Off-grid electrification with solar home systems: the experience of South Africa

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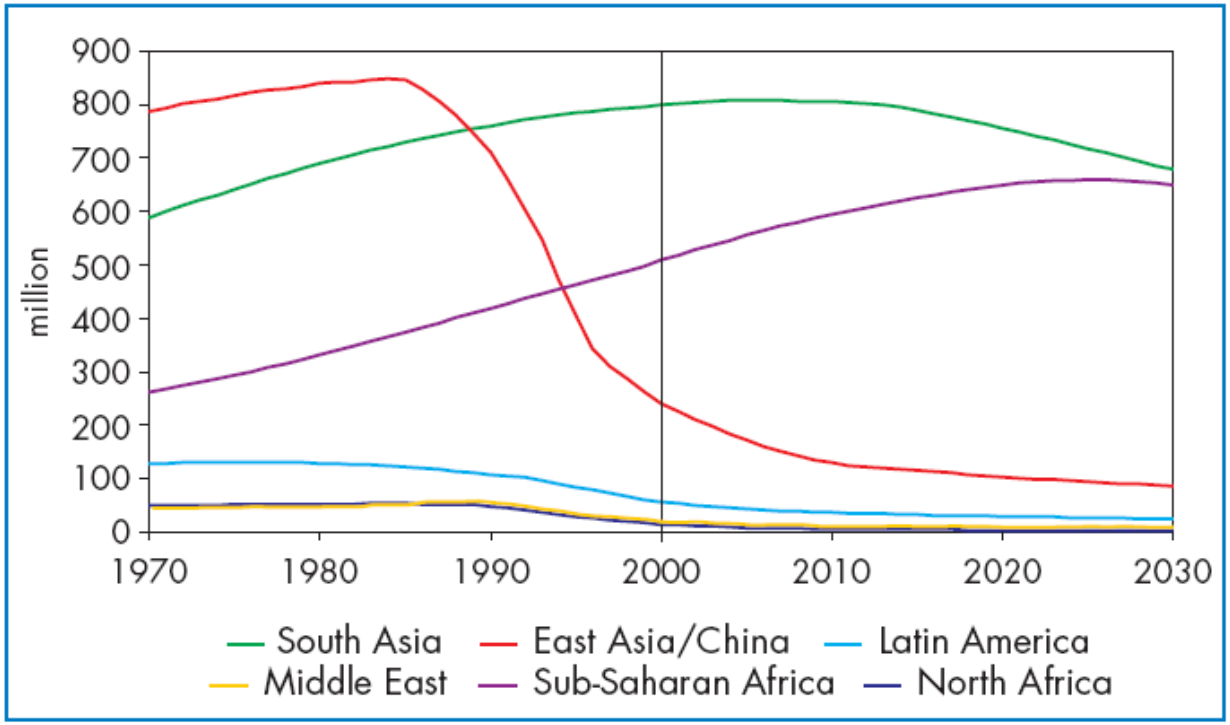
Outline

- Introduction: solar electricity in Africa
- The experience of South Africa
- Conclusion: lessons for off-grid regulation

Number of people without electricity is far from decreasing…

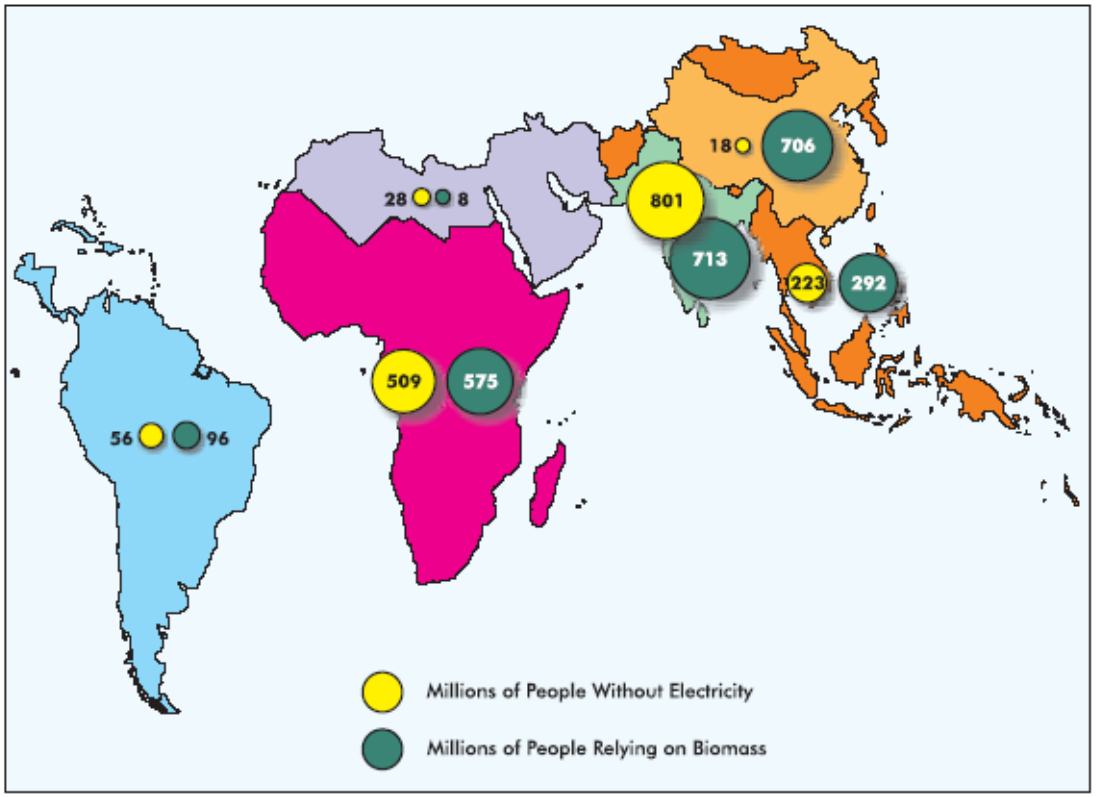
Figure 13.8: **Number of People without Electricity, 1970-2030**



Source: IEA analysis.

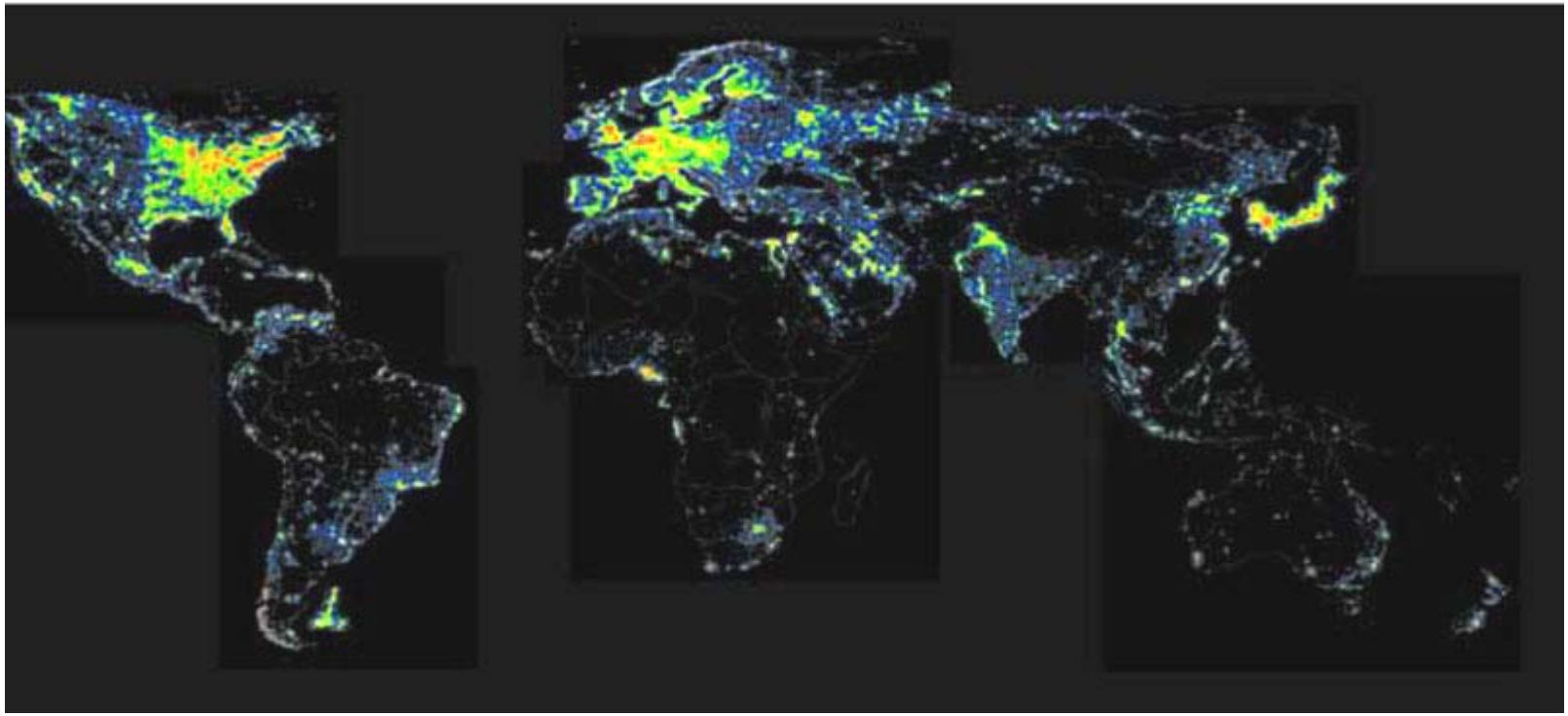
High disparity between continents

Figure 13.3: **Global Energy Poverty**



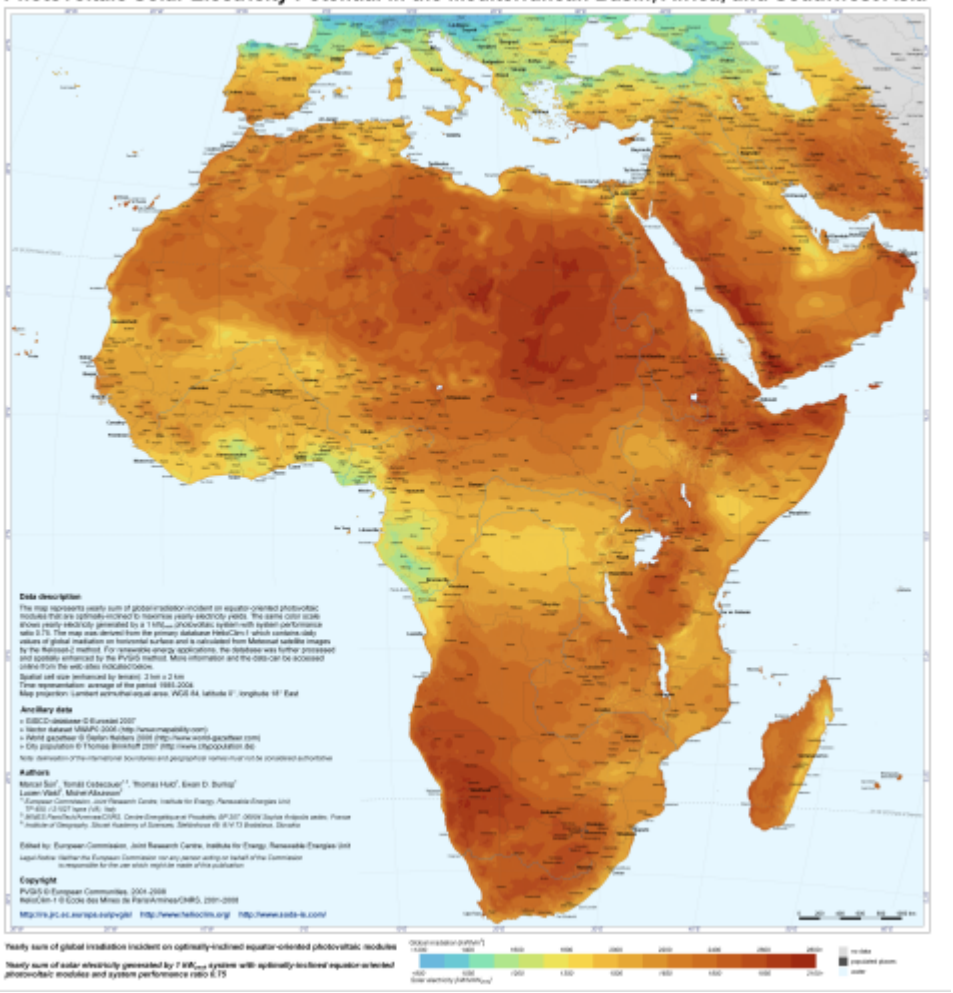
Source: IEA analysis.

Large part of the world in the dark



The amount of electricity consumed in one day in all sub-Saharan Africa, minus South Africa, is about equal to that consumed in New York City (Fatih Birol, IEA's chief economist)

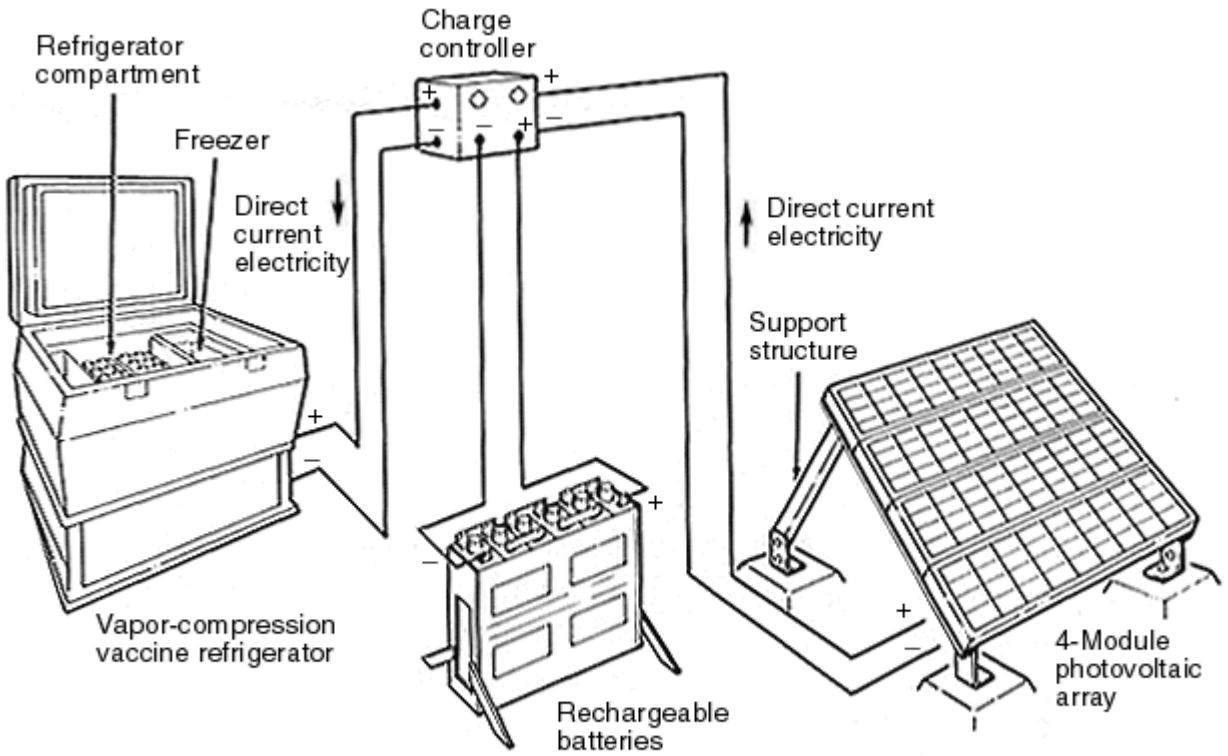
Photovoltaic Solar Electricity Potential in the Mediterranean Basin, Africa, and Southwest Asia



PVGIS copyright European Commission 2001-2008 and HelioClim-1 copyright Mines ParisTech / Armines 2001-2008. Source:

http://www.soda-is.com/eng/map/

Photovoltaic system = basic or complex system?



Vaccine Refrigerator Powered by a Photovoltaic System

Particular interest of solar PV

- Reduction of the cost / W_p of more than 80% since the 1980s of the solar panels from the manufacturers. Current growth rate of the photovoltaic market + 40%/year
  - BUT photovoltaic panels only part of the cost (40/50%)
  - against batteries (20%)
  - and installation costs (40%)

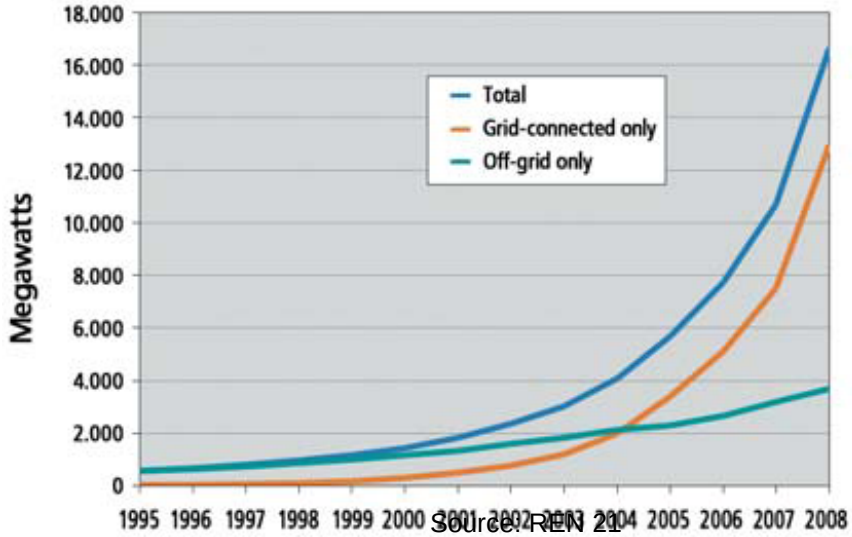
- Cost decreasing but still quite high initial investment (500-1000 US$ for a 50 W_p system) if it has to be borne by end-users.

- Solar interesting in remote areas/scattered houses for low loads compared to:
  - Candles, paraffin - quality of light with PV is superior
  - Diesel generators - mechanical parts and cost of fuel
  - Connection to the grid - high costs of substation

How rural areas could benefit from new technologies?

Paradox of solar energy: in rural areas of developing countries where it could be very useful – solar remains quite expensive

Figure 3.
Solar PV, Existing World Capacity, 1995–2008



Source: REN 21

Costs of Solar Home Systems in selected African Countries

Table 4: Costs of Solar Home Systems in Selected Countries

Country	No. Installed SHSs 2000	Prices for SHS (US$/Wp)	Estimated SHS Cost (50 Wp) US$	GNI (US$)/capita 2001
Kenya	150,000	9.5	550	350
Uganda	20,000	11	730	260
Tanzania	10,000	14	850	270
Ethiopia	5,000	13	750	100
Eritrea	5,000	13	650	160
Somalia	<100		>800	296
Sudan	<1,000	12	650	340
Zimbabwe	85,000	17	800	387
South Africa	150,000	10		1,221
Ghana		14		290
Namibia		22		823
Swaziland		17		1,300
Botswana	5,700	16		3,100
Zambia	5,000		1200	320
Lesotho			1000	530

Sources: (Nieuwenhout, van Dijk et al. 2001; Karekezi and Kithyoma 2002; ESD 2003; World Bank 2003)
Note: Solar PV system cost includes solar panel, battery, 4 lights, charge controller, installation materials, and installation

Source: M. Moner-Girona, 2006.

Pico-PV

Source: Lighting Africa

Toward a new generation of projects?

1) First generation of projects funded by aid

transfer of technology ➔ passivity of receptors

- **Renewable systems were given**
- **Not maintained by local beneficiaries of aid**

2) New generation of projects

Energy just a technical problem?

- **Social needs (not just kWh!)**
  - **➔ To provide a service (not just to sell & install a product)**
- **Maintenance of systems even if the cost is low has to be borne by the end-users**
  - **➔ Clients selected = purchasing power**
  - **➔ Selection of local entrepreneurs**
- **Market-driven (and not just donor-driven)**
  - **➔ Institutions and organisation of the market**
  - **➔ Regulation**

Far larger scale than previous projects

➔Economies of scale and density

➔Standards

Change of paradigm for renewable energy

Old paradigm		New paradigm
Technology assessment	→	Market assessment
Equipment supply focus	→	Application, value-added, and user focus
Economic viability	→	Policy, financing, institutional, and social needs and solutions
Technical demonstrations	→	Demonstrations of business, financing, institutional and social models
Donor gifts of equipment	→	Donors sharing the risks and costs of building sustainable markets
Programs and intentions	→	Experience, results, and lessons

Figure 1 Renewable energy: from technologies to markets.

Source: Annual Rev. Ener. Envt, 2002

Table 1. Matrix of Electricity Supply Models

FORM OF OWNERSHIP		GRID EXTENSION	CONNECTED VILLAGE MINIGRID	ISOLATED VILLAGE MINIGRID	SINGLE-USER SYSTEM
		GRID <----------			----------> OFF-GRID
Private (for profit)	Small, decentralized	Small grid reseller (India)	Hydro minigrids selling to local customers and to the main grid (China, Nicaragua) Formerly isolated minigrid now connected to grid, (Cambodia)	Diesel or hydro minigrid (Cambodia, Ethiopia)	SHS (Honduras, Indonesia, Kenya, Sri Lanka) PV/wind/diesel water pumping (Brazil, Chile, Mexico) WHS or pico hydro (Argentina, Mongolia, Nepal)
Private (for profit)	Large, centralized	Privatized concessionaire extends grid (Argentina, Chile, Guatemala, Uganda)	Technology neutral electrification concession (Senegal)	Off-grid concession (Argentina)	SHS (Bangladesh, Bolivia, Morocco, South Africa)
Nongovernmental	Cooperative	Cooperative finances grid extension (Bangladesh, Costa Rica, United States)		Multi-service Coop with diesel or hydro microgrid (Bangladesh, Bolivia, Philippines)	Agricultural Coop using diesel genset (Bolivia)
Nongovernmental	Other community organizations	Small "community gateways" (Bolivia)		Community microgrids (Brazil, Cambodia, Honduras, Indonesia, Nicaragua, Sri Lanka)	Diesel genset or renewable energy to power a school, clinic, community center (Argentina) PV Battery Charging Stations (Nicaragua)
Public (state-owned)	Small, decentralized	Small state-owned utility extends grid (Brazil, Colombia)		Municipal diesel or hydro minigrid (Bolivia)	
Public (state-owned)	Large, centralized	State utility extends grid and sells at retail (Botswana, Mozambique, Thailand, Tunisia)		Residual state-owned isolated diesel-minigrids with fuel subsidies (Cambodia Nicaragua)	SHS (Mexico)

Source: World Bank/ESMAP, 2008.

Large-scale dissemination and regulation

- **(Un)regulated competitive private sector (regulation / quality)**

  "dealer sales model"

  - Kenya +200,000 SHS BUT quality?
  - Sri Lanka (micro-credit), China, Vietnam, Indonesia, India, Bangladesh

- **Regulated rural energy services concessions (regulation / price + quality)**

  "fee for service model"

  - Photovoltaic
    - South Africa currently 35,000 / target: 300,000 SHS; Zambia
  - Hybrid
    - Morocco (+80,000 target: 150,000), Argentina (+70,000), Peru, Bolivia, Dominican Republic (+5,000?), Benin, Togo, Cap Verde, Namibia, Senegal,…

- **TOTAL world wide +2,400,000 households**

Fee for service – Utility model ("ESCOs")

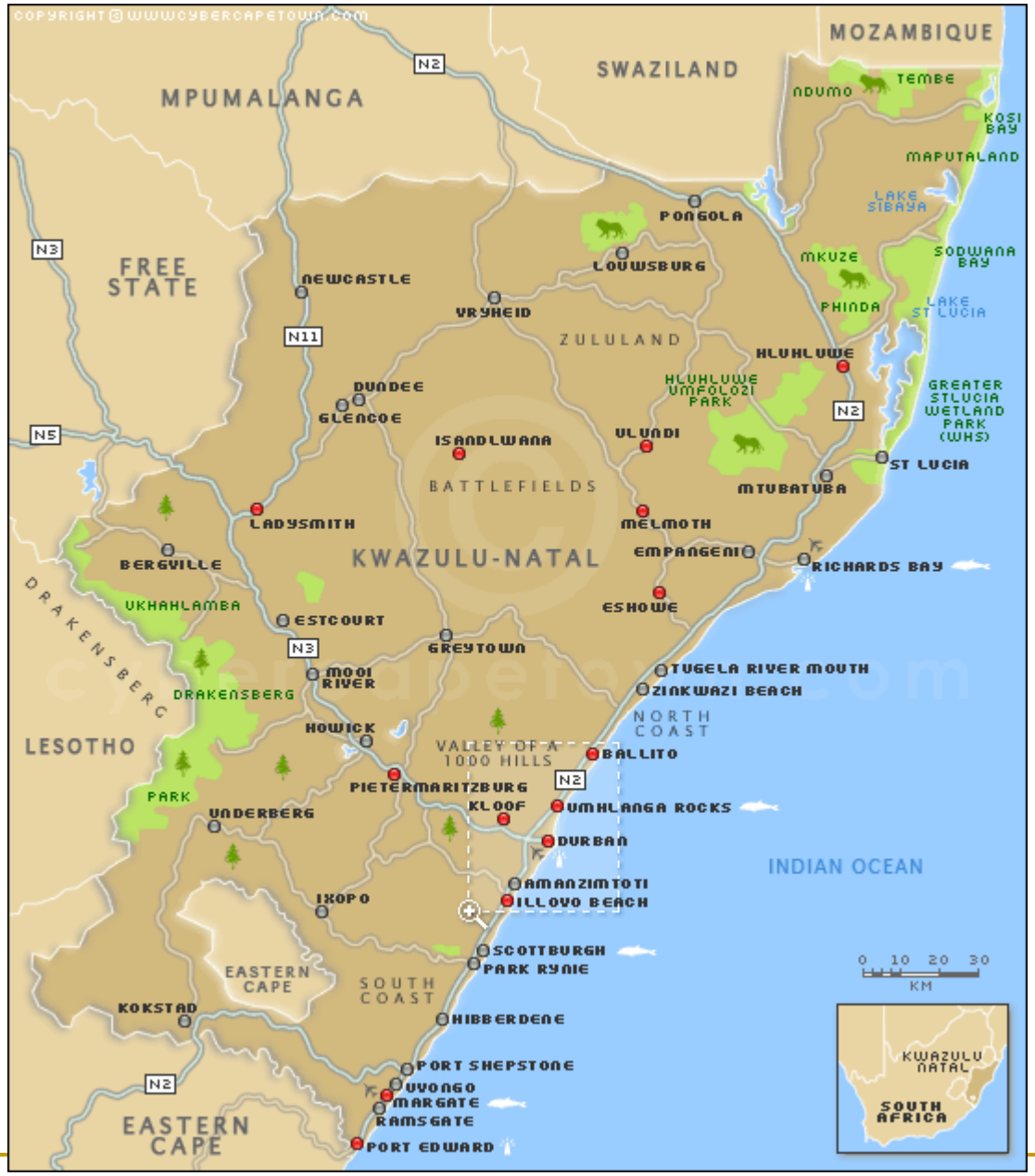
1. Government gives a subsidy to an enterprise to buy PV solar systems & install them in the houses of their clients
2. Clients pay a monthly fee to get the small utility to maintain the PV solar systems for them.

This kind of scheme helps to solve the question of up front cost and the question of maintenance unlike a simple loan

It helps also to centralise decisions and aggregate environmental benefits of individual systems (bulk purchase, CDM), facilitate also enforcement of standards and codes of practices and therefore lower costs of systems for users

Rural electrification in South Africa

- Massive rural electrification effort since 1994, end of apartheid.
- More than 2.5 million households connected to the grid BUT more than 1.5 million households in remote areas unlikely to be connected.
- Concessionaire fee for service with solar photovoltaic has been adopted in 1999 to install more than 300,000 Solar Home Systems.
- Currently 5 concessions, only 34,000 SHS. Subsidies for extension stopped while other PV projects (schools, health centres).
- Project initially monitored by the national regulator, now Department of Mineral and Energy.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MOZAMBIQUE
SWAZILAND
MPUMALANGA
FREE STATE
N2
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TEMBE
NDUMO
KOSI BAY
MAPUTALAND
LAKE SIBAYA
PONGOLA
LOUWSBURG
MKUZE
SODWANA BAY
PHINDA
LAKE ST LUCIA
NEWCASTLE
VRYHEID
ZULULAND
HLUHLUWE
HLUHLUWE UMFOLOZI PARK
GREATER ST LUCIA WETLAND PARK (WHS)
DUNDEE
GLENCOE
ISANDLWANA
BATTLEFIELDS
VLAADI
ST LUCIA
MTUBATUBA
LADYSMITH
MELMOTH
BERGVILLE
KWAZULU-NATAL
EMPANGENI
RICHARDS BAY
DRAKENSBERG
UKHAHLAMBA
ESTCOURT
ESHOWE
GREYTOWN
TUGELA RIVER MOUTH
MOOI RIVER
ZINKWAZI BEACH
DRAKENSBERG
NORTH COAST
LESOTHO
HOWICK
VALLEY OF A 1000 HILLS
BALLITO
PIETERMARITZBURG
KLOOF
UMHLANGA ROCKS
PARK
UNDERBERG
DURBAN
INDIAN OCEAN
AMANZIMTOTI
IXOPO
ILLOVO BEACH
SCOTTBURGH
PARK RYNIE
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PORT EDWARD
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KWAZULU NATAL
SOUTH AFRICA

Rural Concessions in South Africa

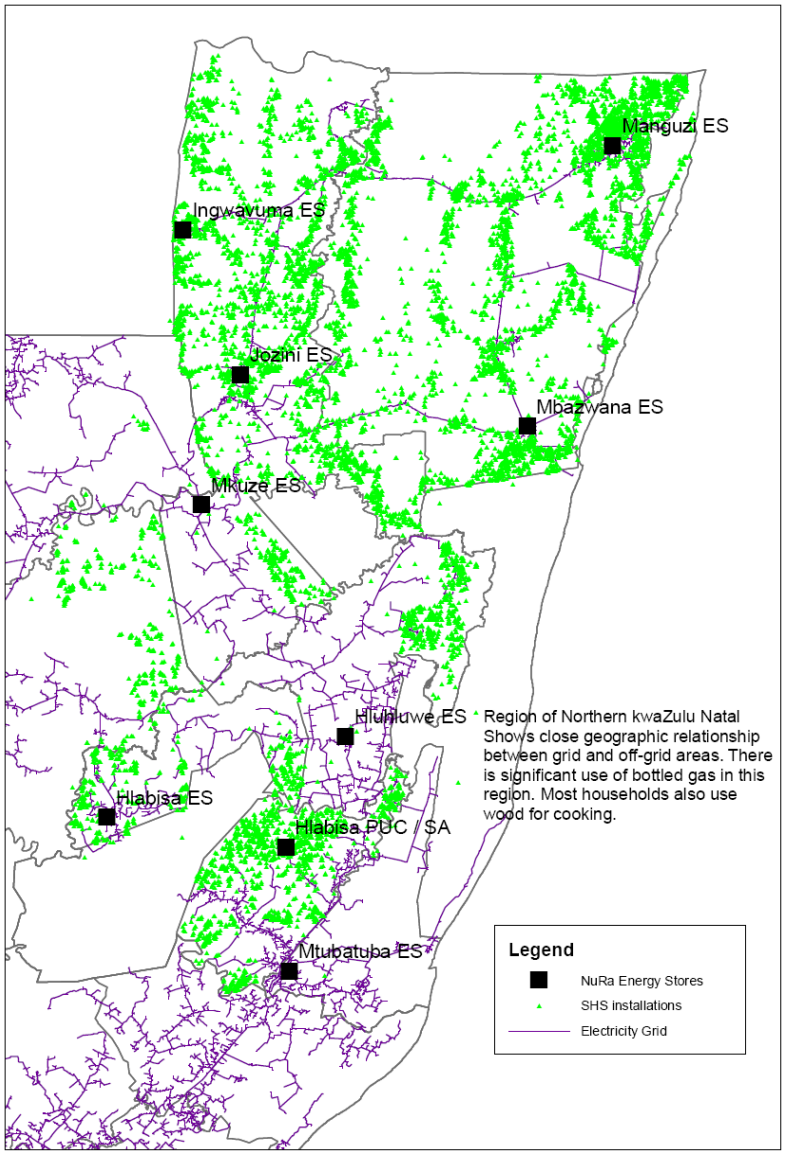
The Nura Concession

The biggest and most successful concession in South Africa

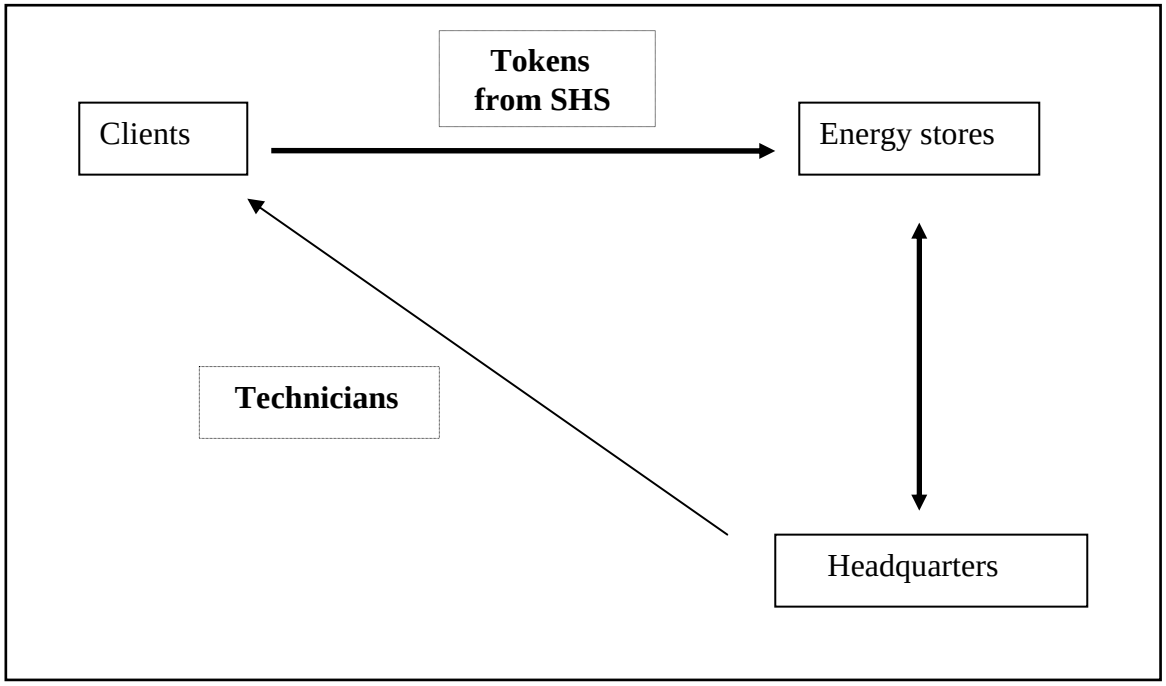
Very large concession of 10.000 Km2 with 11.000 Solar Home Systems

Multi energy stores (LPG + Solar electricity)

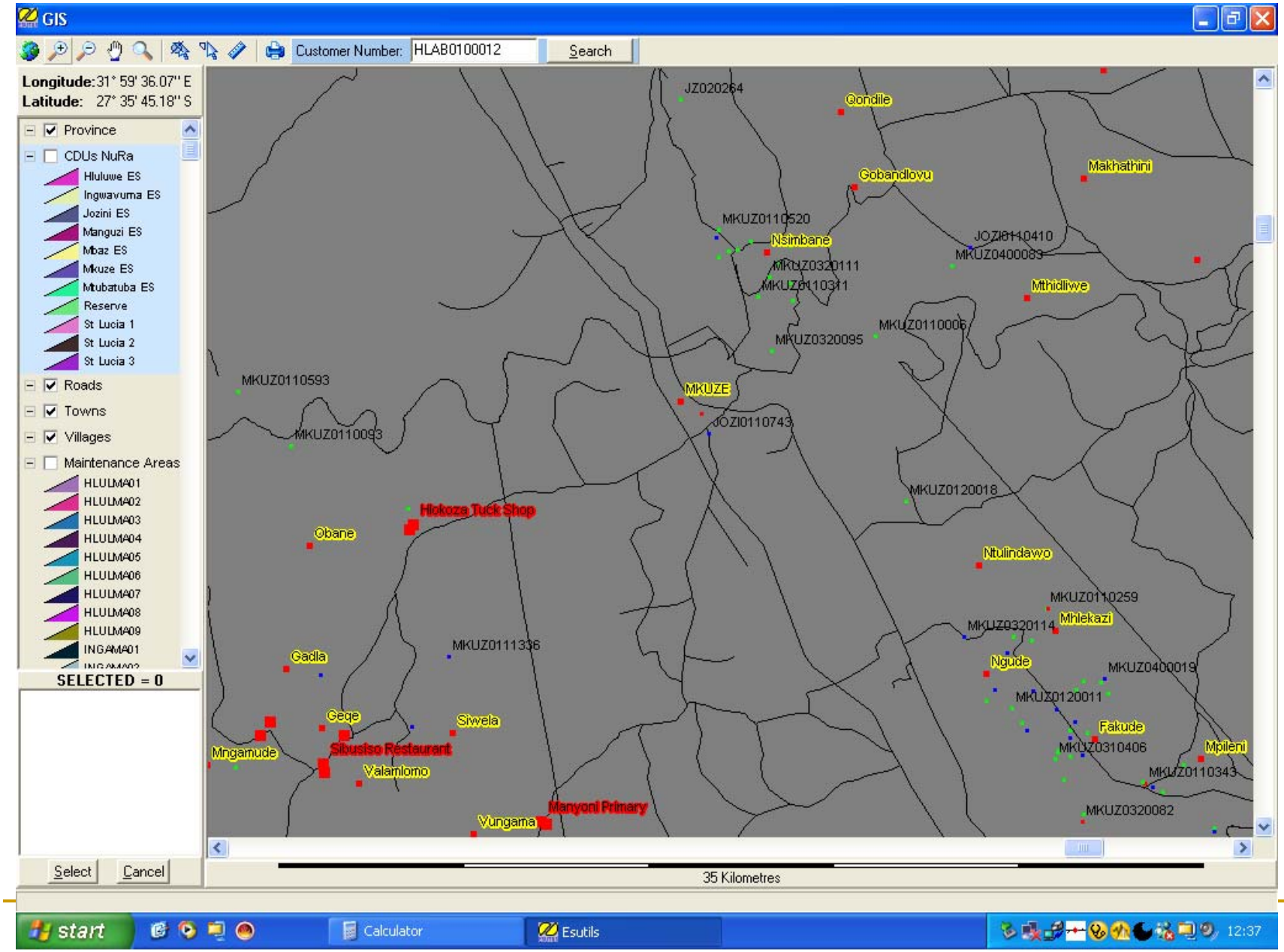
Economies of scale and more than 70 jobs created



Organisation of the reporting system



Source: Xavier Lemaire, REEEP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Latitude: 27° 35' 45.18" S
Province
CDUs NuRa
Hluluwe ES
Ingwavuma ES
Jozini ES
Manguzi ES
Mbaz ES
Mkuze ES
Mtubatuba ES
Reserve
St Lucia 1
St Lucia 2
St Lucia 3
Roads
Towns
Villages
Maintenance Areas
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Manyoni Primary
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start
Calculator
Esutils
12:37

Small versus Large companies?

Status : Interest of having separate entities for rural electrification for decentralised system. Cooperatives or local private companies or associations reactive; their survival linked to fees - National public utility? Grid !

Very small companies
(e.g. Zambia, Pacific)

- **50-150 clients each**
- **900 US dollars/SHS**
- **2-4/5 jobs**
- **Only photovoltaic**
  - **Specialised technicians**
  - **Low maintenance**

➔**Cost of systems remain high**
➔**Proximity with the client**
➔**Customer basis limited**
➔**Fragile-only highest income**

Large companies
(e.g. South Africa, Indonesia)

- **11,000 -30,000 clients each**
- **550 US dollar/SHS**
- **+ 80 jobs**
- **Multi-energy**
  - **LPG, paraffin,…**
  - **Other RE and diesel**

➔**Reduction of costs?**
➔**Logistic difficulties**
➔**Complexity management**
- **Local stores**
- **System of reporting**

➔ **Min break-even point?**

Successes and difficulties

- **Proximity with clients and delay in maintenance?**
  - **good human resource management**
  - **Software + system of reporting + GPS**

- **Complaints mainly linked:**
  - **To small size of the systems (no colour TV! no cooking!)**
  - **Cost of the fee (4-8 US dollars) even subsidised remain high for rural people**
  - **Understanding of the contract? Question of ownership of the systems**

- **Difficulties linked to :**
  - **Lack of coordination with grid authorities**
  - **Differentiated fees due to non-homogeneous interpretation of free tariff**
    - **Fees can vary according to the policy of the municipalities who give or not a subsidy (Free Basic Electricity for first 50 kWh/month) (since 2007 Free Basic Alternative Electricity of 55 R)**
  - **Lack of continuous support**
    - **No more/limited subsidies to buy new systems and increase the number of systems managed**

Design institutional and regulatory framework

- Public-private partnership
- Overcome barriers of up-front costs
  - Access to specific sources of funding
  - Rural electrification ➔ subsidies
- Reduce costs of installation & maintenance
  - Clear definition of who is responsible of systems – learning curve
- Find good combination of technologies
  - Integrated energy services
- Long-term commitment of public authorities
  - Stable regulatory framework

References to go further

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