal, Cape Verde

- Lowering the LCOE



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Case study: Sal, Cape Verde

- Renewable Energies
  - Wind
  - PV
  - Biomass

- Demand$_{2020}$: 86 GWh/a
- Supply$_{2020}$:
  - SCENARIO-1: Pumped hydro
    145 GWh/a *[68% oversupply]*
  - SCENARIO-2: Synthetic methane
    127 GWh/a *[48% oversupply]*

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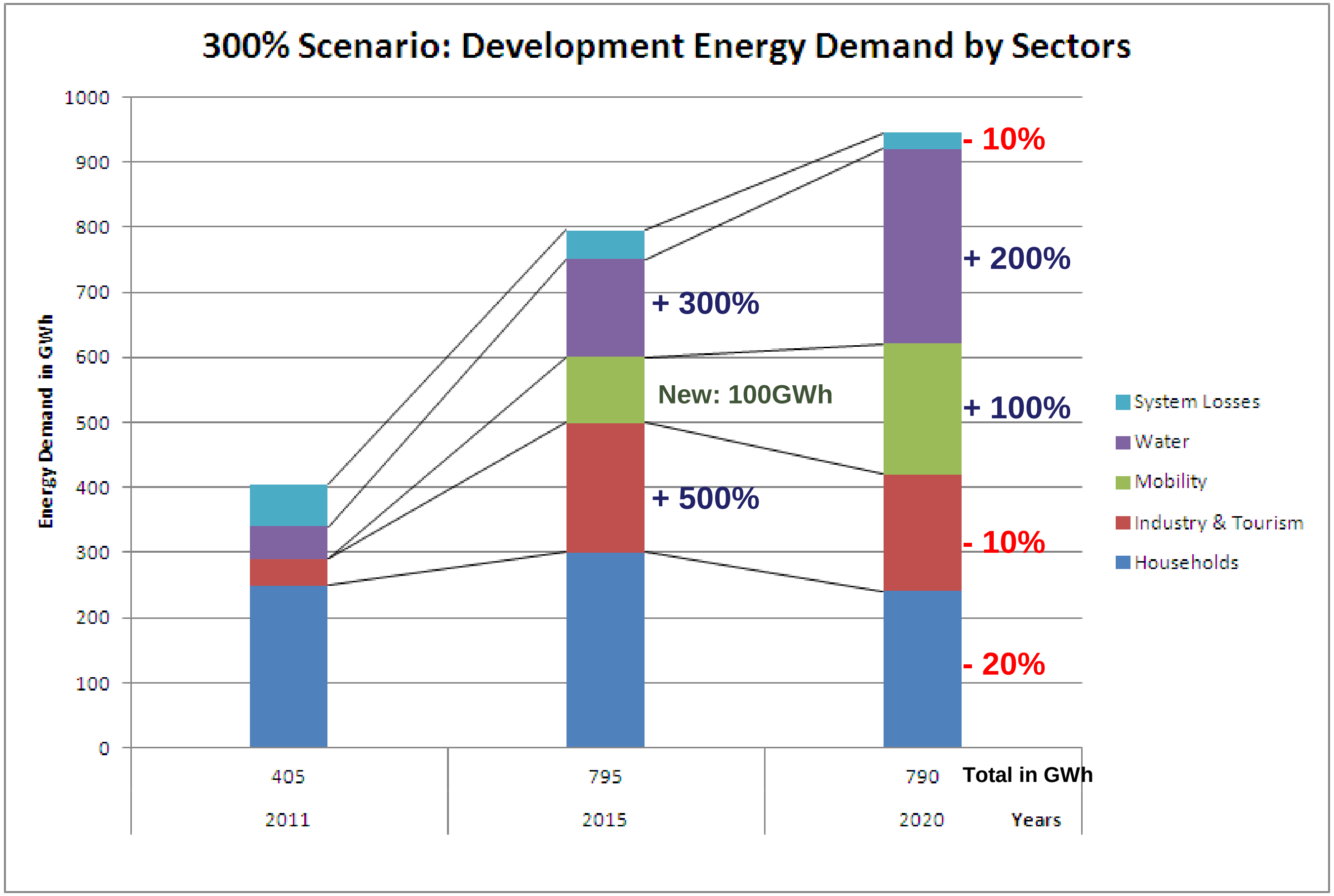

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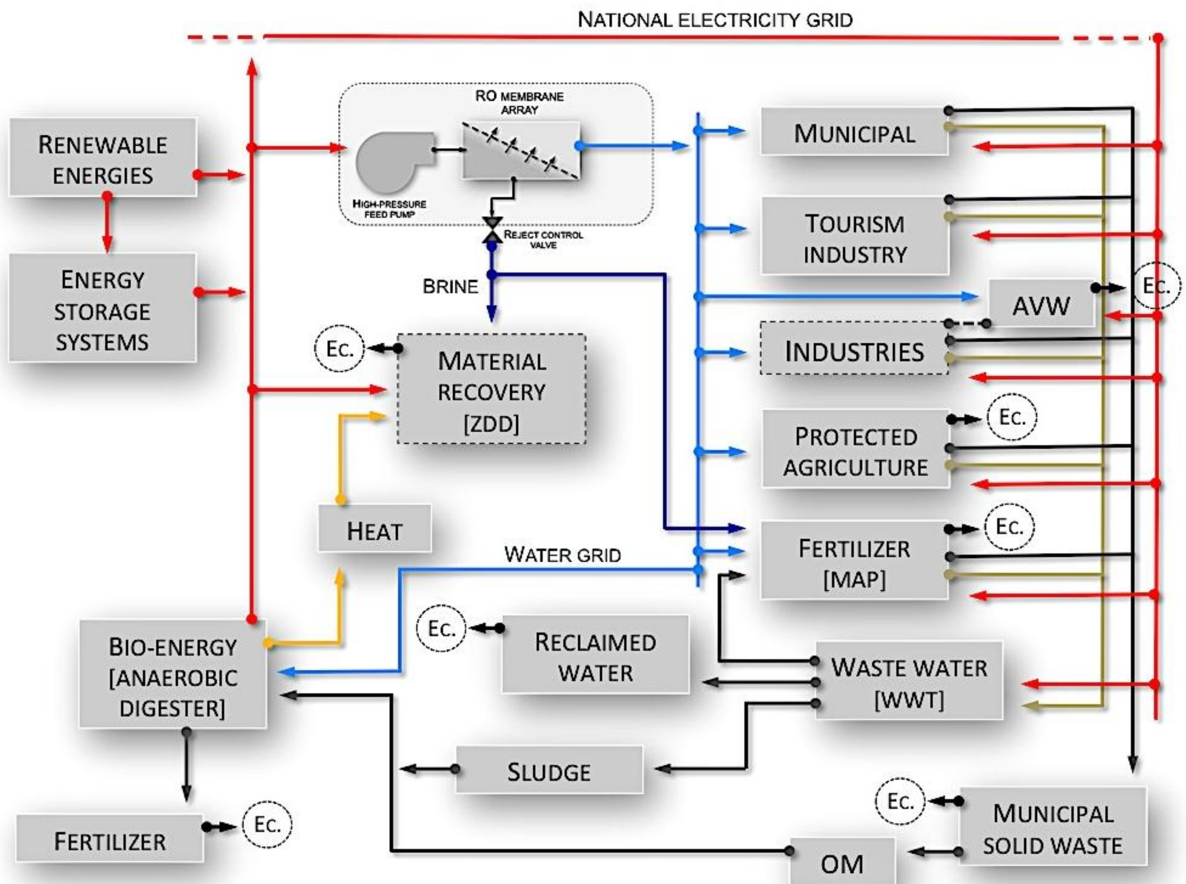
Case study: Sal, Cape Verde

▶ Water-energy-food nexus



(Ec.): Products with economic value

AVW: Added Vale Water [bottled water]

OM: organic matter

ZDD: zero discharge desalination

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Case study: Sal, Cape Verde

- Equivalent service/product of excess energy

Scenario	Total investment* *[million EUR]*	e-Mobility *[million km]*	Cooking gas *[cylinders]*	Desalinated water *[million m³]*
Scenario 1 *[68% over supply]*	162	234,000	149,000	14.6
Scenario 2 *[48% over supply]*	125	165,000	105,000	10.3

** Investment for power generation & storage infrastructure includes; solar PV, wind convertors, battery & seasonal storage*

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Case study: Sal, Cape Verde

- Municipal use
  - Meet the WHO minimum

    Sal-Current: 34 L/c/d

    WHO $_{min}$: 50 L/c/d

    Social & economic development $_{min}$: 135 L/c/d
  - Increase the grid connectivity

    Sal-Current: 65%

    Target $_{2020}$: 100%
  - Reduce the costs of water

    Sal-Current: 2.67 - 5.27 EUR/m^3
- Energy production - AD of Biomass
- Industries
  - Added Value Water, ZDD, Protected Agriculture,

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Case study: Sal, Cape Verde

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- Cultivation of high-value crops under GH conditions
  - Increase food security
  - Strengthen economy [reduce imports]
  - Social engagement/employment

- Example:

	Tomato	Cucumbers	Paprika	Salad	Total
Cultivated Area (ha)	10	10	10	10	**40**
Water Demand (m³/a)	182.500	146.000	127.750	75.000	**531.250**
Elec. Demand Cultivation (kWh/a)	55.275	49.875	49.875	134.555	**289.580**
Elect. Demand RO (kWh/a)	1.003.750	803.000	702.625	412.500	**2.921.875**
Harvest (t)	2.500	2.200	1.080	3.000 t-Stück	
Economical Result (€/a)	**416.156**	**-225.389**	**-5.420**	**563.953**	**749.299**

- Water $_{TOTAL}$: 531,250 m^3/a *[~5% of the water over supply!]*
- Energy $_{TOTAL}$: 3.2 GWh/a *[~8% of the energy over*

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Case study: Sal, Cape Verde

- Options for excess energy…
  - More cultivable land

    eg. 4% of Sal island is cultivable

  - Reduce postharvest losses

    eg. increased cold storage capacity for fruits, vegetable and fisheries products

  - Innovative technologies for new products/services

    eg. Material recovery, Added Value Water, Fertilizer from wastewater etc.

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Case study: COPAG, Morocco

- Feasibility study for the construction of an agricultural biogas plant aiming at the sustainable energy supply of the production site of the agricultural cooperation COPAG

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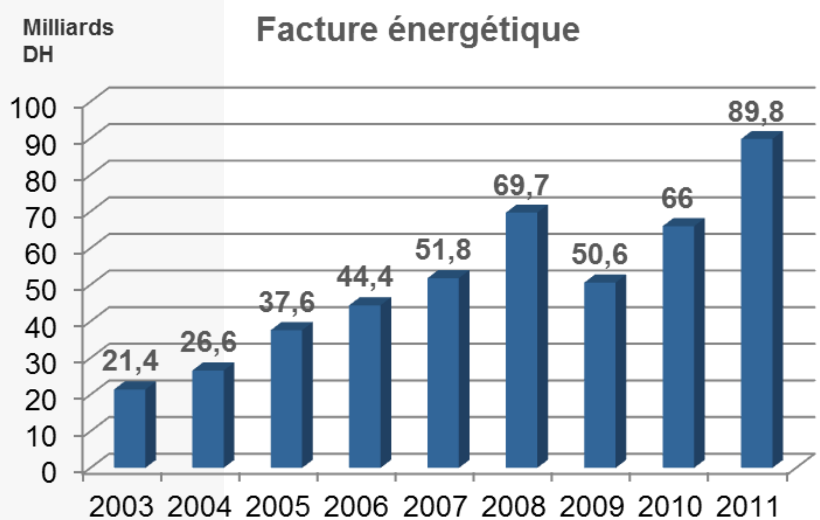
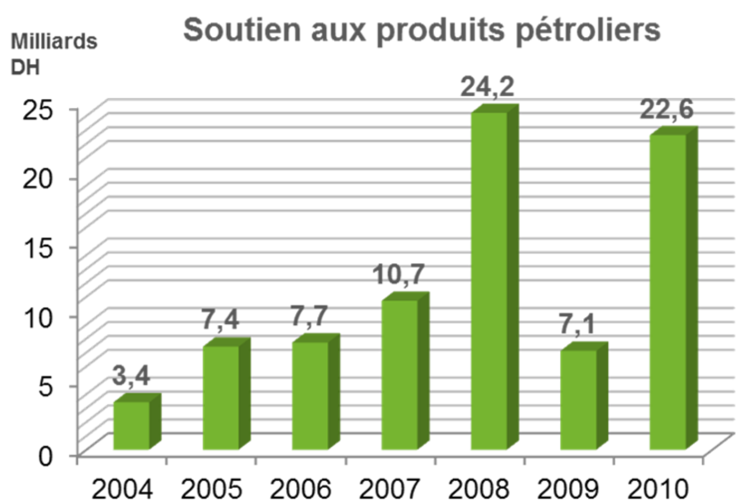
Energy sector in Morocco

- High energy dependance: energy dependance reached 95,5% in 2011
- In order to save the purchasing power of the local popualtion petroleum products have been subsidized with 22,6 billion DH



MEMEE: Les caractéristiques du secteur énergétique marocain en 2011



MEMEE: Les caractéristiques du secteur énergétique marocain en 2011

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Case study: COPAG, Morocco

- COPAG is the 2nd largest producer of milk products in Morocco
- Business sectors
  - Milk production: pasteurised milk, UHT milk , fermented milk, yogurt, cheese, butter
  - Citrus fruit conditioning
  - Juice production: orange juice and concentrate
  - Animal food production
  - Animal husbandry

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Case study: COPAG, Morocco

- Project idea
  - Planning and construction of a biogas plant for the valorization of organic residues and the sustainable energy supply of the agricultural cooperation COPAG
- Objectives
  - Renewable energy production (electricity, heat) of different organic materials and organic residues
  - Use of the generated energy in the production processes (juice production, milk factory, slaughterhouse, etc.)
  - Production of a high quality soil conditioner for local farmers
- Elaboration of a feasibility study for the construction of an agricultural biogas plant aiming at the energy supply of the production site
- Longterm goals of the project:
  - Improvement of the decentralised energy supply in rural areas through the valorisation of agricultural residues
  - Production of fertiliser through the use of the digestate of the biogas plant

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Case study: COPAG, Morocco

- Input material

Biomasses	quantité MF (t/a)	quantité MF (t/d)
Fumier bovin	20.000	54,79
Boues physico-chimiques	16.425	45,00
Boues biologiques	29.200	80,00
Restes de fruits (production jus)	0	0,00
Sérum	19.000	52,05
Déchets de fruits	1.000	2,74
Contenu des panses	800	2,19
Sang	850	2,33
Graisses	0	0,00
Os	0	0,00
Jus du 2ieme pressage	1.800	4,93
Total:	**89.075**	**244,04**

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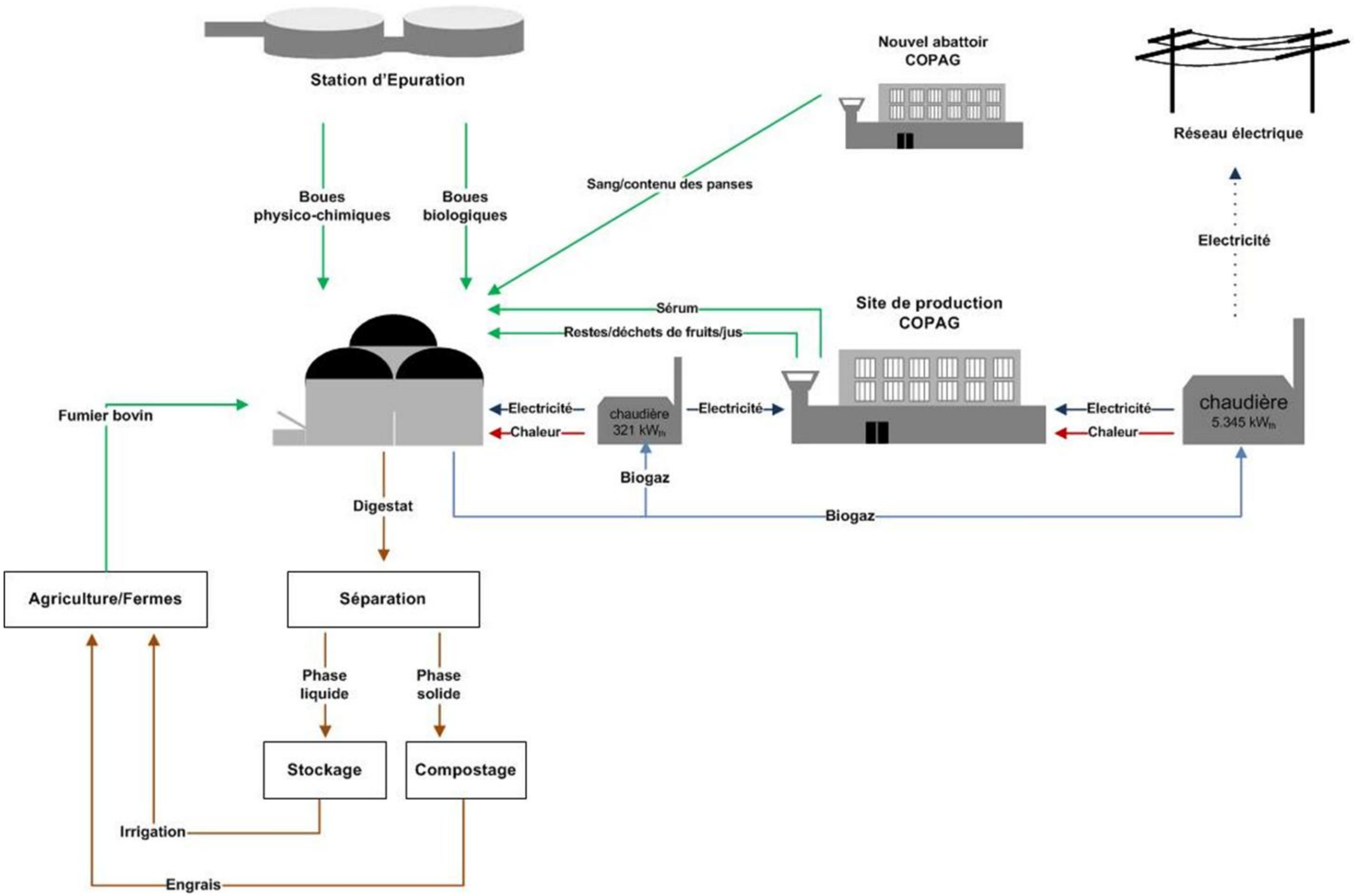
Alternative 3

heat production → two boilers



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Case study: COPAG, Morocco

▶ Summary

Résumé		Alternative 1	Alternative 2	Alternative 3
Electric capacity cogeneration unit 1	kW	870	1.015	
Electric capacity cogeneration unit 2	kW	230		
Thermal capacity biogas boiler 1	kW		321	321
Thermal capacity biogas boiler 2	kW			5.345
Electric production	kWh/a	8.537.436	7.879.333	-
Thermal production	kWh/a	9.850.887	10.694.609	16.996.787
Biomass input	t/a	89.075	89.075	89.075
Production solid fertilizer (MS=25%)	t/a	22.433	22.433	22.433
Production liquid fertilizer (MS=3%)	m^3/a	61.911	61.911	61.911
Internal rate fo return (IRR) - Free Cash Flow	%	12,17%	12,31%	14,88%

→ production of 10-16 Mio. kWh of heat

= replacement of 400.000 -800.000 € of heat energy costs

→ production of ~ 8 Mio. kWh of electricity

= replacement of > 500.000 € electricity costs (alt. 1+2)

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Closed Loops in Agro-Industry

Example of Coconut Industry in Sri Lanka

Recreation of soil properities
(humus content / water storage / nutrient availability)

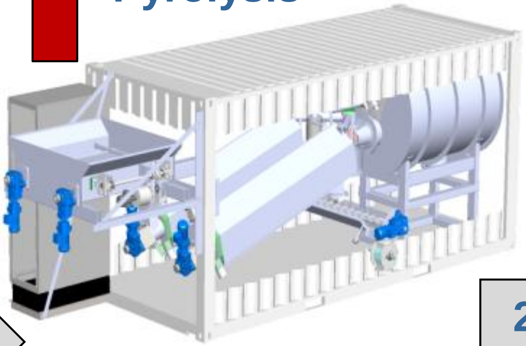
Avoidance of Chemical Fertilizer
(Health / Energy)

8.8 GWh/a heat
1.1 mil. Litre Diesel$_{eq}$
2 mil. LKR

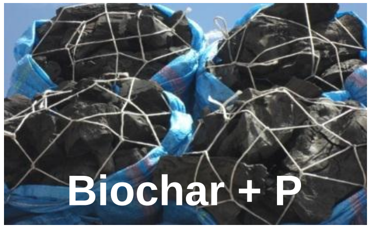
Heat

Pyrolysis

10,000 t/a



2,500 t/a



Avoidance of:
9,000 t CO_2 / a

Market Value:
1.25 – 2.5 mil. €

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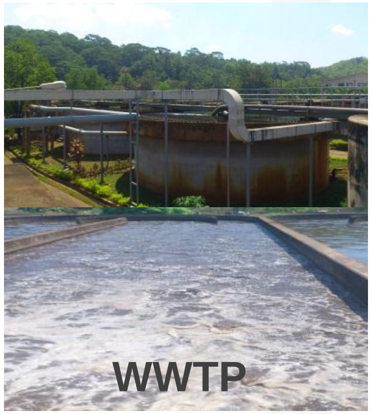
Phosphate Recycling from Sewage Sludge



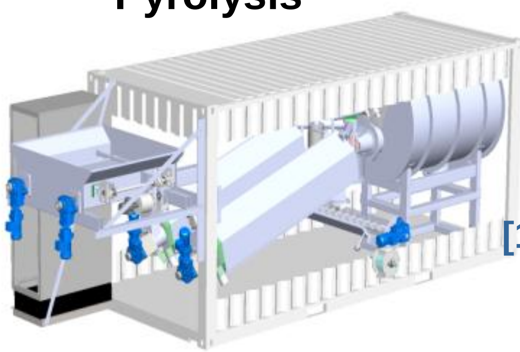
Avoidance of:
3,100 t CO_2 / a
[exploitation and production of P-fertilizer]

40,000 t/a
[3%DM]
c.p. Trier

1,000 t/a

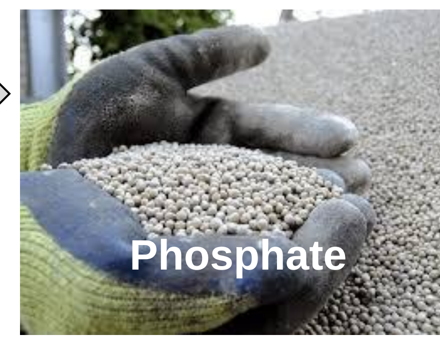
Pyrolysis

1 GWh/a heat



4,800 t/a
[25%DM]

800 t/a
[100%DM]



Market Value:
0.4-0.5 mil. €

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QUESTIONS?