Small wind turbines & hybrid systems

Recommendations for application and their potential

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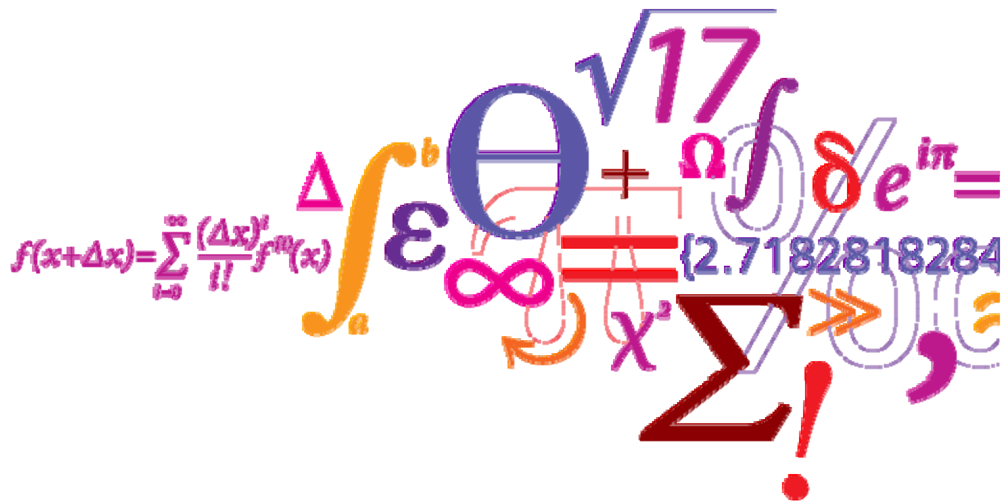


DTU Wind Energy
Department of Wind Energy

Outline

- The applications for SWTs and hybrid systems
- The DTU experience

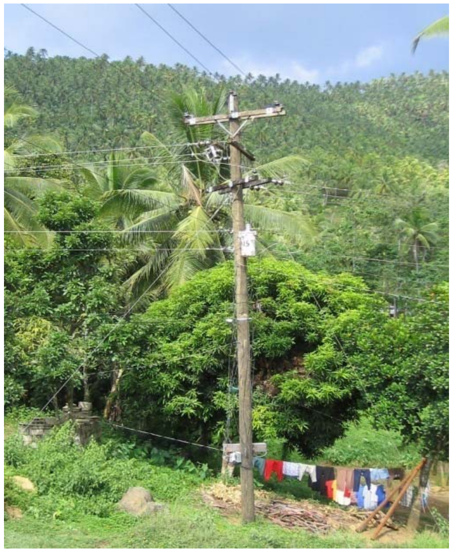
TECHNICAL
- Wind resource
- Small wind turbines
- System engineering

ORGANISATIONAL
- Project implementation
- Operational experience

- Summary of recommendations

Applications for wind-hybrid systems

- Providing power where there is no grid
  - Rural electrification
- Support of grid where it is not economic to extend it
  - More semi-urban locations
- Producing power to contribute to local consumption
  - Use local grid as ‘storage’: requires a good grid



The DTU experience

DTU Wind Energy
Department of Wind Energy

- SWT testing & approvals
- Wind-hybrid system simulation

DTU Electrical Engineering
Department of Electrical Engineering

- Smart grids with renewable energy
- SYSLAB research facility
- System engineering software

UNEP RISØ CENTRE

- Sustainable energy policies in rural areas
- Capacity building

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Wind resource

- Challenge: Even if a hybrid system is well designed...if there's not the wind that was expected then the system won't work as designed

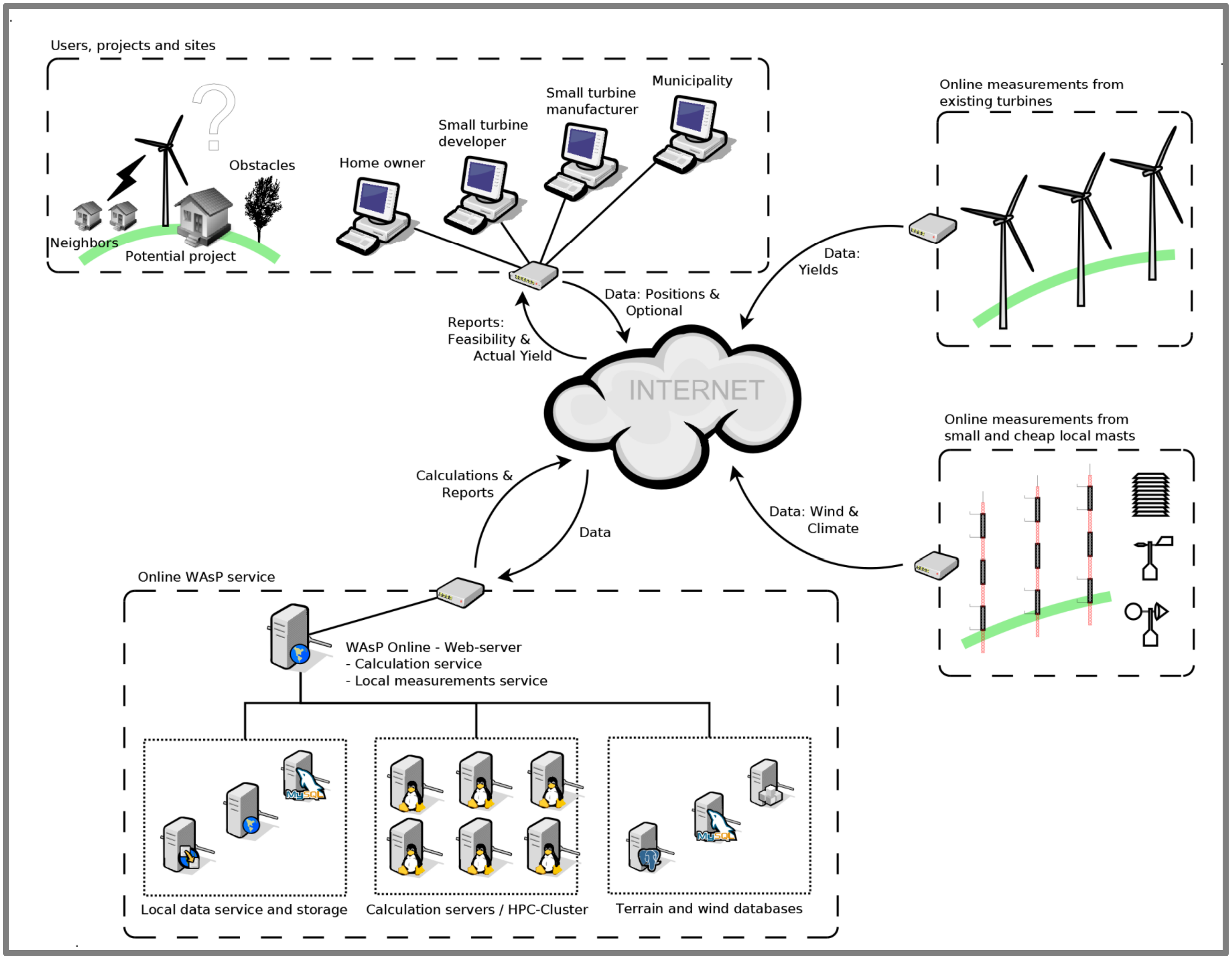
- Recommendation: A thorough wind resource study

- ....but thorough wind resource studies are expensive and a small wind-hybrid project cannot support this.

- Recommendation
  - Use latest developments in internet-based tools
  - For example:
    - Global wind atlas (2015)
    - 'Online WAsP' (end 2015)

Online WAsP

- Online tool using global databases as input
- Calculation of energy production and key economic figures
- Designed for small and medium size wind turbines
- Internet based: no need to have software locally
- An initiative by DTU Wind Energy and EMD International
- Two-year project starting beginning of 2014


Users, projects and sites
Neighbors
Potential project
Obstacles
Home owner
Small turbine developer
Small turbine manufacturer
Municipality
Online measurements from existing turbines
Data: Yields
Data: Positions & Optional
Reports: Feasibility & Actual Yield
INTERNET
Online measurements from small and cheap local masts
Calculations & Reports
Data
Data: Wind & Climate
Online WAsP service
WAsP Online - Web-server
- Calculation service
- Local measurements service
Local data service and storage
Calculation servers / HPC-Cluster
Terrain and wind databases

Small wind turbines

- Challenge: historically have not performed as expected
- Recommendation: implement an approval process to ensure a certain standard
- For example in Denmark:
  - The 'Energy Agency's Secretariat for the Danish Wind Turbine Certification Scheme' managed by DTU.
- Legal Frame for certification:
  - Technical certification scheme for wind turbines: Executive Order no. 73 of 25 January 2013
- Website: http://www.wt-certification.dk

All WTGs in Denmark must be certified

1-200m²: ≈ <40kW

- Certification of wind turbines with a rotor area of less than $200m^2$ shall, as a minimum, include requirements corresponding to the mandatory modules and requirements for type or prototype certification stipulated in the IEC standards as applied in Denmark: *DS/EN 61400-22 and DS/EN 61400-2*

However there are optional Danish simplified requirements for:

5-40m²: ≈ 1-10kW

- Certification of wind turbines with a rotor area of more than $5m^2$ and up to $40m^2$ shall, as a minimum, include requirements corresponding to simplified Danish requirements.

1-5m²: ≈ <1kW

- Wind turbines with a rotor area of more than $1m^2$ and up to $5m^2$ are exempted from certification.

Special Danish option: <$40m^2$ rule:

Turbine

1. Design evaluation for tower and rotor based on measurements
2. Tower Strength Testing & Blade/Hub testing (300N/m2 swept rotor area)
3. Static blade testing
4. Safety and Function; Over-speed Control test
5. Turbine O&M guidelines
6. Duration testing 500 FLH + 2 * 6 hour @ > 12 m/s

Prototype

1. Basic Design evaluation
2. Prototype Test Plan evaluation
3. Safety and Function Test
4. Prototype Certificate (max three year validity)

As a minimum, wind speed, output and energy production must be measured

Example

- Thy Møllen
  Certified to the Danish 5 to 40 m^2 rule

		TWP40-6kW	TWP40-10kW
Rotor diameter	[m]	7,13	7,13
Hub Height	[m]	21,4	21,4
Power	[kW]	6	10
Nom speed	[rpm]	98	106

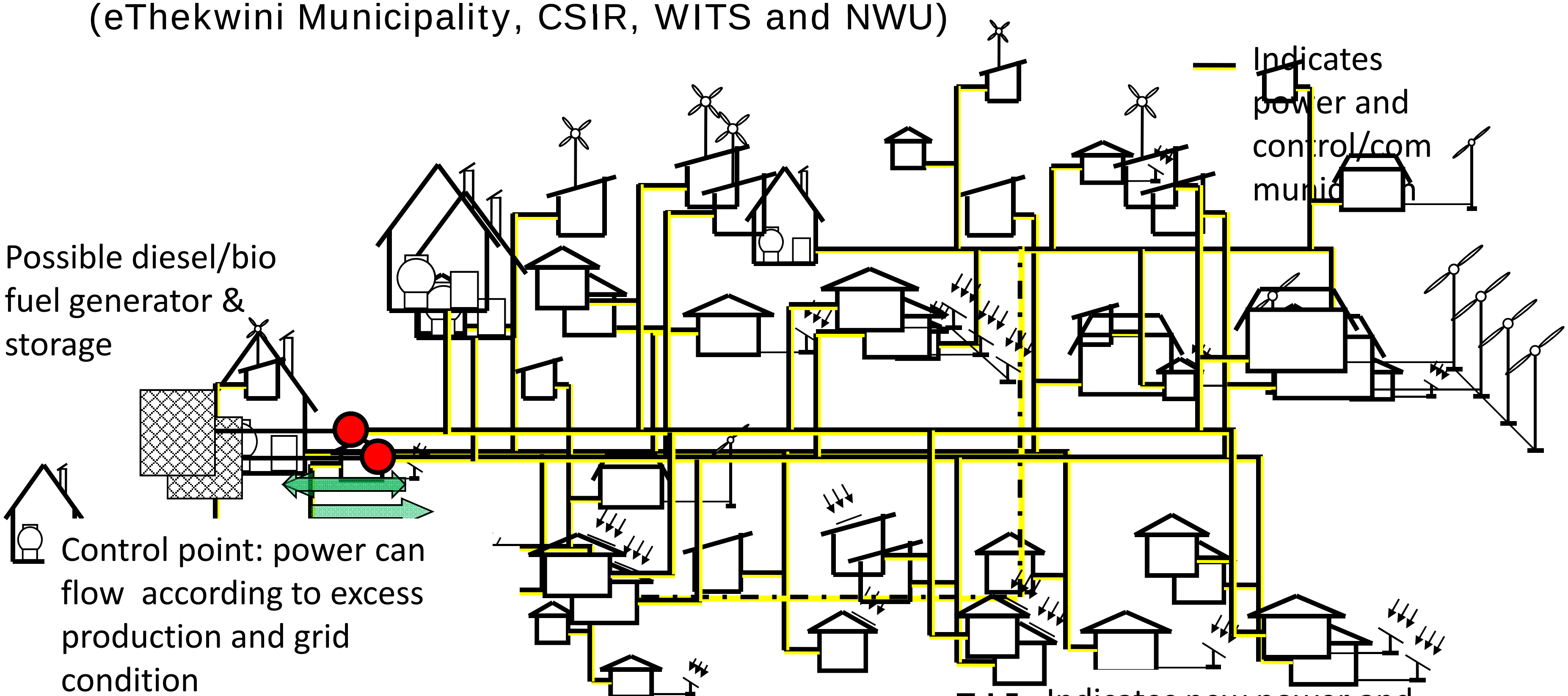
System engineering of wind-hybrids

- Challenges:
  - if the national grid is extended, system can be redundant
  - wind turbine output doesn't match pattern of energy use
  - using significant storage can be expensive and has limited lifetime
  - components sometimes not well matched when installed

- Recommendation 1:
  - Systems engineered to be modular i.e. flexible, extendible and able to work with a main grid
  - "Modular form of rural electrification"
  - eThekwini Municipality, South Africa

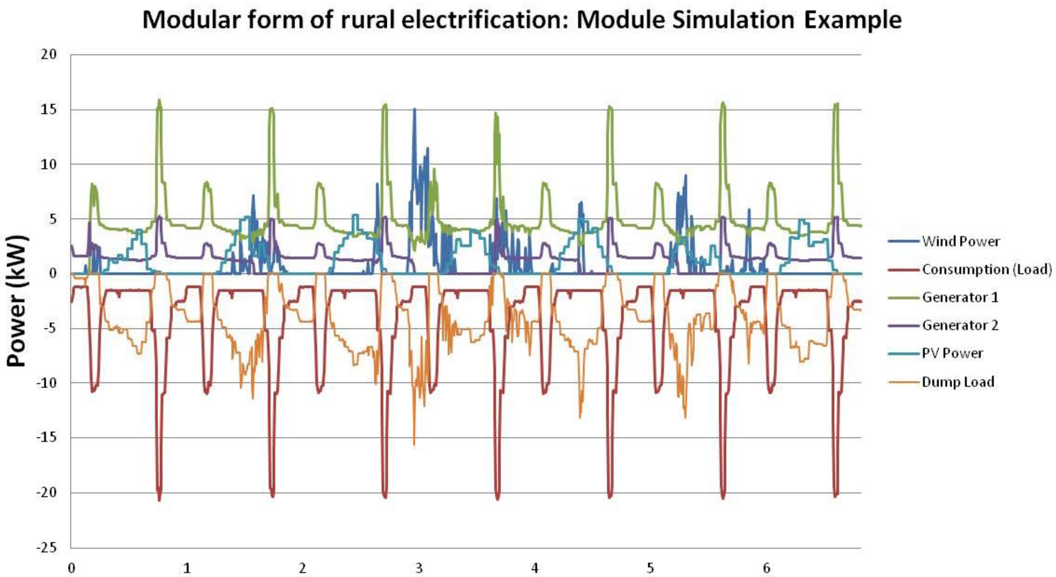
System engineering

- Modular *concept* developed together with South African partners (eThekwini Municipality, CSIR, WITS and NWU)

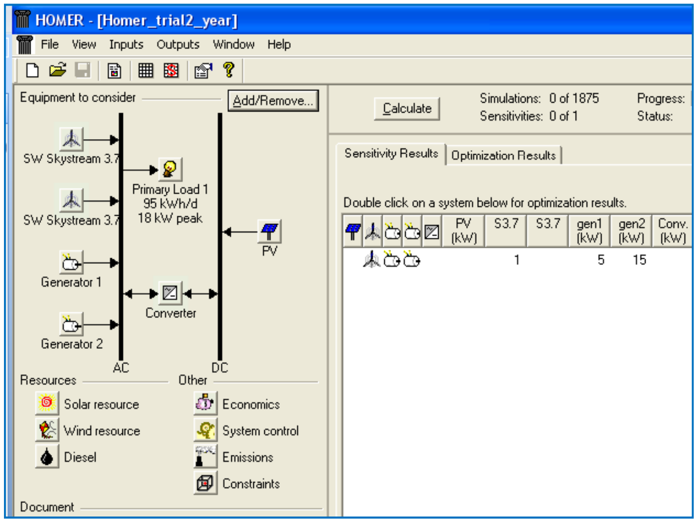


System engineering

- Recommendation 2:
  - Use the latest system simulation software
  - More cost effective than building test systems and can provide a better match between components and minimise storage.



Screenshot of IPSYS simulation output (DTU)



Screenshot of Homer simulation output

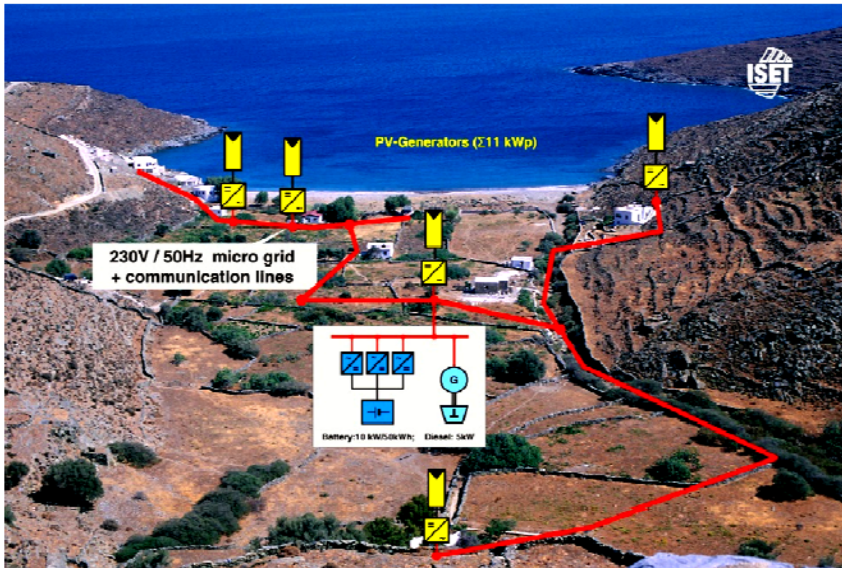
System engineering

- Recommendation 3:
  - ‘smart grid technology’ allows user-participation in matching consumption and production

- Significant development of intelligence in small grids ongoing worldwide
  - load scheduling (move away from ‘connect and forget’),
  - co-ordination of inverters
  - management of data & information (local and remote)

- NTUA & CRES (Greece), DTU (Denmark), Fraunhofer IWES & SMA (Germany), NREL & Homer Energy (USA), NEDO (Japan) and many more.

System engineering
CRES Microgrid on Kythnos Island, Greece



Load: 12 houses connected on a single phase 230 Vac grid.

Generation: 5 PV units connected via standard grid-tied inverters.
A 9 kVA diesel genset (for back-up).

Storage: Battery (60 Volt, 52 kWh) through 3 bi-directional inverters operating in parallel.

Monitoring: Data logging equipment

Source: NTUA, Greece

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Project implementation

- Challenge: one-off projects rarely work
  - Investment is high for individual projects
  - Maintenance always difficult with just one system
  - Weak knowledge transfer between projects

Recommendation: establish a centre for hybrid systems that can

- ➢ Provide a regional framework that allows flexible designs to be rolled out in multiple projects.
- ➢ Carry out testing and proving c conditions
- ➢ Oversee approvals of compone
- ➢ Establish guidelines and refer t
- ➢ Investigate and secure funding
- ➢ Act as a source of information
- ➢ Co-ordinate local training

Benefits:
- ✓ Reduced risk for investors
- ✓ Systems are developed that are more widely applicable
- ✓ Knowledge gained is retained
- ✓ Improves technical quality of components and designs

Operational experience from India

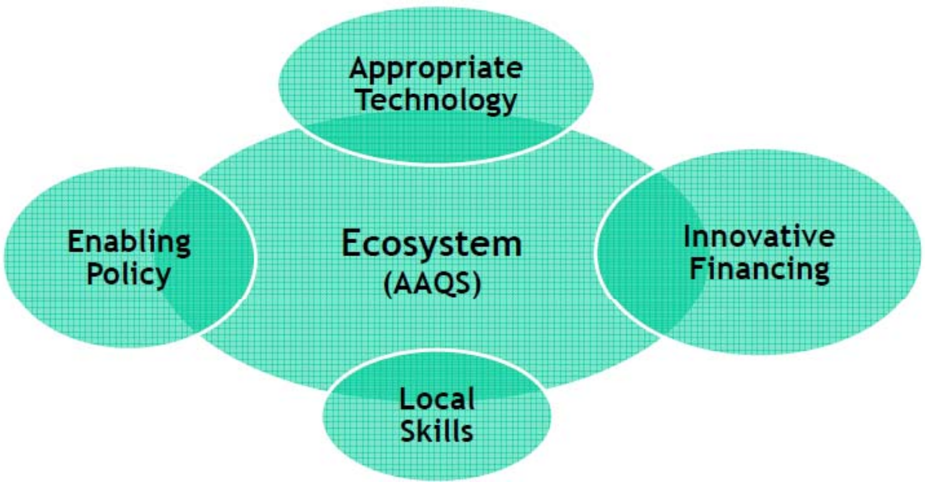
- First operational mini-grid in 1996 (Sunderbands Islands)
- Around 5000 villages supplied through minigrids to date

55kW solar and 3.5kW wind electric generator based hybrid system

Operational experience from India

Conclusions from a presentation by Dr. Palit, The Energy and Resources Institute (TERI), New Delhi

- Cooperative model of service delivery – involvement of local community from an early stage
- Adopt multiple technology and state-of-the-art system design but consider local availability of technical knowledge
- Mini-grids preferred to household systems as they can
  - provide power to enable productive uses
  - Be managed more easily through a proper institutional arrangement
- Bundle projects to improve viability of operation



AAQS=Access+Availability +Quality+Sustainability

Summary of recommendations for hybrid wind

TECHNICAL

- Know the wind resource
- Use simulation software for system engineering
- Design for flexibility and grid interconnection

ORGANISATIONAL

- Create a regional centre
- Test and approve components in relevant conditions
- Apply standards and guidelines
- Ensure user participation from the start

If small wind-hybrid systems are to contribute to rural electrification then avoid one-off projects!

THANK YOU FOR YOUR ATTENTION

SYSLAB – Distributed Energy System Laboratory

SYSLAB at DTU

- is a **platform** for research into Decentralised Energy Resources and testing
- is a flexible experimental setup
- includes several production and consumption units
- has embedded computing power and flexible communication
- has very flexible control possibilities
- can be extended
- is being used for proof-of-concept implementations