Optimal Resource Choice & Configuration for Suriname

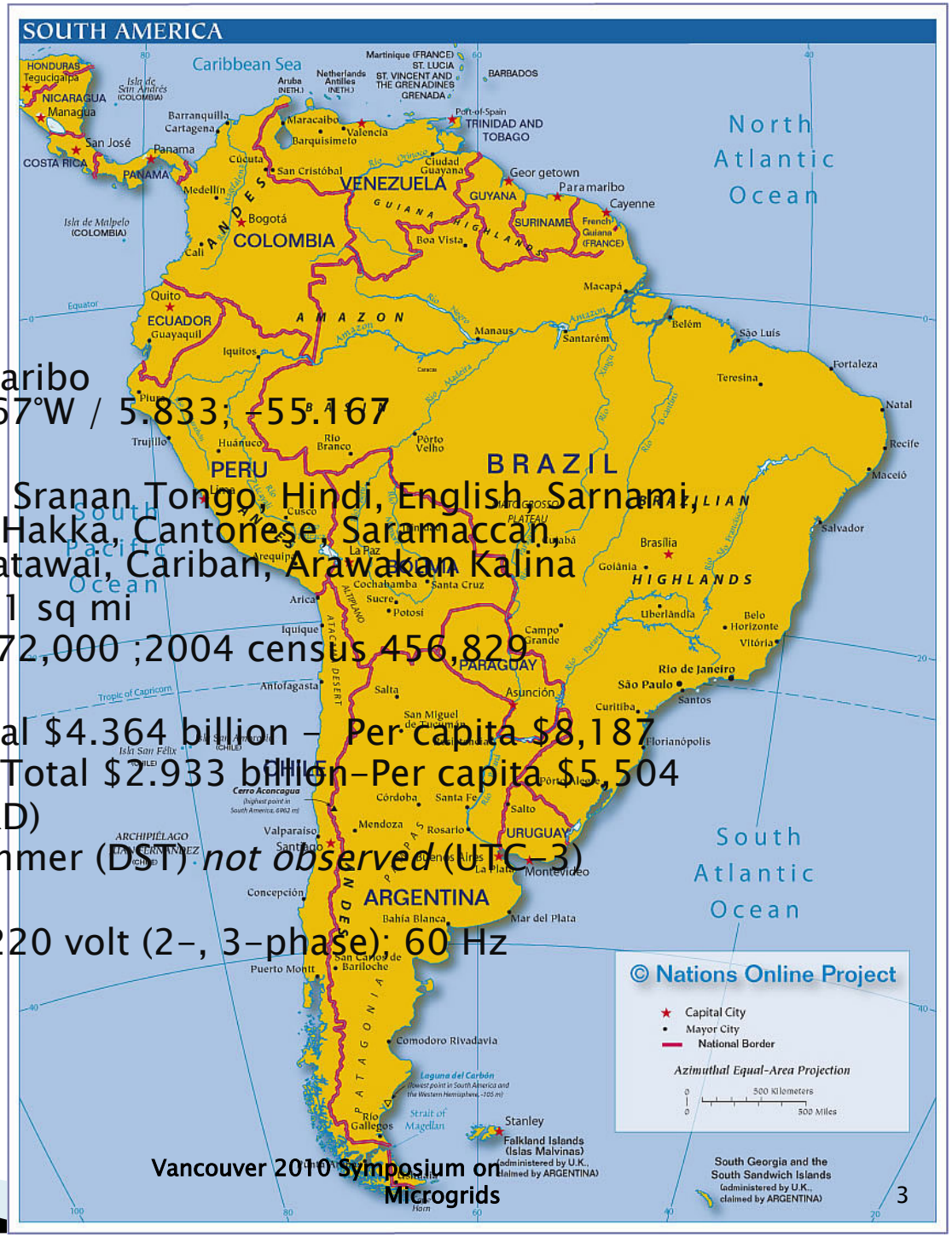
Vancouver 2010 Symposium on Microgrids
July 22nd, 2010
Anand Kalpoe

Agenda

- Introduction
- RE Resources Suriname
- RE integration into Power Systems
- Expected results

Introduction

- **Republic of SURINAME**
  - **Capital** (and largest city): Paramaribo 5°50′N 55°10′W / 5.833°N 55.167°W / 5.833; -55.167
  - **Official language**: Dutch
  - **Recognized regional languages**: Sranan Tongo, Hindi, English, Sarnami, Javanese, Indonesian, Bhojpuri, Hakka, Cantonese, Saramaccan, Paramaccan, Ndyuka, Kwinti, Matawai, Cariban, Arawakan Kalina
  - **Area**: Total 163,821 km^2; 63,251 sq mi
  - **Population**: – 2009 estimate 472,000 ;2004 census 456,829
  - **Density**: 3.0/km^2 ; 7.8/sq mi
  - **GDP** (PPP) 2008 estimate – Total $4.364 billion – Per capita $8,187
  - **GDP** (nominal) 2008 estimate – Total $2.933 billion–Per capita $5,504
  - **Currency**: Surinamese dollar (SRD)
  - **Time zone**: ART (UTC-3) – Summer (DST) *not observed* (UTC-3)
  - **Drives on the left**
  - **Electricity**: 127 volt (1-phase); 220 volt (2-, 3-phase); 60 Hz



- EPAR-system
  - (Energievoorziening Paramaribo en omstreken)
- ENIC-system
  - (Energievoorziening Nickerie)
- District power systems
- Rosebel gold mines
- Brokopondo distribution system
- Small isolated remote power systems (111 villages)

Electrical Power System in Suriname

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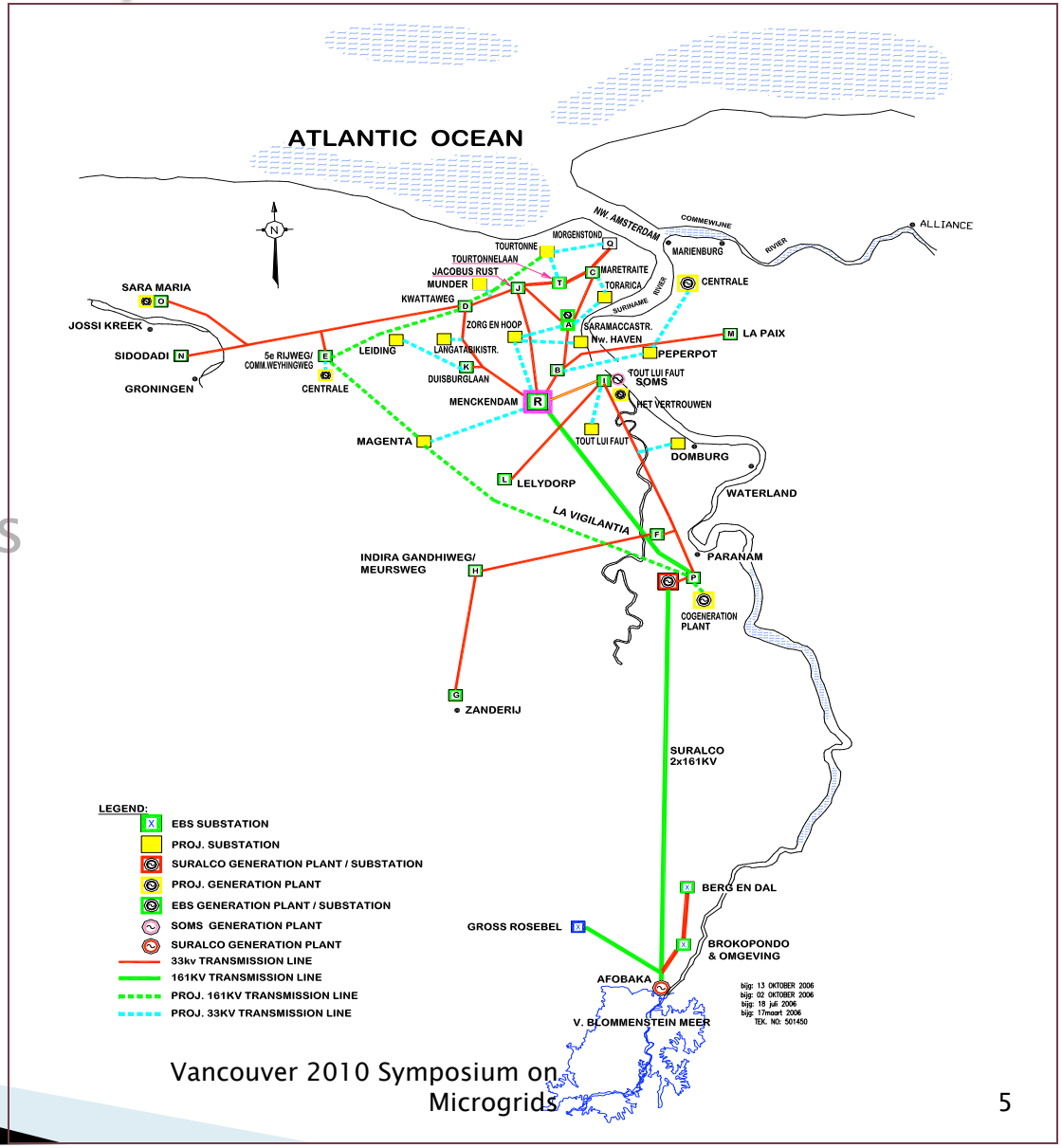

BROKOPONDO KRACHTCENTRALE

Overview of main location of villages in Suriname's interior. Source: Dr. S. Naipal, Anton de Kom Universiteit van Suriname.

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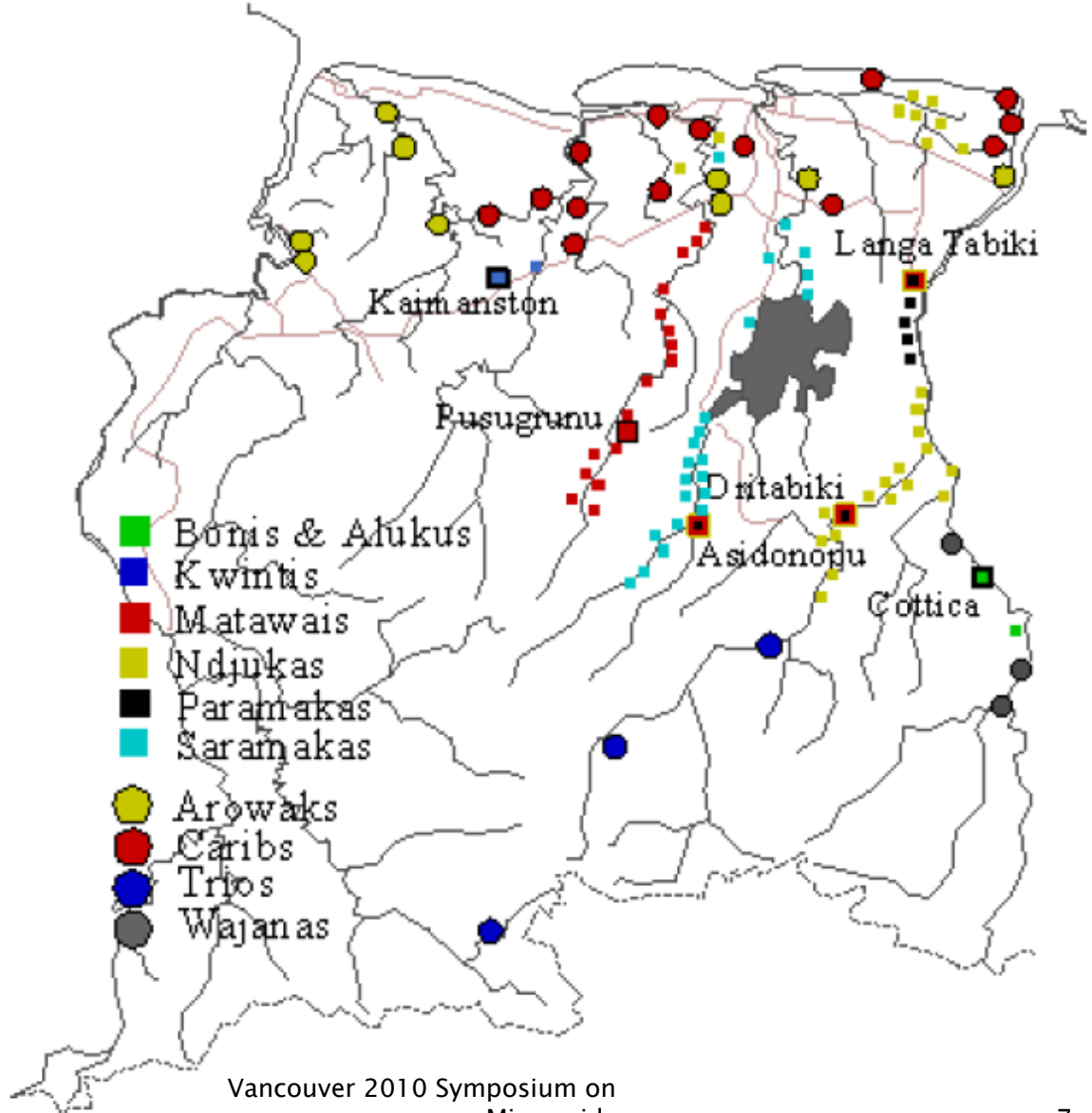


Introduction

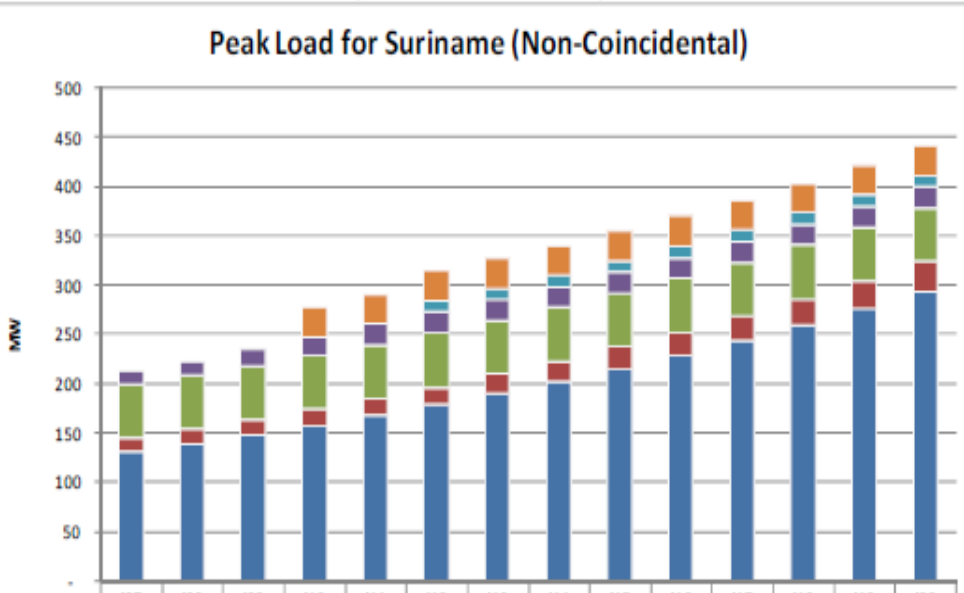
- Electricity access rate
  - Source: Suriname Power Sector Assessment and Alternatives for its Modernization: Preliminary Assessment Report, by KEMA, July 2008

Electrification rates in Suriname: Distinction between EBS, DEV and no access. Source: ABS census and own estimations.

	Persons	Percentage
Total Population	492,829	
EBS electrified	387,364	79%
DEV electrified	30,000	6%
No Access	75,465	15%

Introduction

- Peak load projection (total/non coincidental)



	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	'18	'19	'20
Total	212	222	235	277	290	314	327	340	355	370	386	403	422	442
Others				30	30	30	30	30	30	30	30	30	30	30
Staatsolie		-	-	-	-	12	12	12	12	12	12	12	12	12
Iamgold	14	14	17	19	21	21	21	21	21	21	21	21	21	21
Suralco	55	55	55	55	55	55	55	55	55	55	55	55	55	55
Districts	14	14	15	16	17	18	20	21	22	24	25	27	29	30
EPAR	130	139	148	157	167	178	189	201	214	228	243	259	275	293

Operator	Area	Installed Generation Capacity (MW)	Peak Demand (MW)	Consumption(MWh)
EBS	EPAR	82	130.3	727,364
EBS	ENIC	15. 9	10.0	547,460
EBS	Albina	2. 9	0.58	3,674
EBS	Apoera	1.44	0.2	936
EBS	Boskamp	0.6	0.08	601
EBS	Brokopondo	0		462
EBS	Coronie	3.15	0.54	3,157
EBS	Moengo	4.7	1.5	8,768
EBS	Wageningen	4.3	0.56	3,054
Suralco	Afobaka	189		
Suralco	Paranam	99	49	429,080
IAMGOLD	Rosebel	0	14.5	118,000
Staatsolie	EPAR	14		
DEV	Interior	+/-1.5		

Remark: Total available for EPAR now maximum +/- 246 MW.

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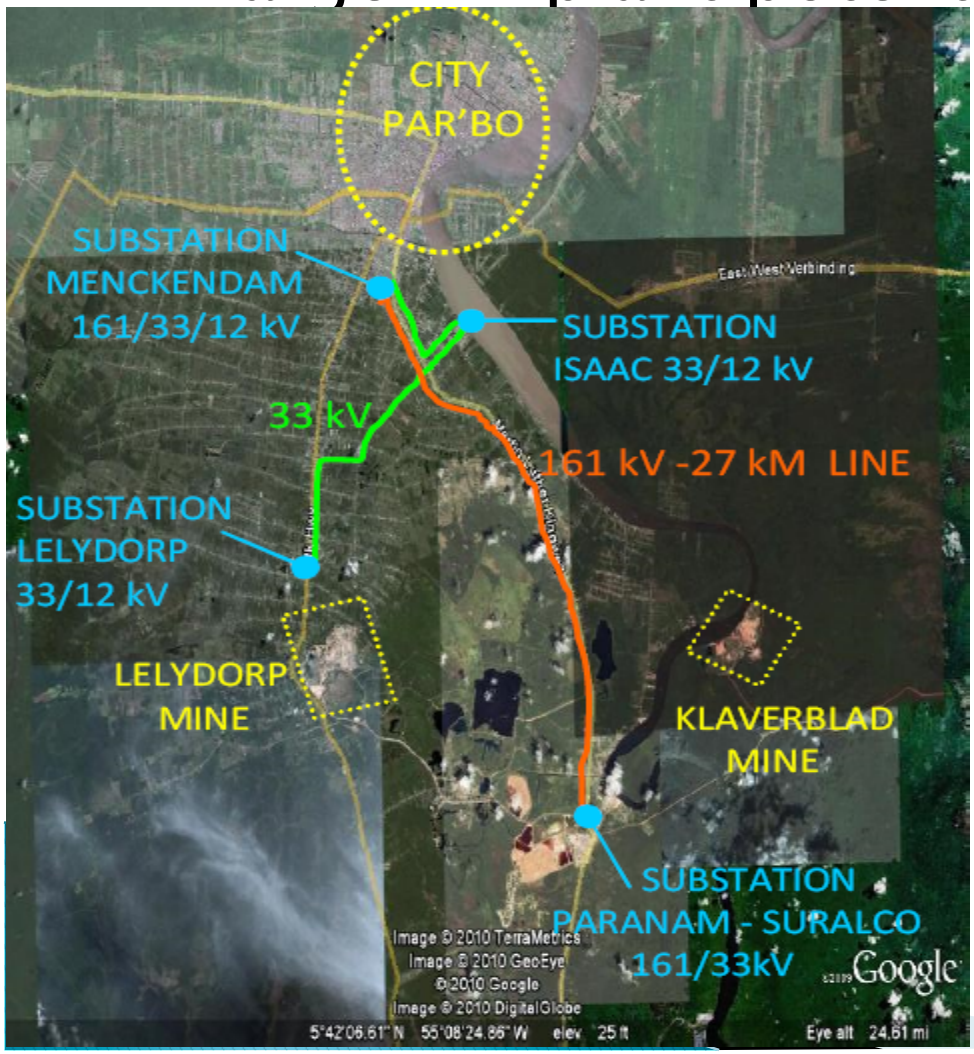
RE Resources Suriname

- Sun
  - Solar radiation and cloud coverage (NASA and Meteonorm)
    - annual mean solar radiation over the period 1981-2000 in Suriname: 1450-1650 kWh/m2
    - mean annual cloudiness 4,6 and 6,2 (on a scale from 0-10)
  - Actual data not yet available
    - Measurements started at University
    - Data collection from pv-systems: to be started
    - Result: Solar radiation map for Suriname

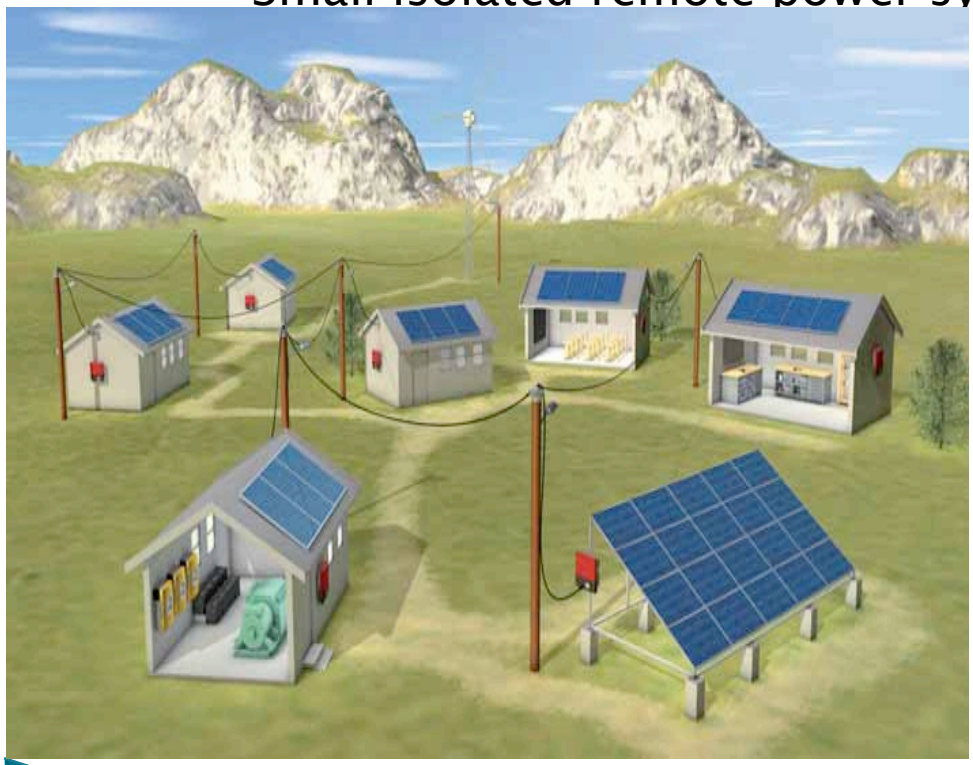
RE Resources Suriname

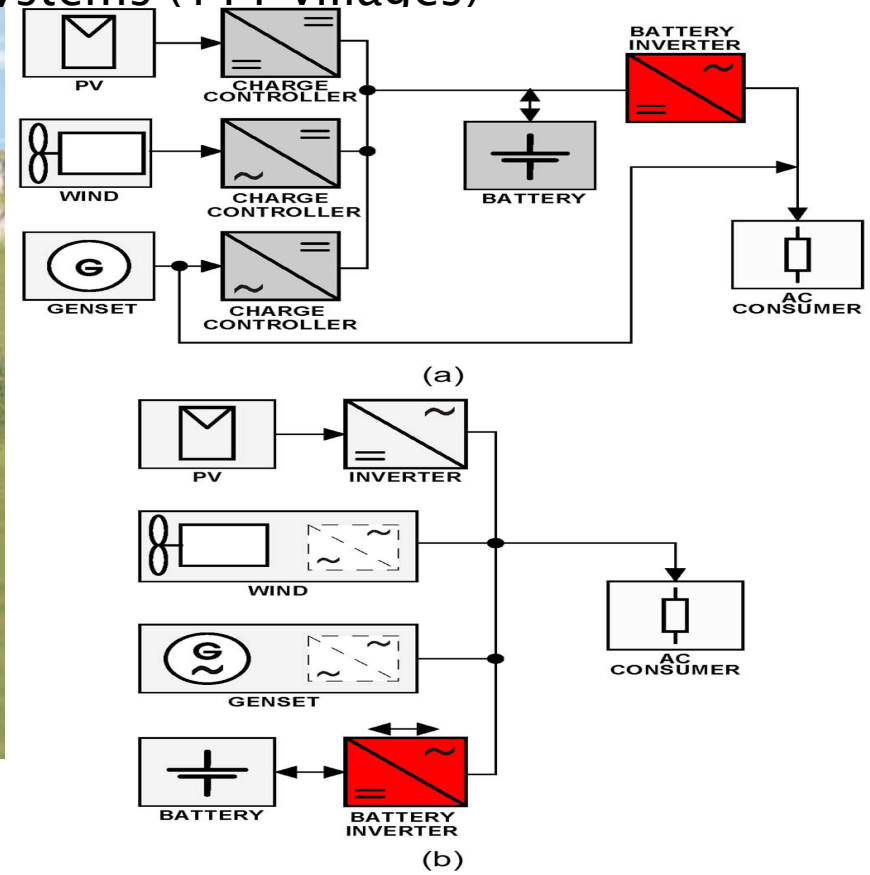
- Large PV-plant potential



RE Resources Suriname

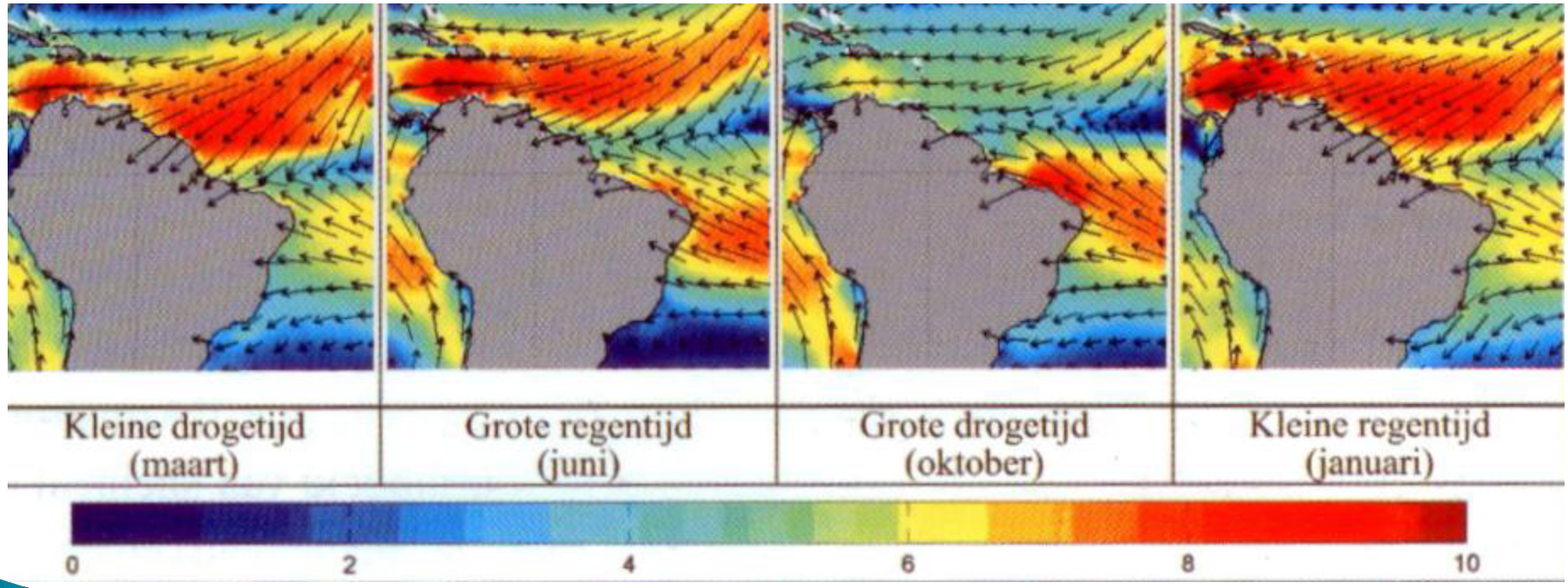
- Small PV-plant potential
  - Small isolated remote power systems (111 villages)





RE Resources Suriname

- Wind
  - Wind vector diagram for different seasons. Wind speed is color coded from 0-10 m/s (Source: NASA)



RE Resources Suriname

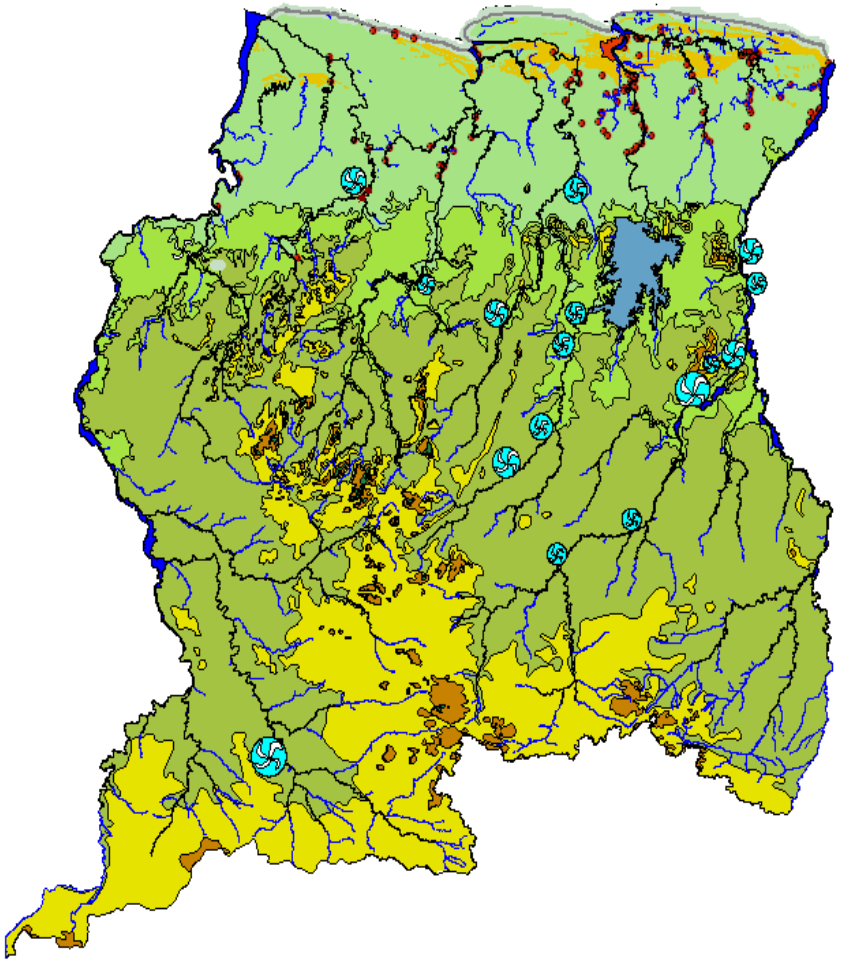
- Wind
  - Wind speed & direction measurements
    - For electrical energy production
    - Two locations
      - East: Galibi➔ no grid available
      - West: Nw. Nickerie➔ grid available
    - Project start: October 2009
    - No off-shore measurements (yet)

RE Resources Suriname

- Hydro (Large)
  - Afobakka: installed capacity = 180 MW
  - Kabalebo: projected up to 850MW

RE Resources Suriname

- Hydro (Small)
  - Source: Dr. S. Naipal



Location	River	Useful power(kW)
Tapawatra	Gran Rio	200
Gran Dan	Gran Rio	530
Dangogo	Pikin Rio	25
Felusie(Afobasu)	Suriname	40
Felusie(Mindrihati)	Suriname	250
Boespapja	Sipaliwini	15
De Karina Ituru	Kutari	25
Sir Walter Raleigh falls	Coeroni	150
Marchallkreek	Suriname	40
Njun Jacobkondre	Saramacca	40
Poketie	Tapanahony	40
Stoelmanseiland	Marowijne	60-120
Poesoegroenoe	Saramacca	40
Ladoeani	Suriname	40
Kwamala semutu	Sipaliwinie	40
Kwamala sula	Lawa	40
Langa tabbetje	Marowijne	40
Botopasie	Suriname	40
near Raleighfalls	Coppename	40

RE Resources Suriname

- Hydro (Small)
  - Source: Dr. S. Naipal

Location	River	Stream flow (m^3/s)	Head (m)	Min Power (kW)	Useful Power (kW)	Turbine type
Tapawatra	Gran Rio	14.3	4.2	354	200	Kaplan
Gran Dan	Gran Rio	17.7	6.0	625	530	Kaplan
Dangogo	Pikin Rio	4.9	1.2	35	25	Propeller
Felusie (Afobasu)	Suriname	5.0	1.6	47	40	Kaplan
Felusie (Mindrihati)	Suriname	15.0	3.1	274	250	Kaplan
Boespapja	Sipalawini	3.1	1.2	21	15	Kaplan
De Karina Ituru	Kutari	3	2.2	39	25	Kaplan
Sir Walter Raleigh val	Coeroni	6 -10	5.0	206	150	Propeller

RE Resources Suriname

- Waste Valorization (landfill)

Year	Average waste generated (T)	Total amount of energy (MJ)	Total amount of energy/year (GWh)
2002	46,364	501.32	140
2003	71,648	774.72	217
2003	54,604	590.42	165

Zuilen L. Planning of an integrated solid waste management system in Suriname: a case study in Greater Paramaribo with focus on households. PhD thesis, Ghent University, 2006, 366 p.

- Bio-crops / Bio-mass
  - Rice husk
  - Sugar cane (pilot-project)
- Bio-fuel
  - Jathropha (pilot-project)

RE Resources Suriname

- Other
  - Tidal/wave power
  - Osmotic power
  - CCS on land

Optimal Resource Choice

- Based on (annual contributions):
  - Available resource
    - Total resource
  - Technical potential
    - Accessible resource
  - Practicable potential
  - Economic potential

Optimal Resource Choice

- Which Resources/technologies are expected to play a major role?
  - Available resources assessment (potential energy output)
    - Practicable potential
  - Estimating future costs
    - Engineering assessment (refinement and development of technologies)
    - Learning curve (extrapolation of historic relationships between cost reduction and cumulative production)

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RE integration into Power System

- Distributed Energy Resources
  - Electricity generation
    - Optimal deployment of renewable energy systems in Suriname
      - Technology potentials for Suriname
        - Small scale
          - Rural electrification: island mode; micro grids; issue of scale; storage
        - Large scale
          - Interconnected systems: on- and off grid operation; system balancing; penetration levels; intermittency
        - Comparison ➔ best practices for implementation

RE integration into Power Systems

- Distinctive features RE-plants
  - Variability and predictability
    - Fluctuations can be predicted
  - Resource location
    - Close to demand centers or electrical networks
  - Electrical characteristics
    - Capabilities: voltage/frequency control

RE integration into Power Systems

- The “Suriname case”

RE integration into Power Systems

- Configuration choice for Suriname based on:
  - System operation, balancing and system reserves
    - Reserve requirements
    - Forecasting
    - Excess RE production
    - Ancillary services
      - Operating reserve; reactive power through short circuit current contribution; black start capabilities
    - Transmission and distribution system operation
      - Congestion and unpredicted flows
      - Distribution grids
  - Network reinforcements
  - Connection rules and codes for RE
  - RE penetration levels and the resulting system adequacy (capacity credit)
  - Electricity market design and rules

Expected results

- Ranking of renewable technologies for use in Suriname
  - Large scale and small scale systems
- Best practices for implementation of micro-grids in Suriname
  - Remote and isolated micro-grids
  - Micro-grids connected to the grid (with island mode)

Thank you for your attention

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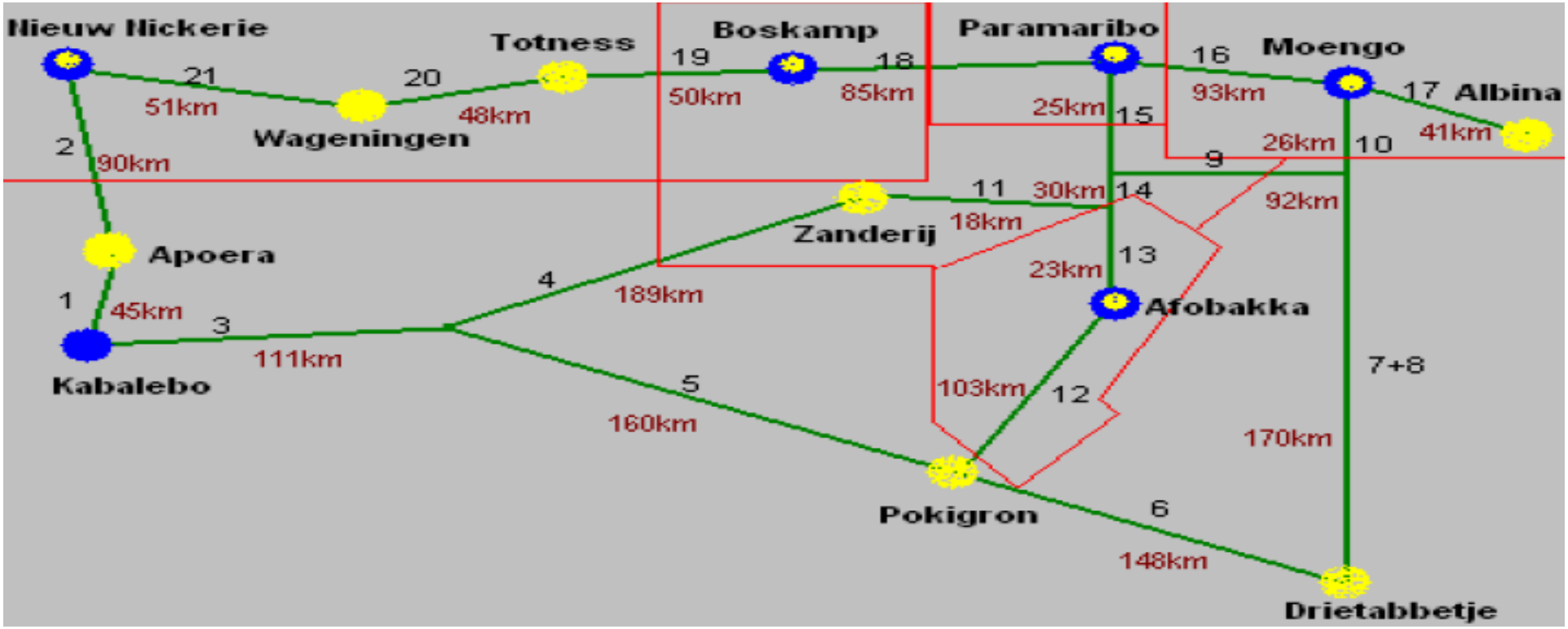
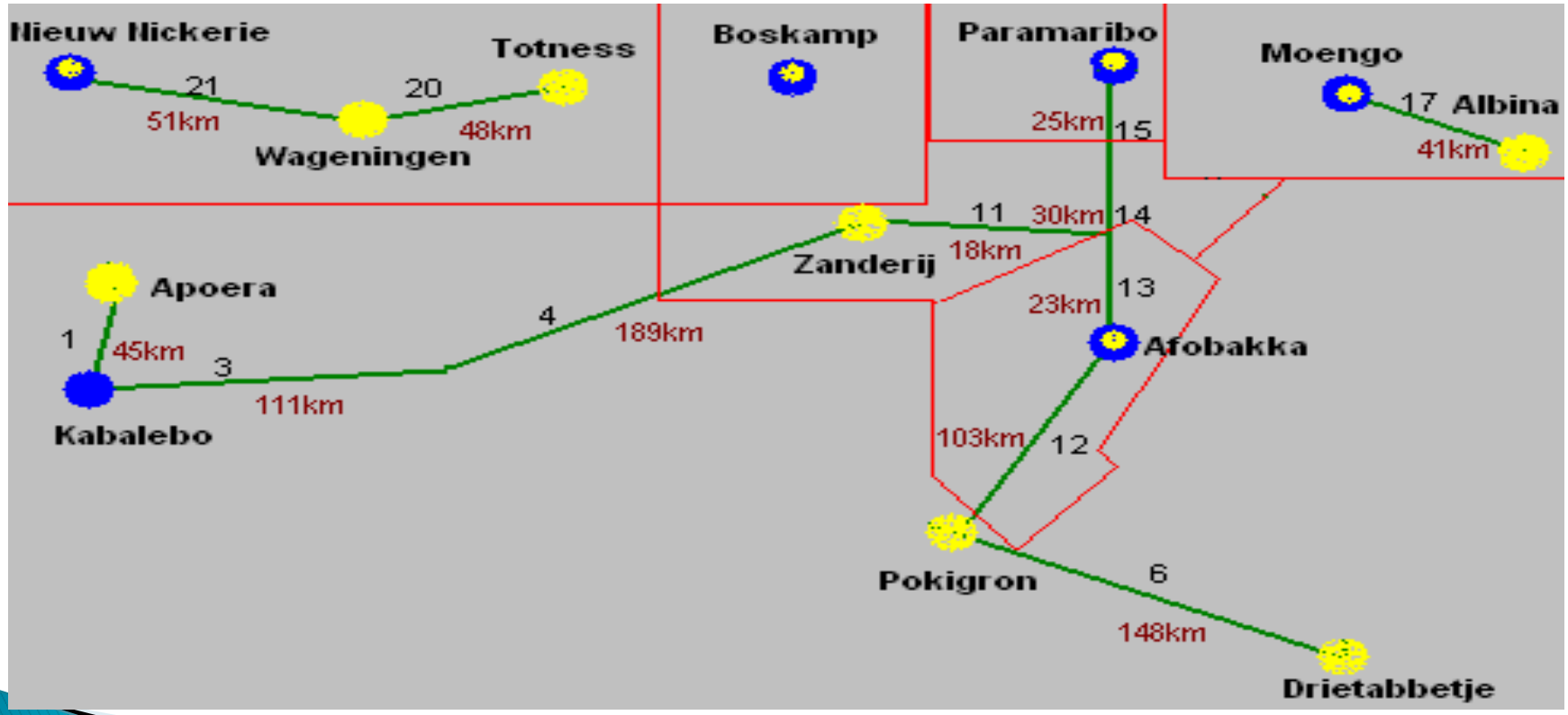
New configuration: Power System of Suriname

- Conventional plants & large hydro



New configuration: Power System of Suriname

- Conventional plants & large hydro: normal operations



Distributed Generation: What Is It?

Distributed Resources (DR) are small (usually under 10 MW), modular electric generation and storage technologies that provide electric capacity and/or energy when and where needed. DR may either be interconnected with the electric grid or isolated from the grid in "stand-alone" applications, but its locational value is important to its economics and operation.

Distributed generation = DG
Distributed storage = DS

2009 10 11

Tariff survey CARILEC

Country	Utility	Average cost/kWh for billing category – 100 kWh
Suriname	NV EBS	(0.054 SRD) 0.0189 US$
Trinidad	T&TEC	0.0500 US$
Belize	BEL	0.2200 US$
Aruba	NV Elmar	0.2549 US$
Bahamas	GB Power	0.3000 US$
Barbados	BL&P	0.2500 US$

Table 1. Average cost/kWh (US$), category - 100 kWh, Source: CARILEC tariff survey-mid 2008

Introduction

- Anand Kalpoe
- 17 may 1972
- B.Sc.-Electrical Energy Systems, 1996
- M.Sc.-Energy Systems, 1998
- Lecturer, 1999 – present day
  - Courses
  - Positions / duties
  - Projects

Introduction

ADEKUS

http://vlir-iuc.uvs.edu/