Cape Verde, the road ahead

To build a safe, efficient and sustainable Energy Sector without dependence on fossil fuels

IRENA Renewables and Islands
Global Summit - Malta 2012

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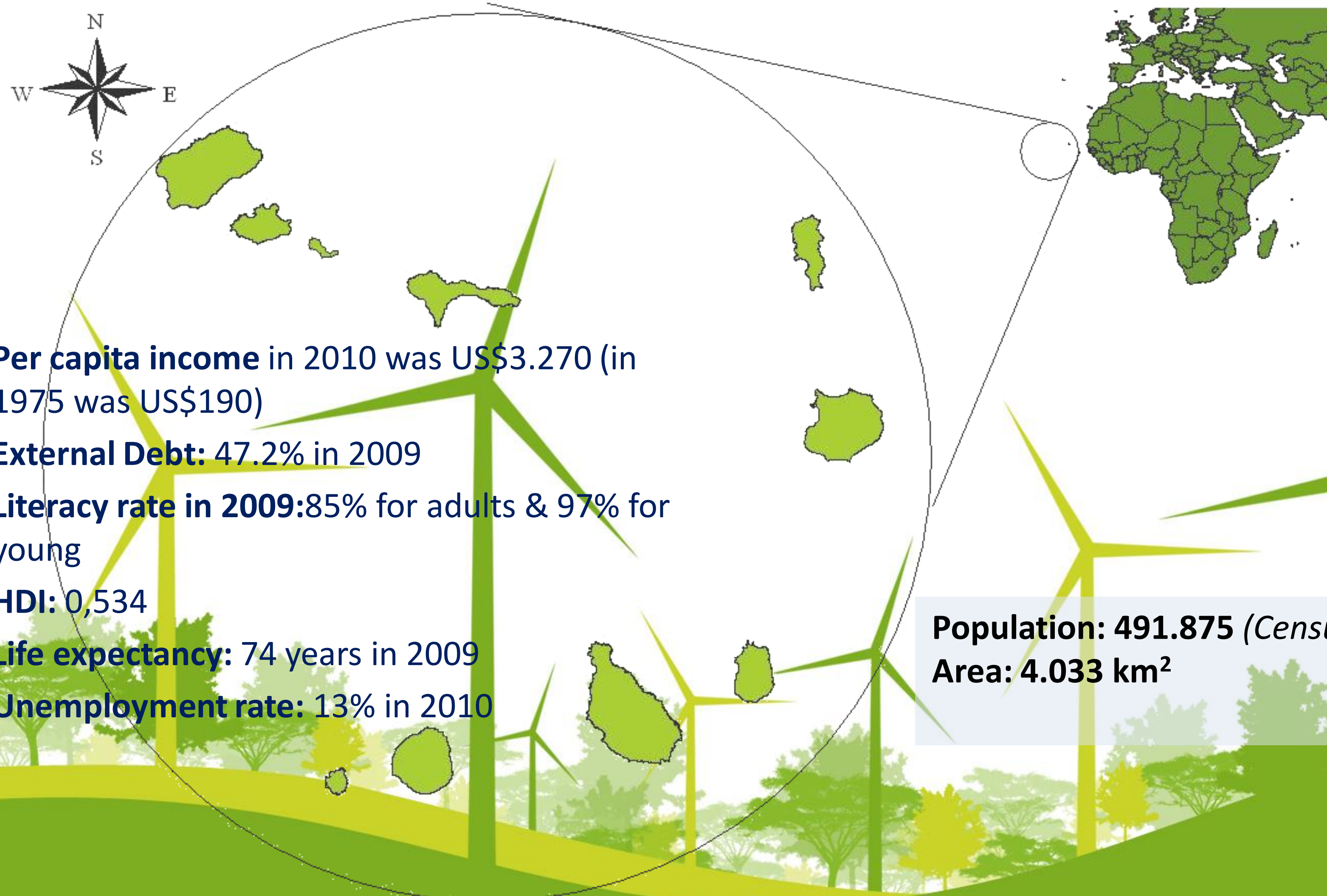
Cape Verde snapshot

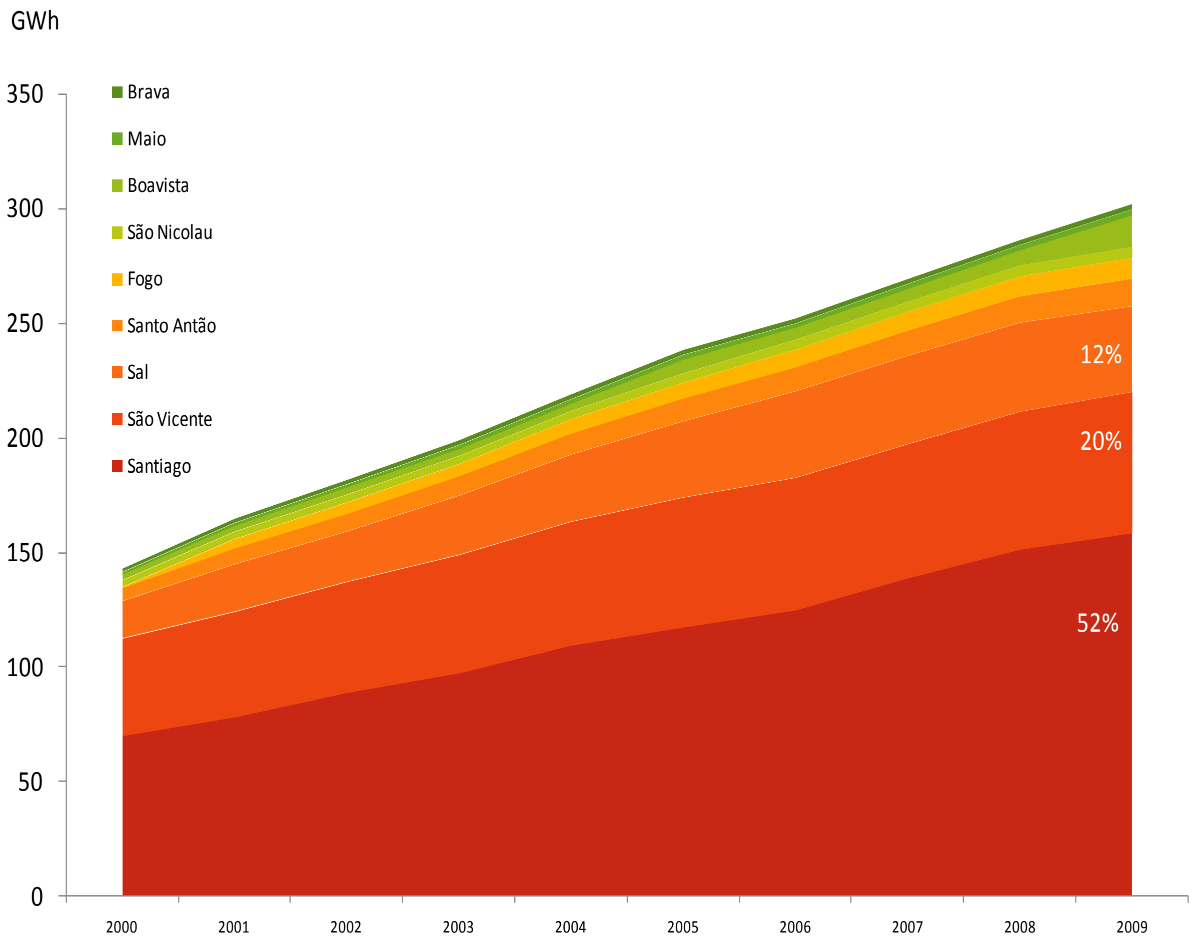


- **Per capita income** in 2010 was US$3.270 (in 1975 was US$190)
- **External Debt:** 47.2% in 2009
- **Literacy rate in 2009:**85% for adults & 97% for young
- **HDI:** 0,534
- **Life expectancy:** 74 years in 2009
- **Unemployment rate:** 13% in 2010

Population: 491.875 *(Census 2010)*
Area: 4.033 km²

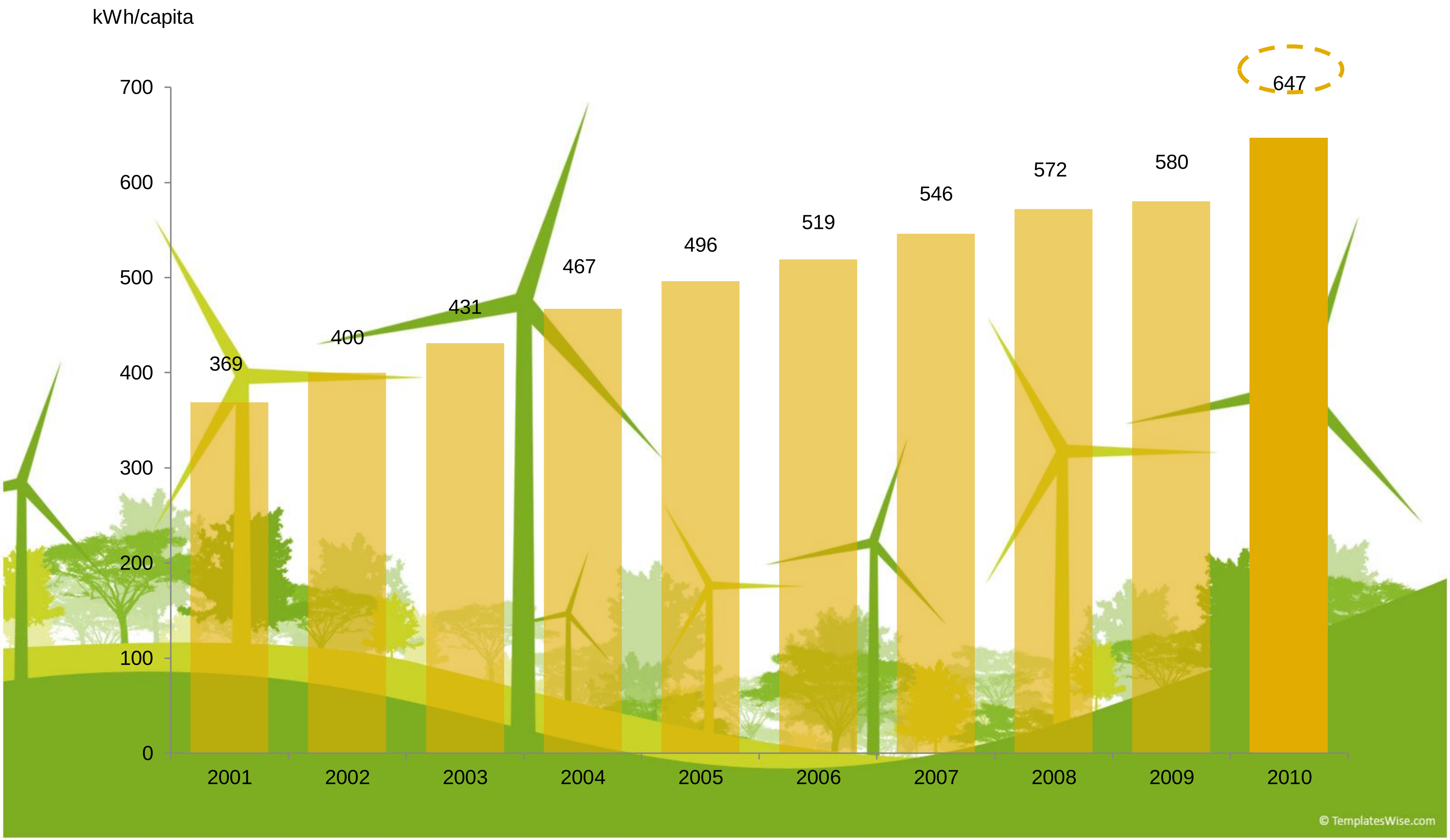
Cape Verde gained independence on 5 July 1975 facing major developmental challenges…

The consumption of electricity has doubled in the last 10 years



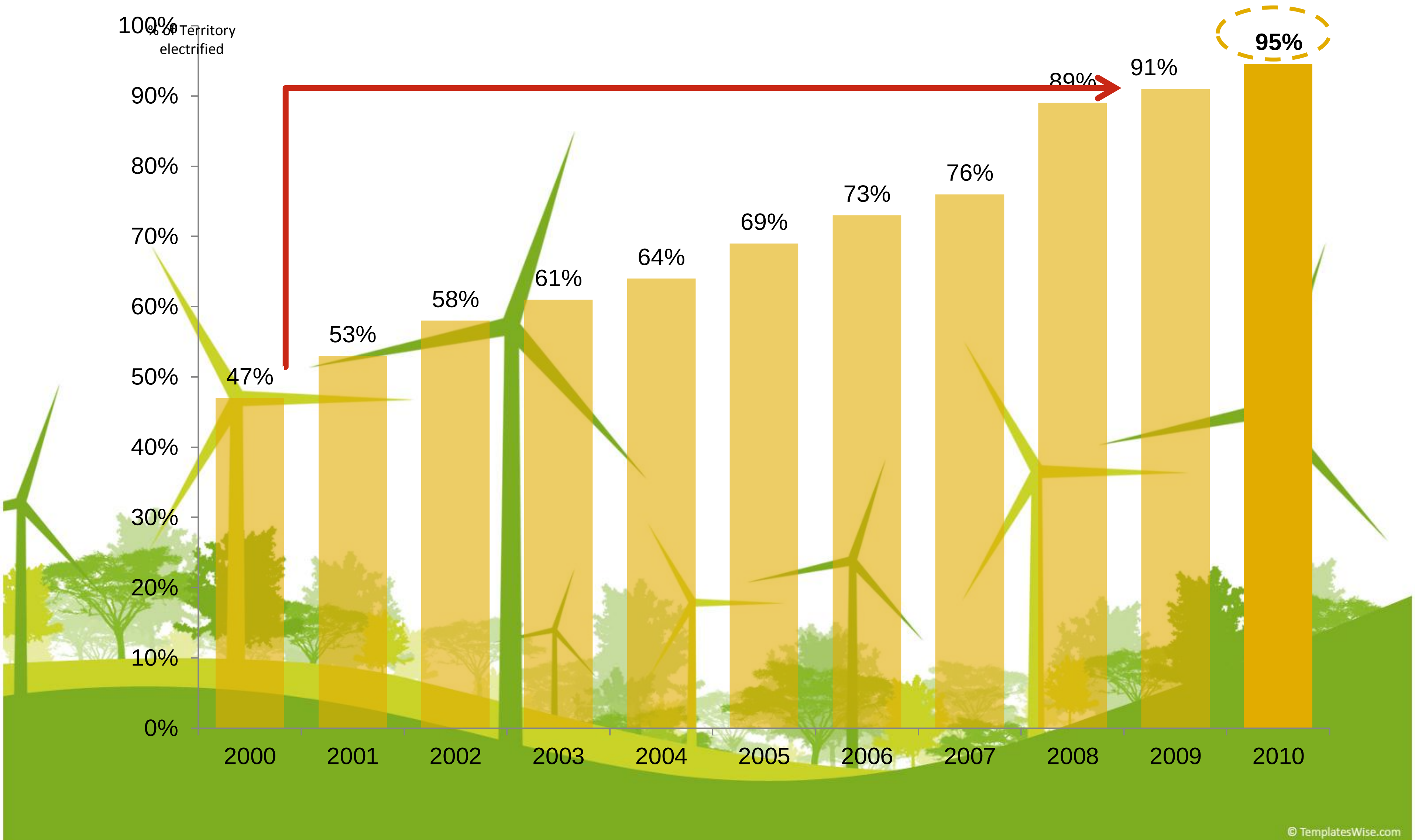
Indicator	Growth rate *2001 – 2010*
Energy Production	+94%
Installed Capacity	+78%
Territorial Elect. Rate	+79%
Demand	+114%
Clients	+112%
GDP	+70%

Strong growth in energy consumption per capita

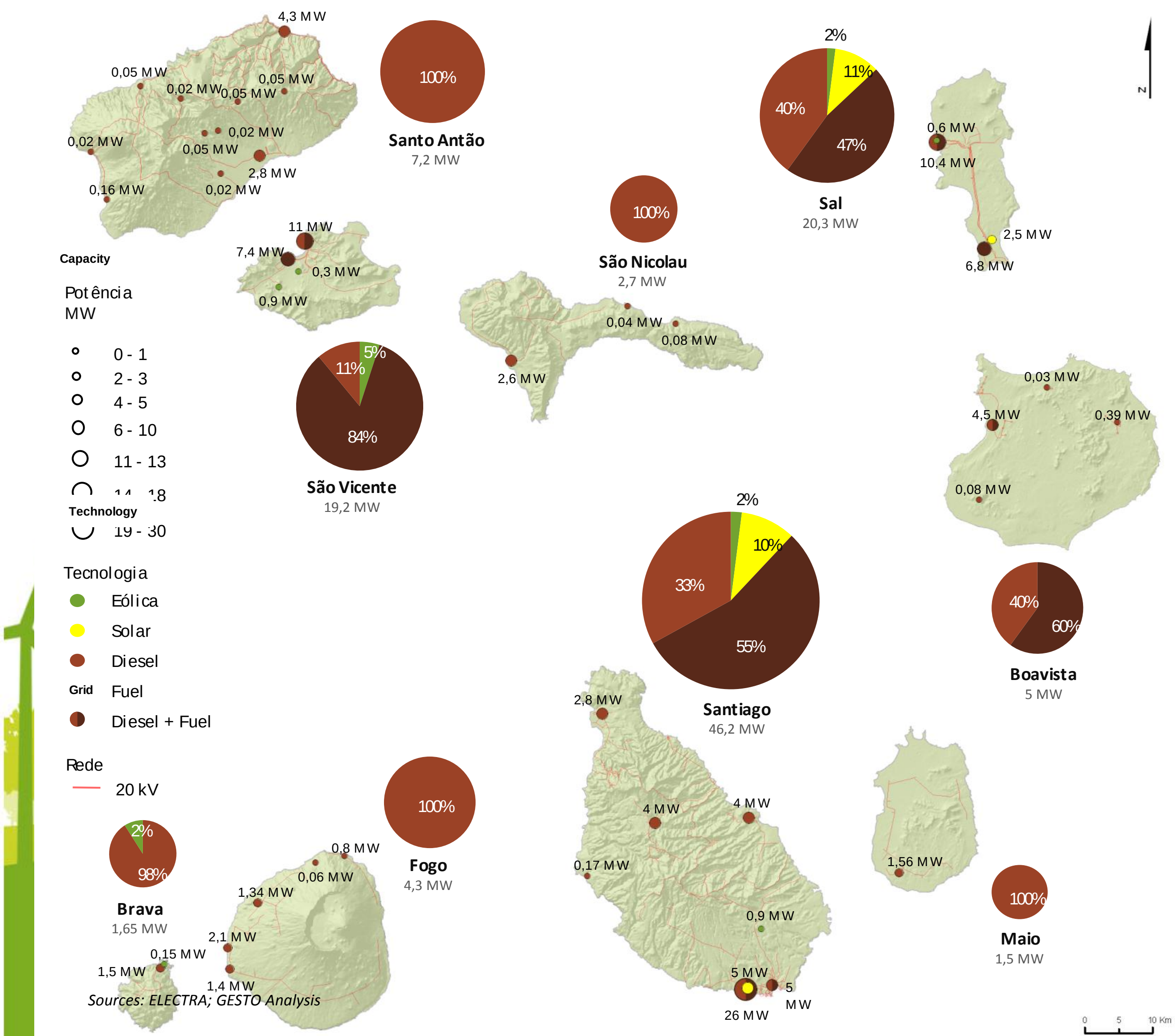


Cape Verde achieved 95% electrification rate in 2010

The penetration doubled in just 10 years



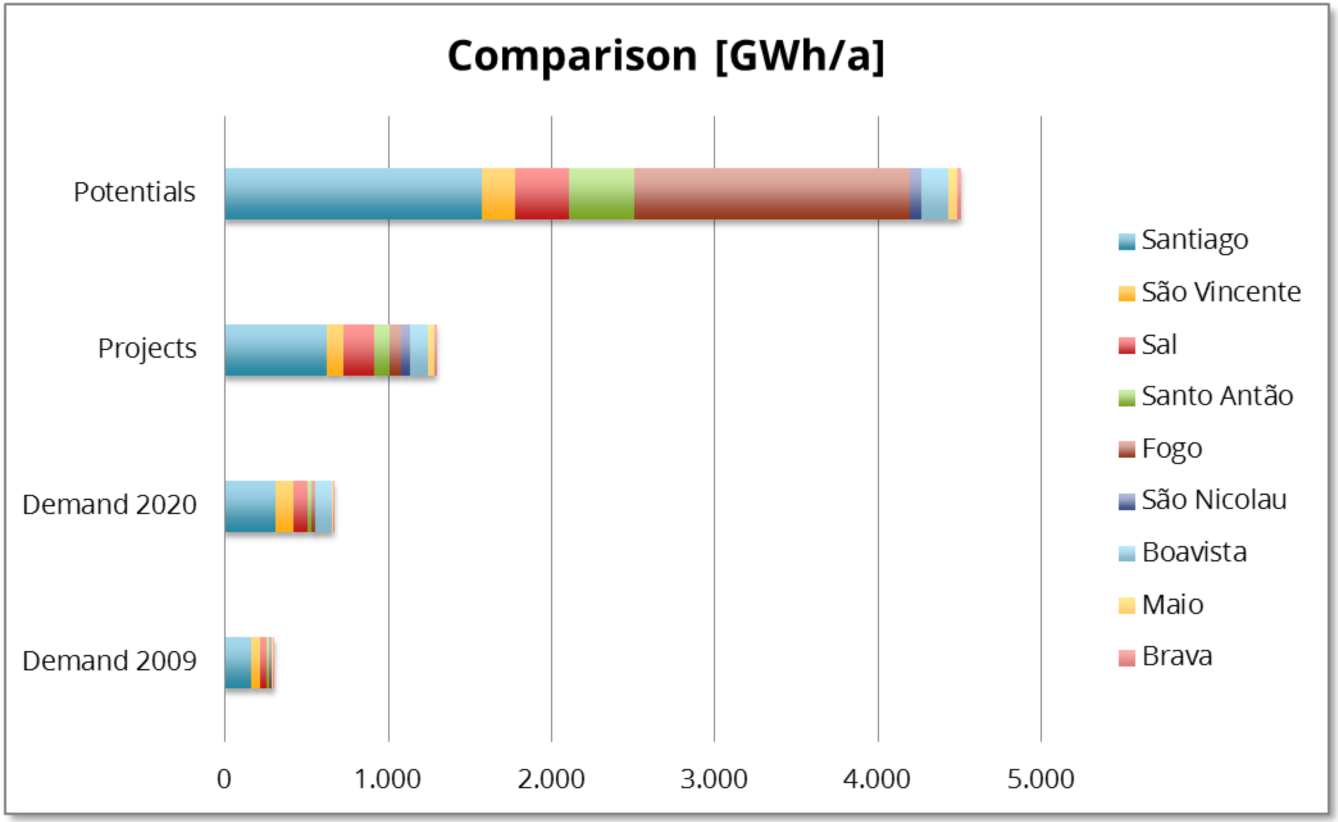
Strong dependence on fossil fuels for electricity generation



Sources: ELECTRA; GESTO Analysis

Products	Growth rate *2002 - 2010*
Diesel	+ 180%
Fuel	+ 500%
Price increase	Diesel +122% Fuel +85%
Current account of balance of payments	- 43%

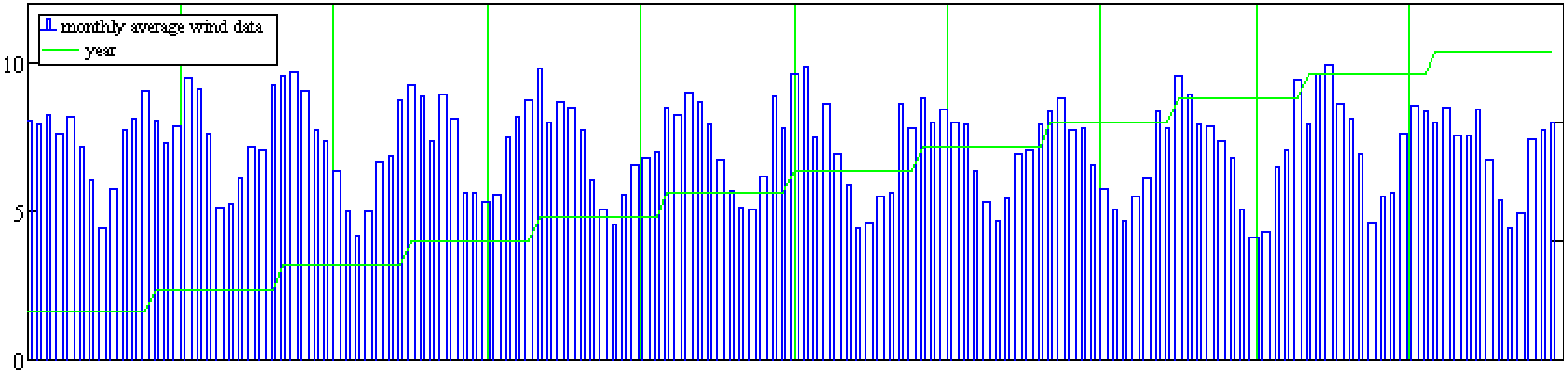
Large potentials identified and manifold surplus in supply from renewable sources



according to Atlas e Projectos de Energias Renováveis de Cabo Verde and Plano Energético Renovável

Good Quality of RE

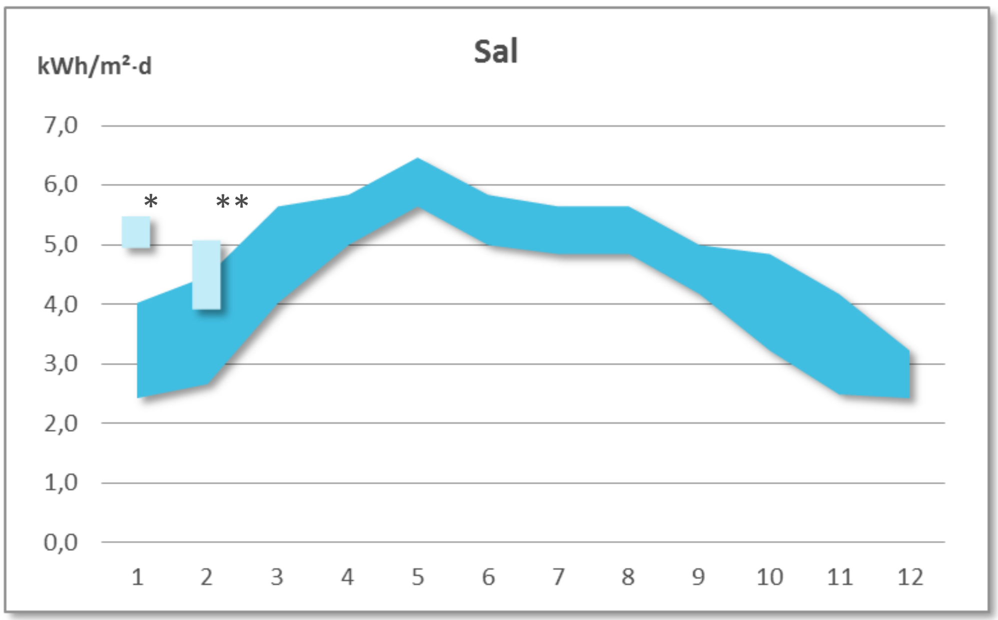
- wind resource in Cape Verde
  - monthly average 1997-2009
  - long term seasonal fluctuation of wind speed

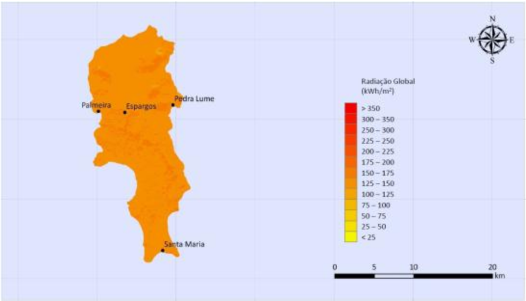


source:
Sinclair Knight Merz (SKM), Newcastle, 2009

Good Quality of RE

- Solar resource in Cape Verde
  - monthly values of global irradiation

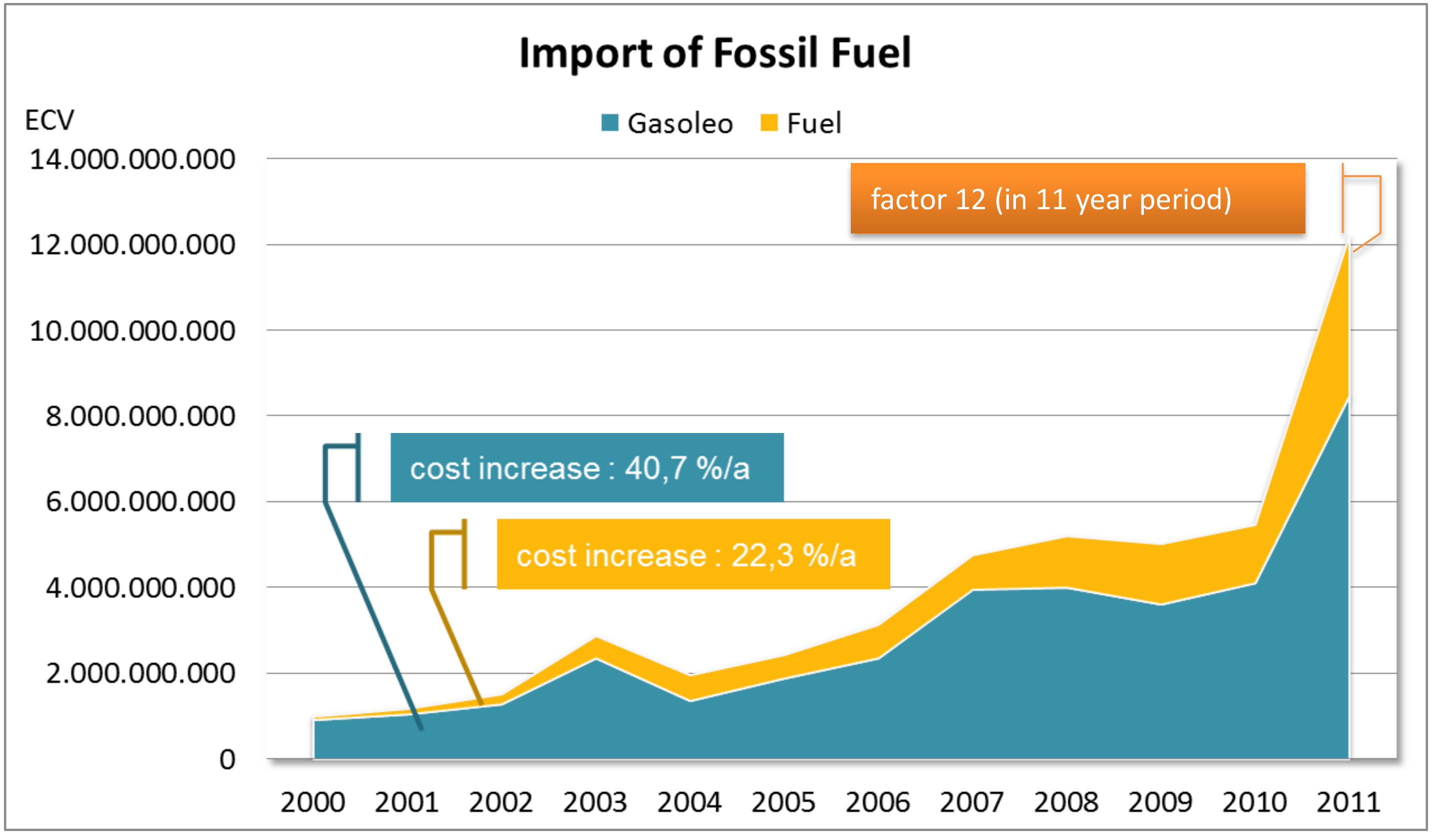




*	daily value from annual average	}	data consistency to be checked
**	daily value from monthly average		

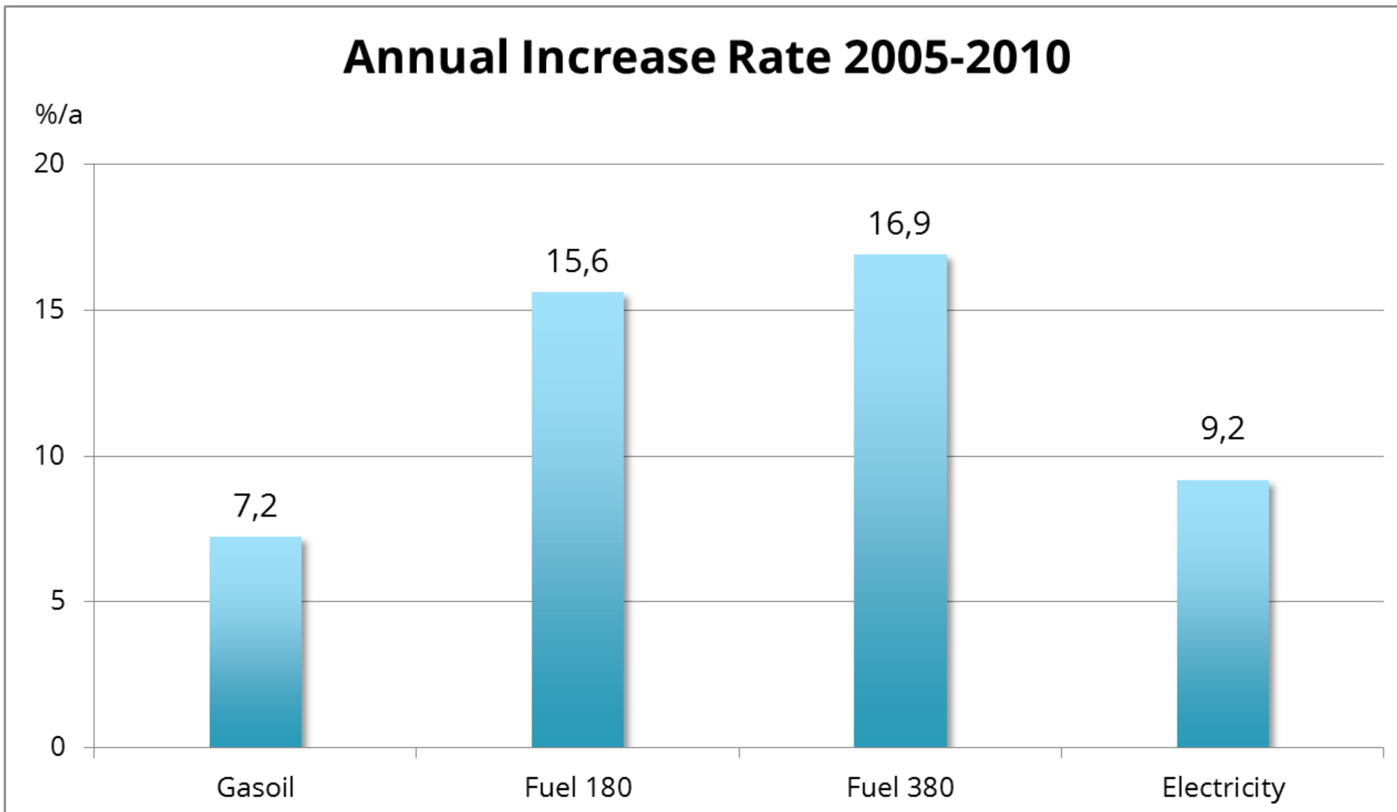
source:
Atlas e Projectos de Energias Renováveis de Cabo Verde

At the same time, Increase in Fuel Price



source:
tables “Energia Nacional”

Increase in Energy Cost



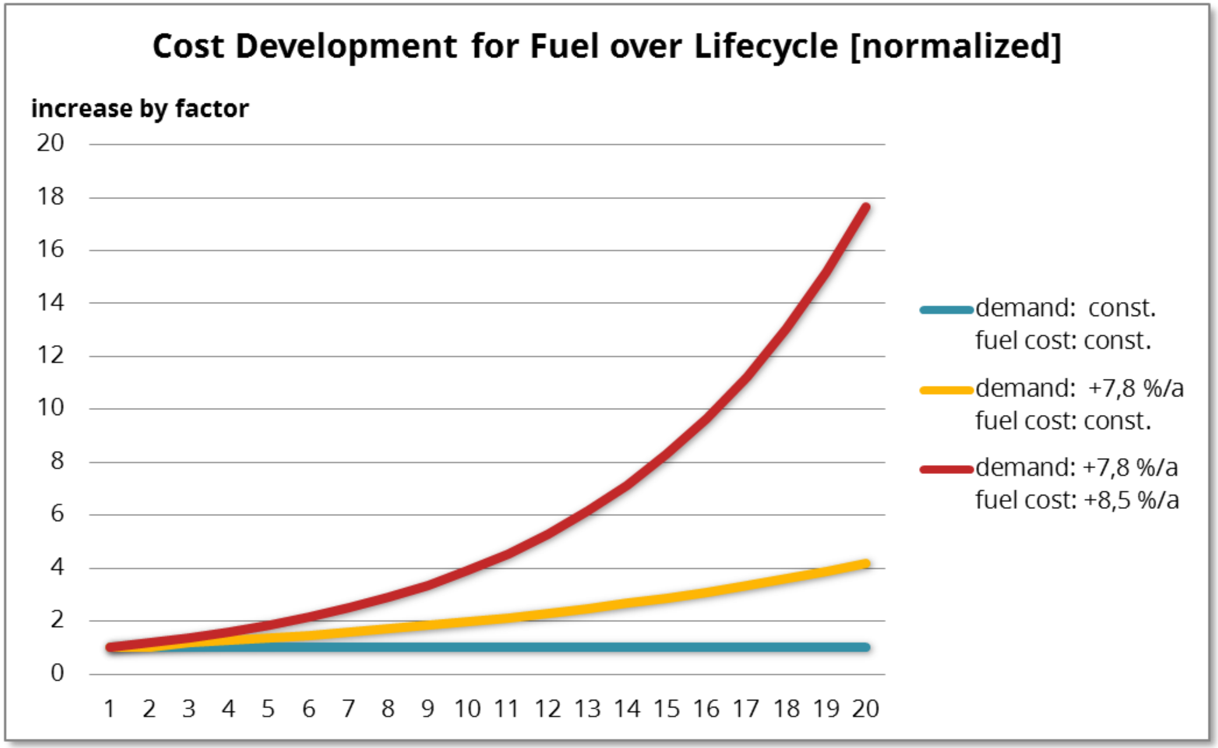
source
PEMFAR

Big Increase in Future Energy Cost

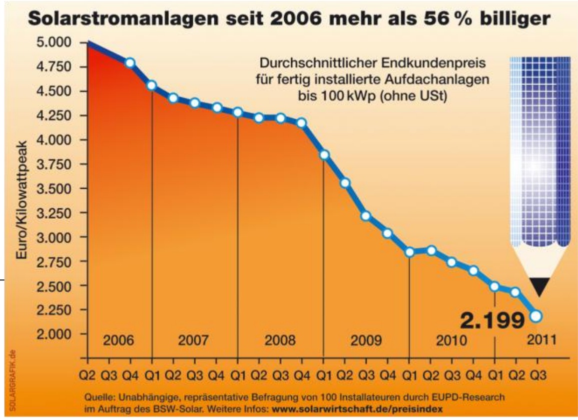
- life cycle cost
  - increase in demand : 7,8 %/a**
  - increase in fuel cost: diesel 8,5%/a*, heavy fuel 15 %/a*

Assumptions

* Extrapolated from historic values 2004-2012
** derived from demand 2020



Decrease in Photovoltaic Price

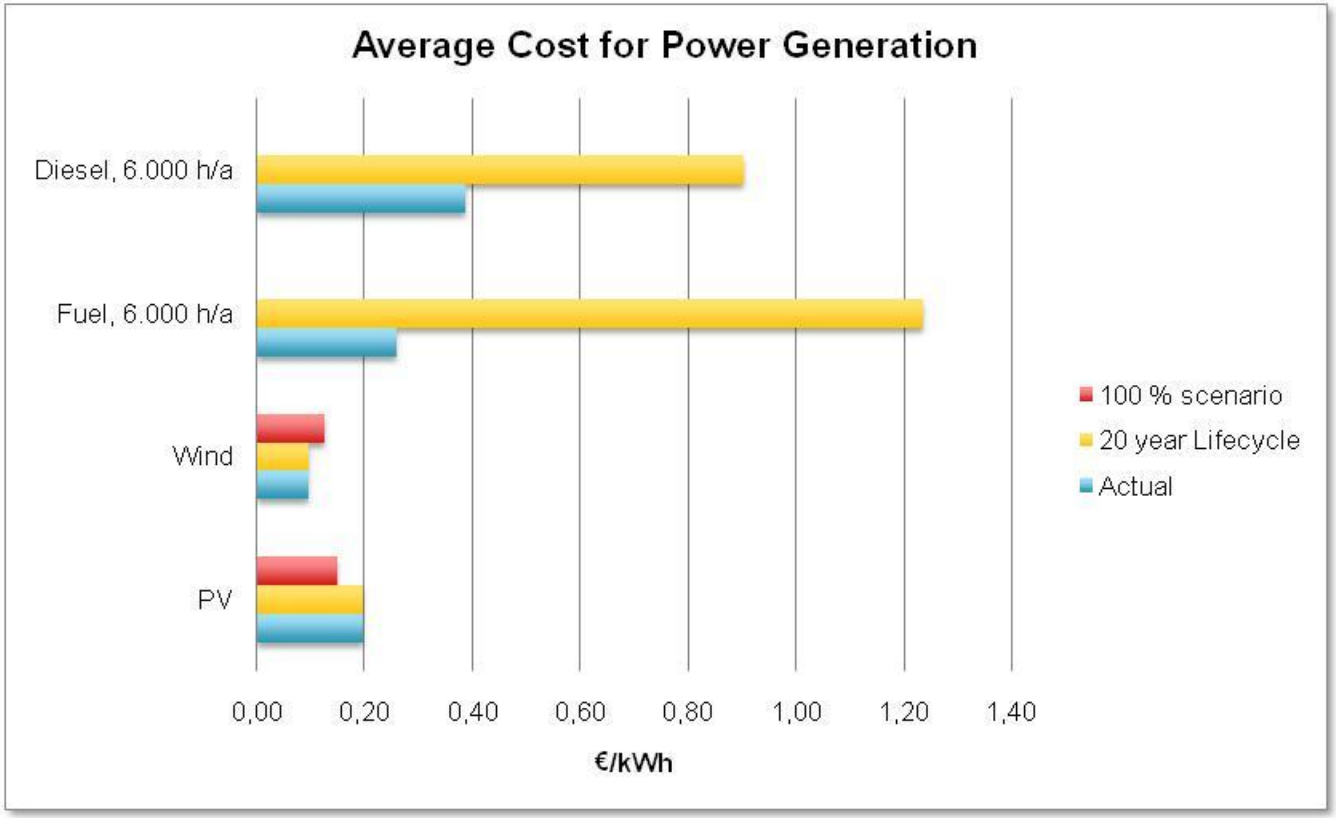


Cost Decrease for Photovoltaic Systems

- since 2000 - 75 %
- since 2008 - 50%
- until 2016 - 50% - on top on 2012 level

Source: Agentur für Erneuerbare Energien, BMU

Comparing electricity production cost



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

Comparing Cost

cost for power generation (ex generator)
- no grid
- no sales

- calculation model
  - 20 year service period

	PV	Wind
Investment	**3.406 €/kW**	**2.212 €/kW**
interest	5 %	5 %
duration	20 a	20 a
annual cost	273 €/a	177 €/a
financial cost	**5.466 €/kW**	**3.550 €/kW**
operation & maintenance	**2 %**	**5 %**
annual cost	68 €/a	111 €/a
operation cost	**1.362 €/kW**	**2.212 €/kW**
service time	**1.745 h/a**	**3.056 h/a**
efficiency		
fuel energy density		
fuel cost (actual)		
increase rate		
annual cost (actual)		
total fuel cost	**0 €/kW**	**0 €/kW**
levelized cost of energy	**0,1956 €/kWh**	**0,0943 €/kWh**

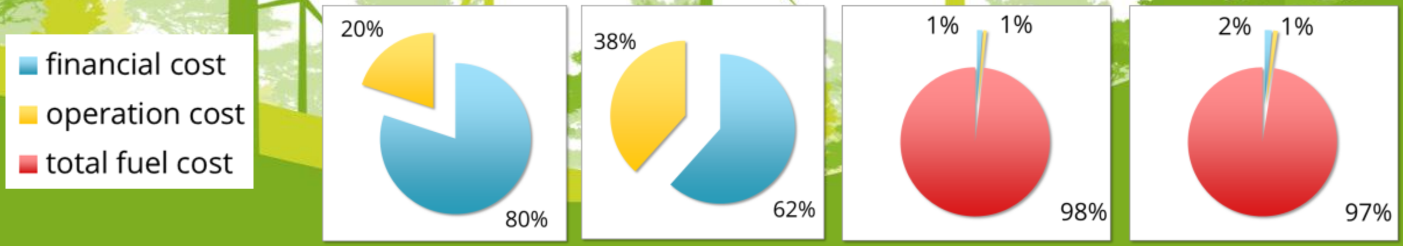
	Fuel 180	Diesel
Investment	**1.066 €/kW**	**1.066 €/kW**
interest	5 %	5 %
duration	20 a	20 a
annual cost	86 €/a	86 €/a
financial cost	**1.711 €/kW**	**1.711 €/kW**
operation & maintenance	**5 %**	**5 %**
annual cost	53 €/a	53 €/a
operation cost	**1.066 €/kW**	**1.066 €/kW**
service time	**6.000 h/a**	**6.000 h/a**
efficiency	38,6 %	33,3 %
fuel energy density	10 kWh/l	10 kWh/l
fuel cost (actual)	0,78 €/l	1,09 €/l
increase rate	13,9 %/a	8,5 %/a
annual cost (actual)	1.212 €/a	1.964 €/a
total fuel cost	**111.847 €/kW**	**97.787 €/kW**
levelized cost of energy	**0,9321 €/kWh**	**0,8149 €/kWh**

source Gesto

Comparing Future Cost Structure

(per KW / 20 years)

	PV	Wind	Fuel	Diesel
Investment	**3.406 €/kW**	**2.212 €/kW**	**1.066 €/kW**	**1.066 €/kW**
interest	5 %	5 %	5 %	5 %
duration	20 a	20 a	20 a	20 a
annual cost	273 €/a	177 €/a	86 €/a	86 €/a
financial cost	**5.466 €/kW**	**3.550 €/kW**	**1.710 €/kW**	**1.710 €/kW**
operation & maintenance	**2 %**	**5 %**	**5 %**	**5 %**
annual cost	68 €/a	111 €/a	53 €/a	53 €/a
operation cost	**1.362 €/kW**	**2.212 €/kW**	**1.066 €/kW**	**1.066 €/kW**
service time	**1.745 h/a**	**3.056 h/a**	**6.000 h/a**	**6.000 h/a**
efficiency			30 %	30 %
fuel energy density			10 kWh/l	10 kWh/l
fuel cost (actual)			0,71 €/l	1,09 €/l
increase rate			15 %/a	8,5 %/a
annual cost (actual)			1.420 €/a	2.180 €/a
total fuel cost	**0 €/kW**	**0 €/kW**	**148.246 €/kW**	**108.238 €/kW**



100% Renewable Supply

- power production cost (sample scenario)

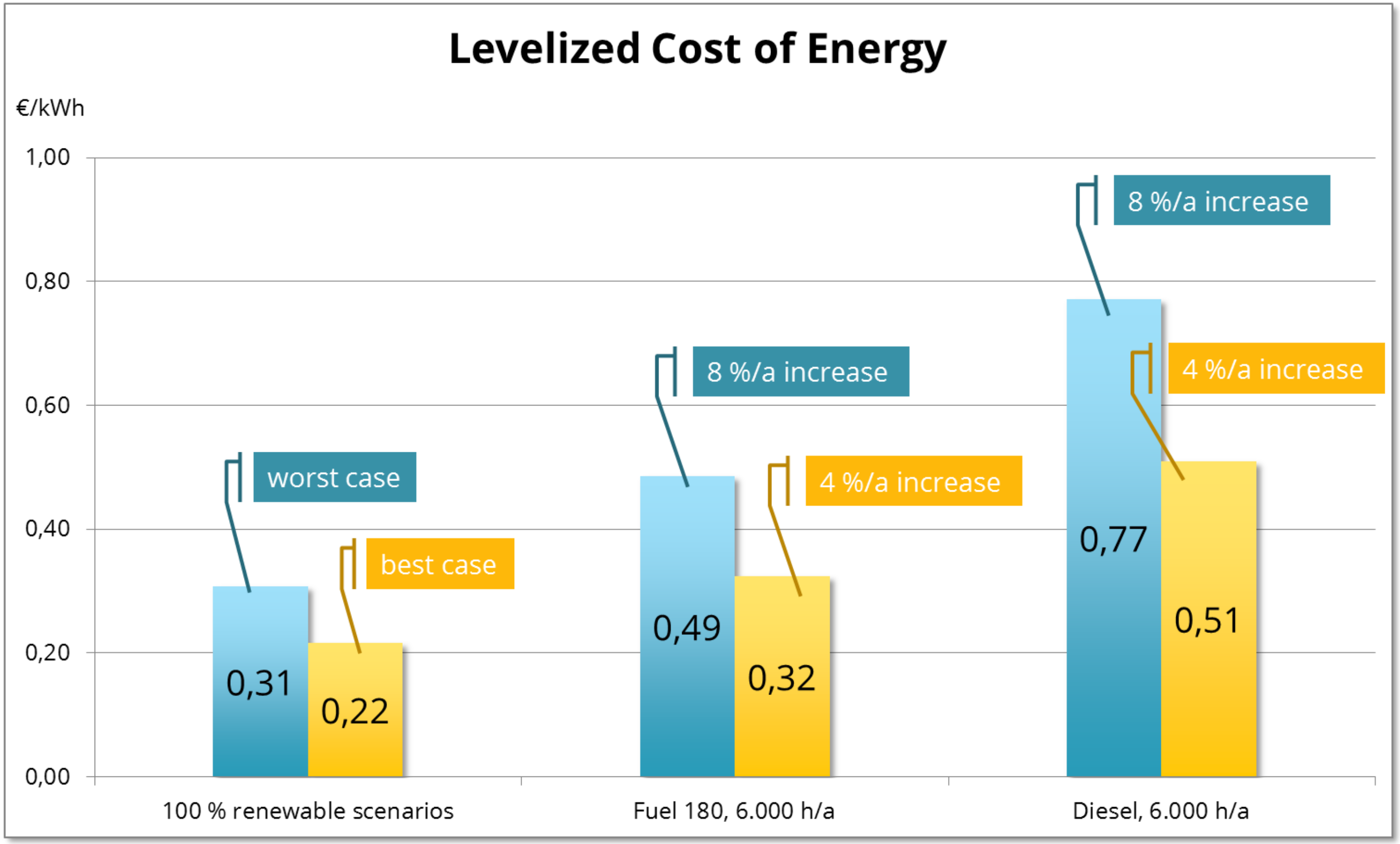
	PV	Wind	Battery	Pumped Hydro		
investment	**2.500 €/kW**	**1.500 €/kW**	**4.000 €/kW**	**1.000 €/kW**	**20 €/kWh**	
interest	5 %	5 %	5 %	5 %	5 %	
duration	20 a	20 a	20 a	40 a	40 a	
annual cost	201 €/a	120 €/a	321 €/a	58 €/a	1,17 €/a	
operation & maintenance	**2 %**	**5 %**	**1,5 %**	**2 %**	**2 %**	
annual cost	50 €/a	75 €/a	60 €/a	20 €/a	0,40 €/a	
service time (proj. Sal)	1.815 h/a	2.750 h/a	h/a	h/a	h/a	
equipment						
per unit	1 MW	0,85 MW	1 MW	15 MW		
			8 MWh		800 MWh	
number of units	30	45	5	1	1	
total power	30 MW	38 MW				
annual production	54 GWh	105 GWh				160 GWh
total demand in 2020						86 GWh
annual cost	7,5 Mio. €	7,5 Mio. €	1,9 Mio. €	1,2 Mio. €	1,3 Mio. €	19,3 Mio. €
power production cost	**0,1381 €/kW**	**0,0710 €/kW**				**0,2247 €/kWh**

Cost Comparison

average over 20 years service period

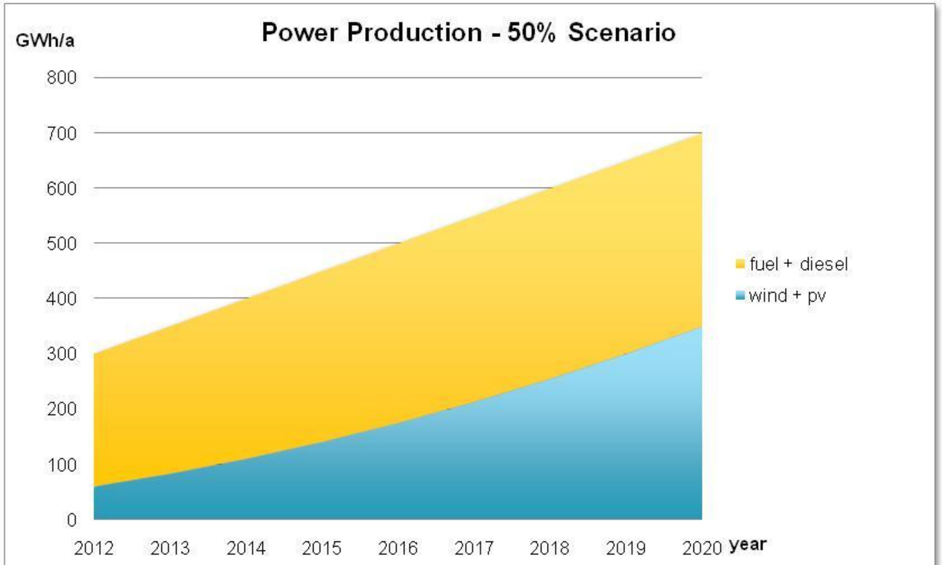
cost for power generation
(ex generator, incl. storage for renewable)

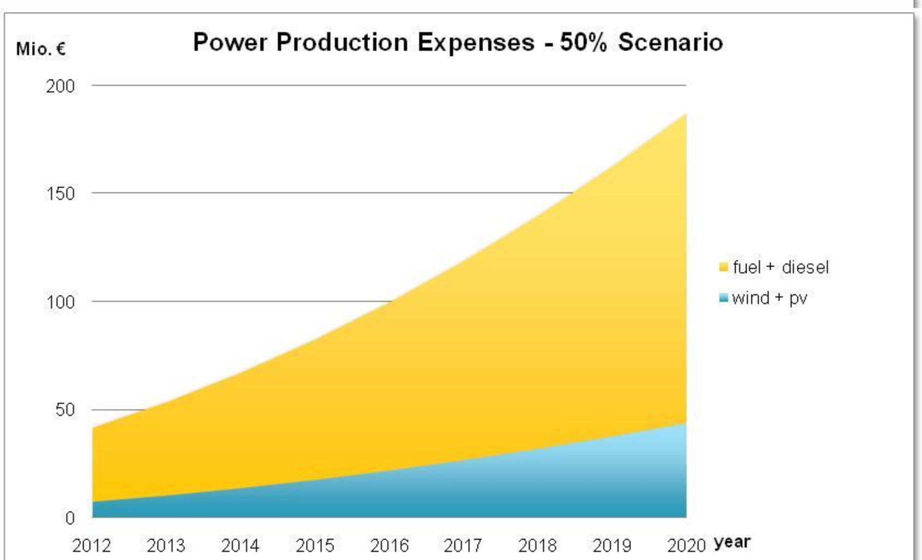
- no grid
- no sales



source
Gesto, Electra, IfaS

Consequence from 50%-Scenario





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Efficiency	30 %
Fuel Cost (act.)	0,71 €/l
Diesel Cost	1,09 €/l
Increase rate	15 %/a
	8,5 %/a
Electr, Prod.	300 → 700
RE	20 → 50 %
Timeframe	2012 → 202

50% Fossil Energy Production

=

75% of the Total Lifecycle Expenditure!

=

+800% of GHG Emissions!

Absolute savings (100% scenario)

450 MW wind and 350 MW photovoltaic equivalent to 330 MW thermal (6.000 h/a)

And 1.5 billion Euros of Investment

Assumptions

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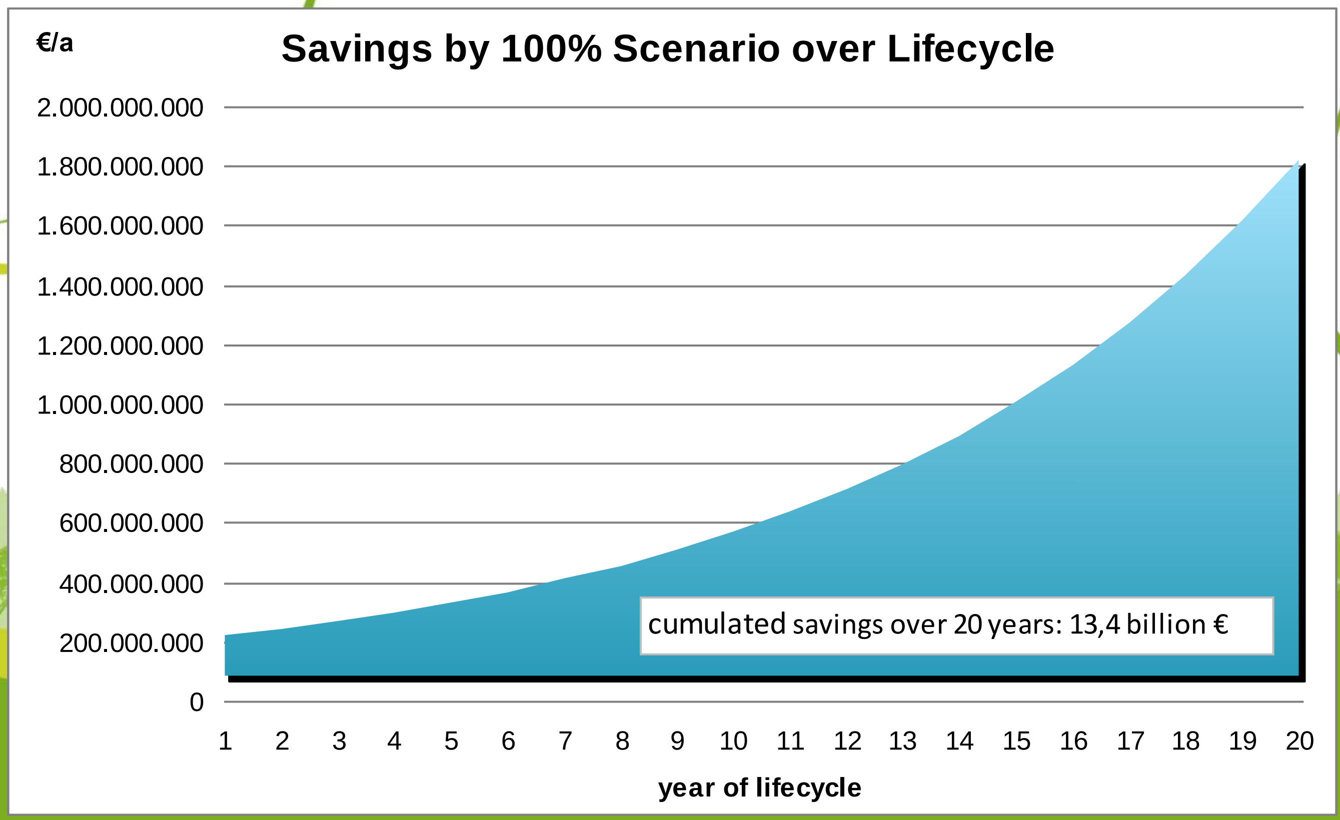


100 % Renewable – Impact on Budget

- taxation
  - compensation for lost energy tax on fossil fuel
    - tax volume 479 Mio. CVE 0,0065 €/kWh
    - tax volume 950 Mio. CVE 0,0129 €/kWh

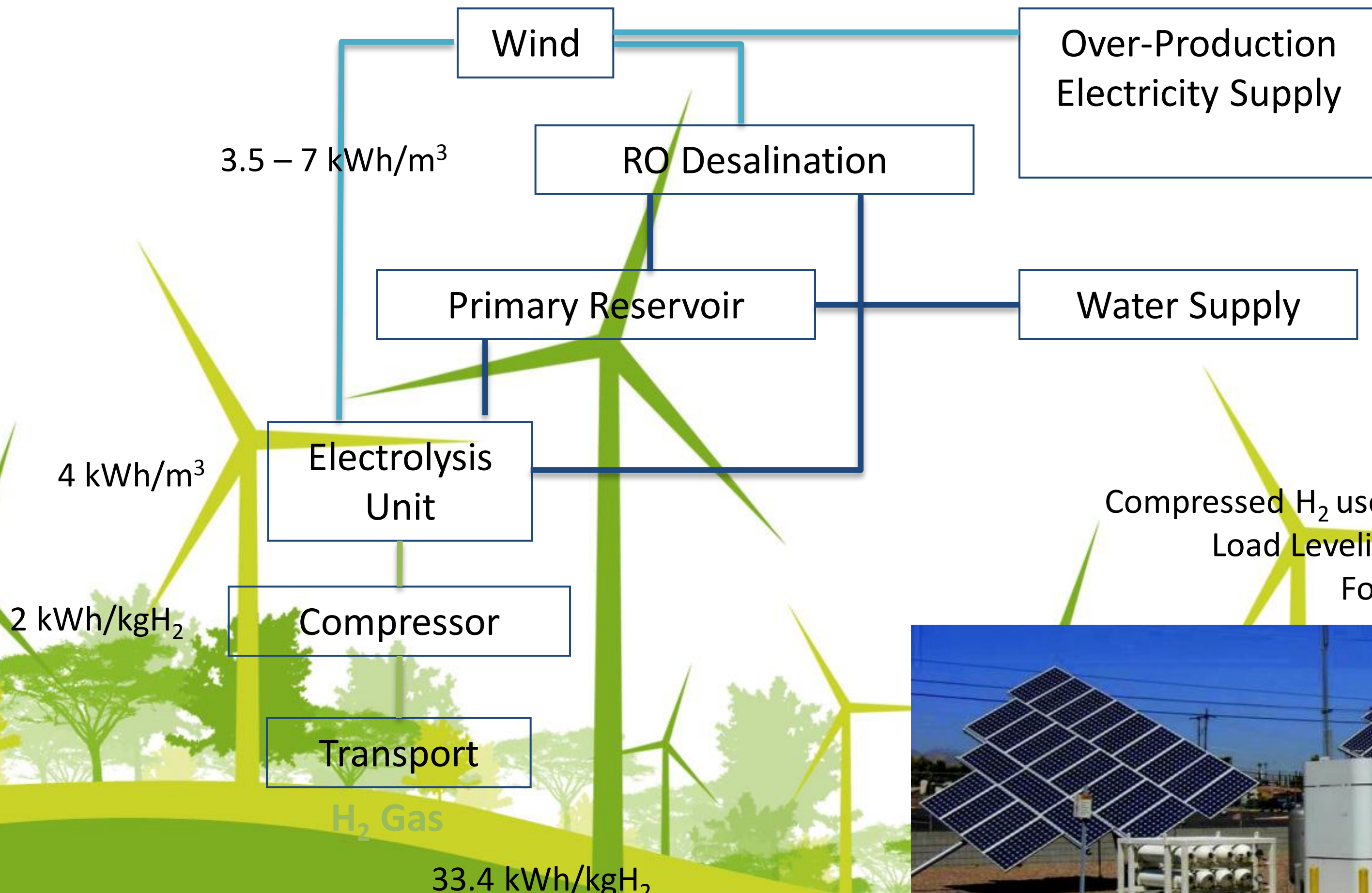
	electricity	diesel + fuel	tax
2010	318 GWh	74 Mio. l	479 Mio. CVE
		6,43 CVE/l	
	1,50 CVE/kWh_{el}	0,64 CVE/kWh_{th}	
2020	670 GWh		
	0,71 CVE/kWh_{el}		479 Mio. CVE
	1,42 CVE/kWh_{el}		950 Mio. CVE
	0,0065 €/kWh_{el}		479 Mio. CVE
	0,0129 €/kWh_{el}		950 Mio. CVE

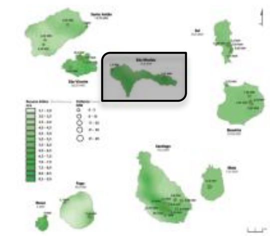
source
PEMFAR, Electra, Gesto

Storage

source
gnu-fdl, Vincent de Groot

Windgas / Hydrogen: 100% Stored Energy





Energy Center

Compressed H_2 used in Micro-Generation
Load Leveling and Back-Up Supply
For Distributed Periphery

Current MSW Management

Santiago, Sao Vicente, Sal and Boa Vista

- No energy recovery and low recovery (re-use) rate of secondary raw materials (recycables)
  - Current recycling actions are organised by informal waste pickers with inadequate work conditions
  - High energy (and recycling potentials) on Santiago (mainly Praia), Sao Vicente (mainly Mindelo) and Sal (mainly tourism facilities)
- Lacking information (quantity, quality and operational costs of the current “system”)
- High local environmental pollution and second infection
- Data on industrial (food processing & market residues) on waste cooking oil are currently not available

Tentative IfaS Assumptions

Waste Generation Geracao de residuos sólidos	Urban Areas Zona urbana Kg/EW*d	Rural Areas Zona rural Kg/EW*d	Urban Areas Zona urbana Kg/EW*a	Rural Areas Zona rural Kg/EW*a	Turismus Turismo Kg/EW*d
Boa Vista	0,75	0,34	273,75	124,1	1,2
Sal	0,80	0,34	292	124,1	1,2
Praia	0,81	0,34	295,65	124,1	1,2
Santiago (ohne Praia)	0,75	0,34	273,75	124,1	1,2
Sao Vicente	0,75	0,34	273,75	124,1	1,2

Anaerobic Digestion and Energy Storage

Further Input Material
(Waste Fat, ildustrial waste)

Total MSW (organic):
~46.000t/a
(Separate Collection or MBT)

120m3 Biogas per ton of organic MSW

Total Biogas:
~5.600.000 m^3

Liquid and Solid Fertilizer (Compost):
~40.000 t/a

Cogeneration Unit (s)

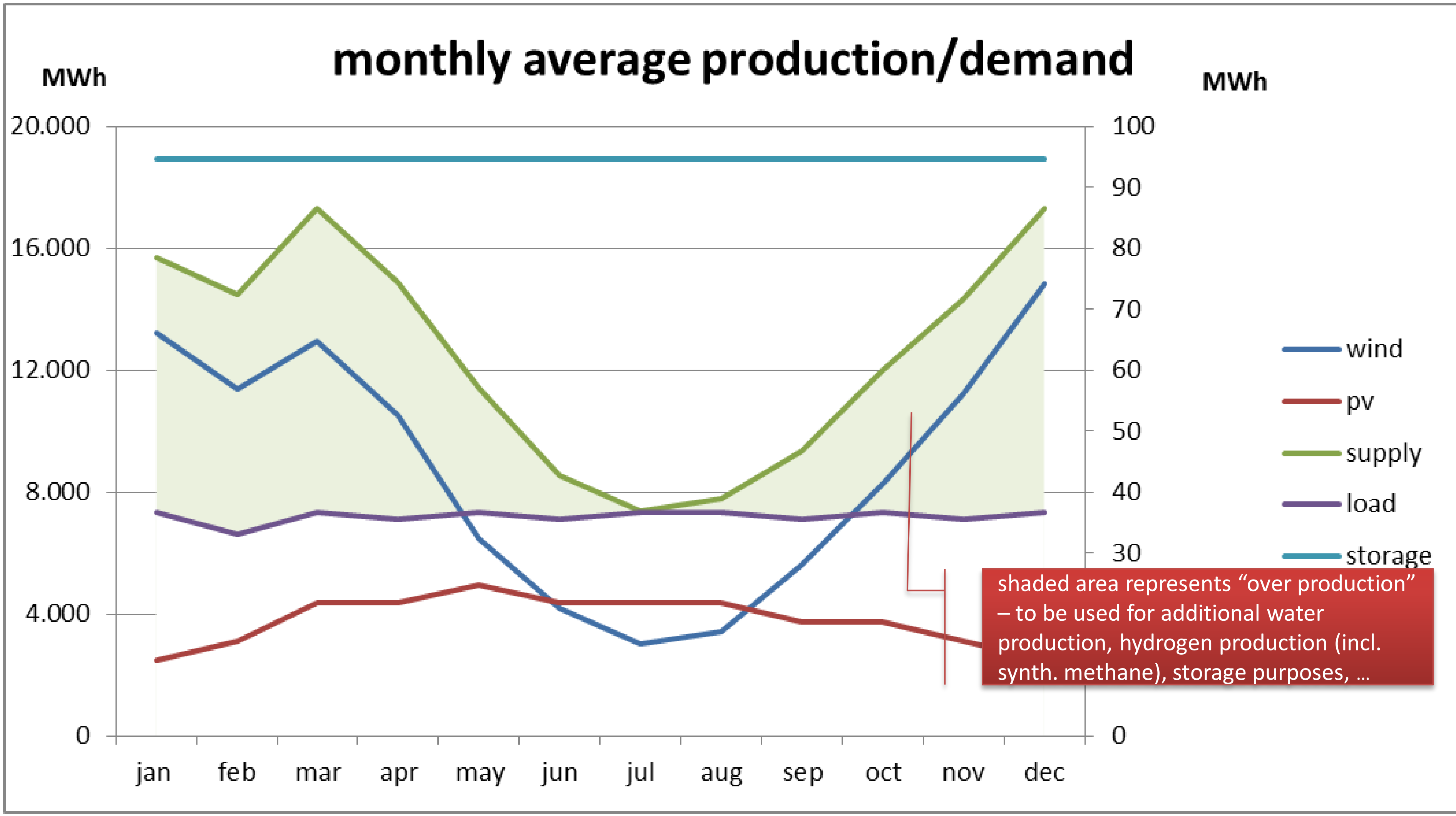
Methanisation
(Injection in National Gas Grid for Mobility or Peak Load)

CO_2 for Hydrogen to Wind-Gas

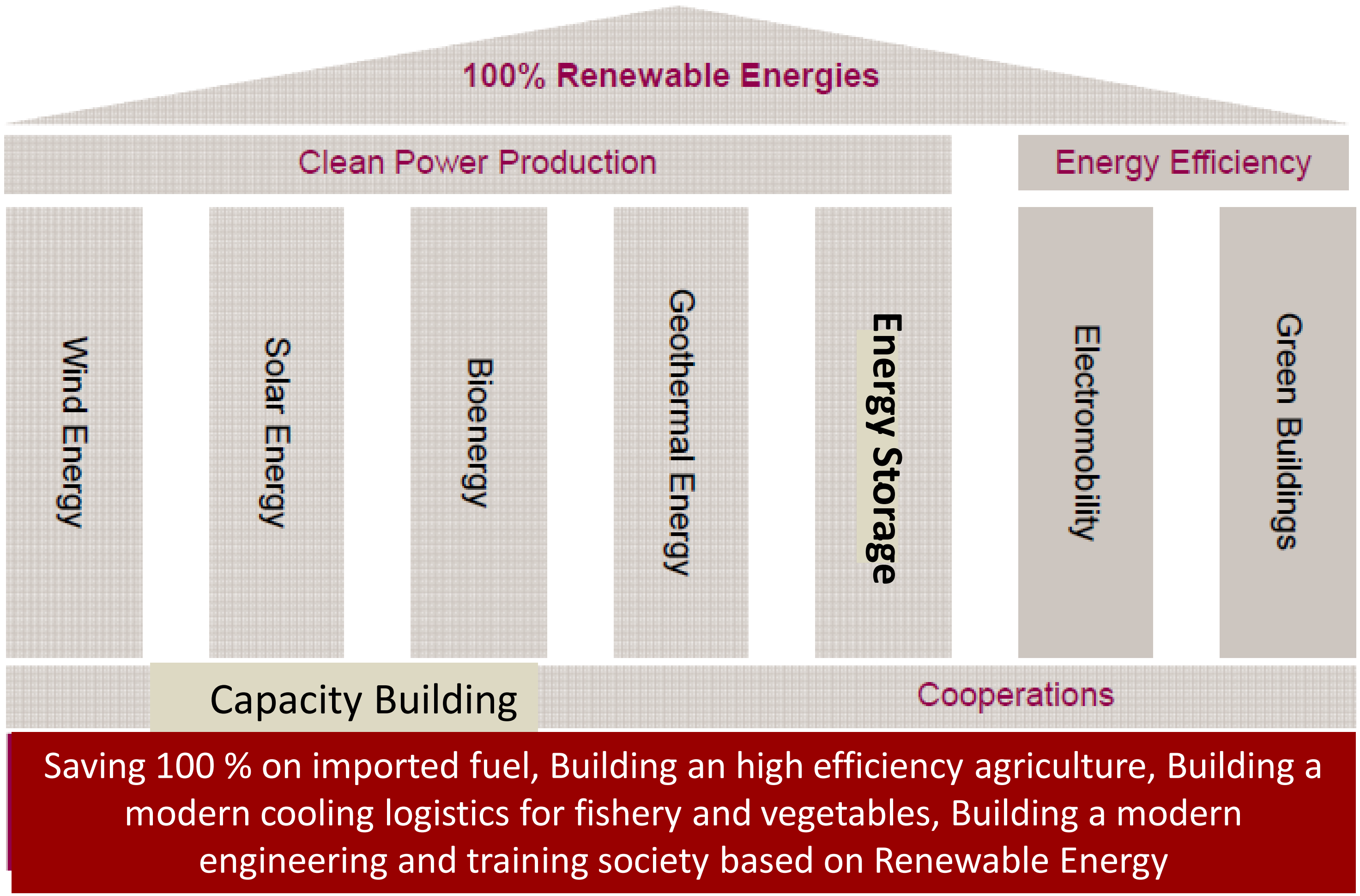
Thermal:
~1.520.000 kWh/a
(in Cooling – absorption chiller)

Electricity:
~1.350.000 kWh/a
(Peak Load)

100% Renewable: Production/Demand



OUR VISION



VISIONARY, AMBITIOUS but FEASIBLE

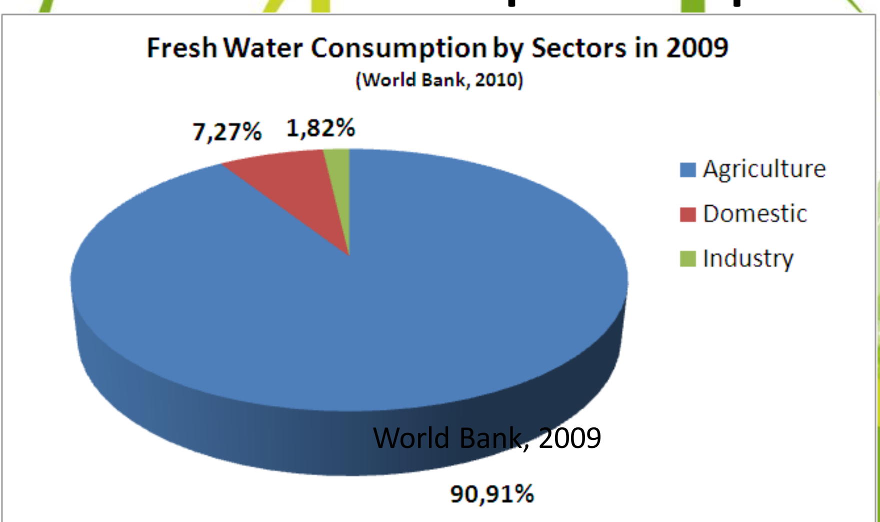
Strategies for Water Supply and Sanitation



- Utilising excess energy for water desalination
  - Continuous decrease of GHG emissions
  - Reduction of water supply costs
- Strategies for sustainable sanitation
  - Recovery of nutrition's and irrigation water
  - Recovery of energy
- Temporary RE storage in water supply systems
  - Pumping energy
  - Operating energy of desalination plants
- Storing Excess energy in agricultural products

Agriculture: Storage Option for Water & Energy

- Current Freshwater Production Costs per m3 are around 3,00 EUR
- Hydroponic farms, Sal and Fogo Island
- 300% Scenario could (until 2015) offer another 50 GWh of affordable energy prices producing up to 10.0 Mio m3



World Bank, 2009

100% Tourism

Brown Field Requirements

Energy Savings Initiatives

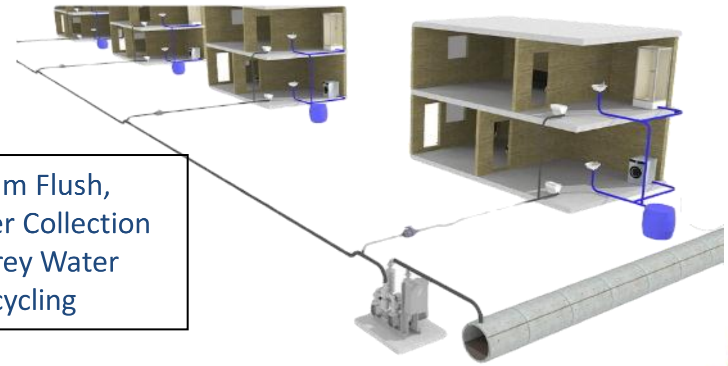
- CFL/LED Lighting
- Solar Water Heating
- Micro Generation

Green Field Requirements

Energy Savings Initiatives

Water Saving Initiatives

- Grey Water Recycling
- Vacuum Toilet Systems
- Rainwater Collection



Vacuum Flush, Rainwater Collection and Grey Water Recycling

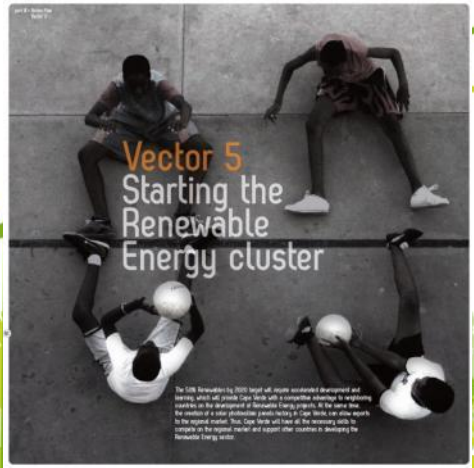
Funding

Eco-Tourism Preferential Loan System

Eco-Efficiency RETROFIT Program

100% Support: Education and Capacity Building

- Technical Transformation towards 100% Renewable Energy requires:
  - New academic courses and programs
  - Non-Academic education (Craftsmanship)
- Continuous scientific research actions
- Sensitisation and environmental awareness campaigns (communication strategy)



- Marketing strategy for education for the ECOWAS region

Cape Verde as a training hub, both theoretical and practical

Cabo Verde: RE as the 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

200-300% Renewables = x% GHG abatement

- 100% RE electricity supply (500-100 GWh/a) equals to min. up to 12.000.000 to CO_2e / 21years (Fossil Fuel Switch)
  - Assumption 1.2 kg CO_2e / kWh (in 2011) declining to 0.1 CO_2e / kWh in 2020
- 100% RE Water Supply (25.000m3/day/21years) equals to min. 1.250.000 to CO_2e / 21years (Fossil Fuel Switch)
- 100% Waste-to-Energy Recovery equals to min. 1.050.000 to CO_2e / 21years (Avoided LFG)
  - Assumption 100to/day and unmanaged landfills
- CONCLUSION: If per ton of CO_2e reduction a ERPA of 10EUR/ton could be established, up to 15% of the the initial investments could be backed.

Challenging Conclusions

- 50% RE is ambitious and unique in Africa but most likely not sufficient!
  - Costs for imported fuel in 2020 are still enormous and fuel supply not at all safe
- 100% demands more engineering intelligence thus providing more chances for an education based society
- 100% creates huge surplus energy which must be used in new industry/consumer chains
- Much higher investment must be organized
- Higher technical complexity „Developing countries cannot do this…“

Let´s get it done, jointly!

IRENA Renewables and Islands Global Summit.

Cape Verde: 300% Renewable by 2020

In corporation with Institut für angewandtes Stoffstrommanagement (www.stoffstrom.org)