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Hybrid Systems for Isolated Communities

Per Lundsager, Henrik Bindner, Jens Carsten Hansen

Risø WindConsult & WES Programme, Department of Wind Energy

Risø National Laboratory, DK-4000 Roskilde

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- Technical & Non-technical Issues & Experience
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Background

- **There is a large potential world wide with**
  - large wind and other renewable energy resources
  - high production costs
  - remote and isolated communities with local power supply systems
- **In these places inclusion of wind energy and other renewables can be very attractive and beneficial**

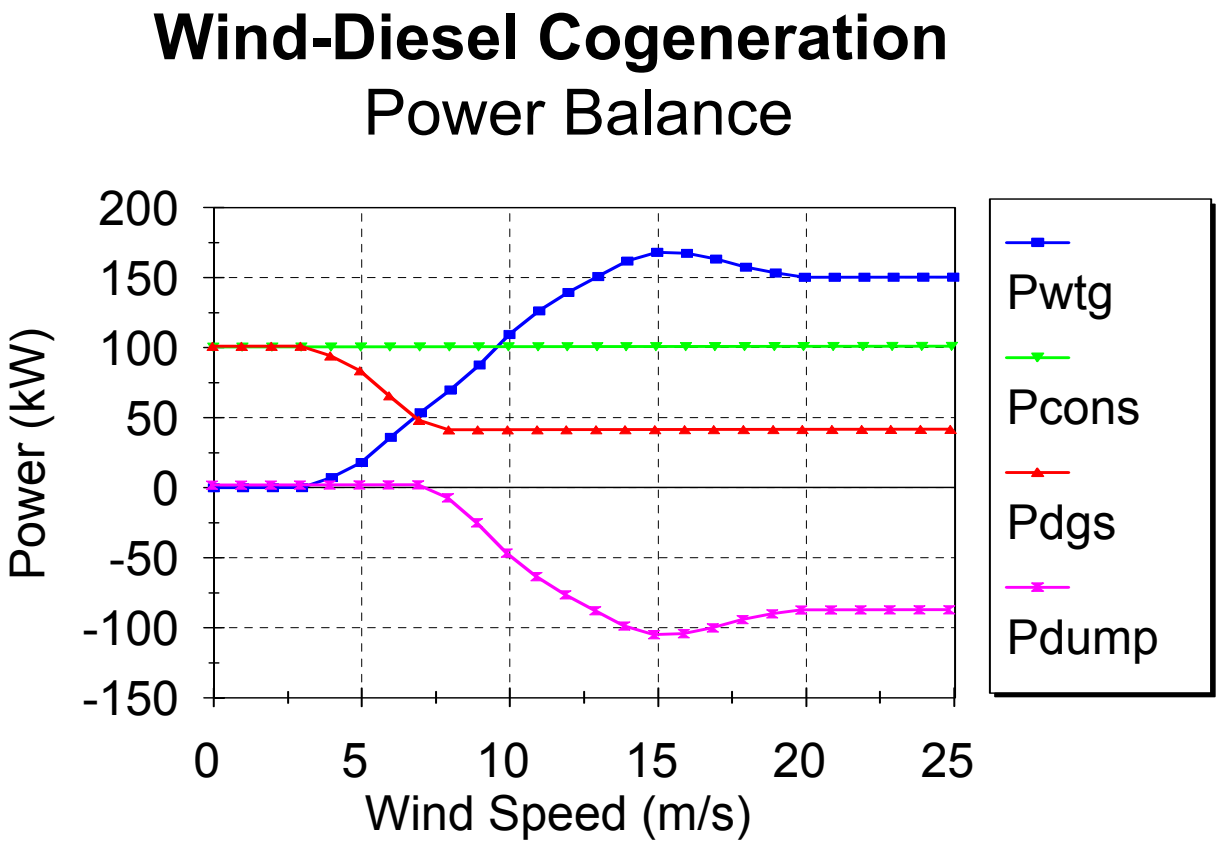
What is a Hybrid System

- **A hybrid system is an isolated power supply system where**
  - the layout of the system and
  - the operation of the rest of the system

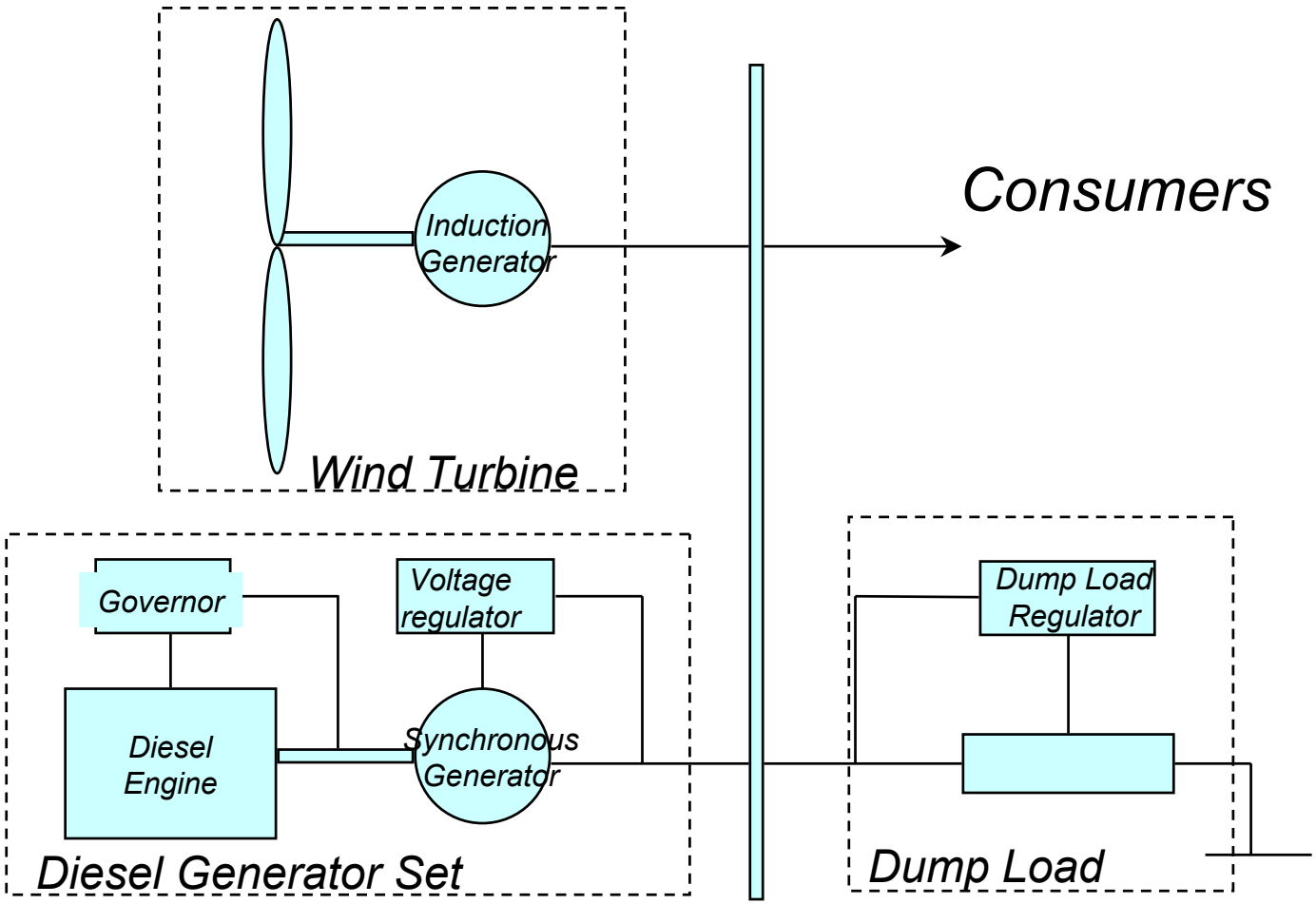
are *significantly* **influenced by the presence of wind power and other renewables e.g start/stop of diesel generators, frequency control and voltage control.**

- **A hybrid system is typically up to a few MW**
- **Typical names**
  - Wind diesel systems (at Risø since 1894)
  - Hybrid power systems
  - Village power systems
  - Isolated systems (with wind power: Risø study for DEA 2001)
  - and more (now being absorbed by Distributed Generation)

Power Balance of SR&R WD System



Basic Wind Diesel Concept



Characteristics of Isolated Power Supply Systems

- Small number of (dispersed) generating units sets
- Simple control (of existing system)
- Difficult infrastructure
- Few resources for maintenance
- Expensive fuel

Technical issues in Hybrid Systems I

- Frequency control and stability
- Voltage control and stability
- Operating condition for especially diesel generators e.g. minimum load
- Efficient utilization of wind power and other renewables
- Use standard components
- Simple layout
- Robust operation
- Cheap maintenance
- Efficient

Technical issues in Hybrid Systems II

- **Utilization of Surplus Energy (available in e.g. the dump load)**
- **Can be used for**
  - fresh water production
  - ice making
  - house heating
  - and much more
- **Concepts**
  - Optional loads
  - Deferrable loads
  - Demand side management
  - and more

Non technical issues in hybrid systems I

- **Unproven (not matured) Technology**
  - Prototypes or near prototypes have been installed in many cases
- **Complicated Systems**
  - There has been a clear tendency to have rather high requirements to performance
  - These requirements can in theory be fulfilled by advanced and complicated systems
  - Real-life performance have often been disappointing
- **Export, not a home market making follow up very expensive**
  - One-off unique systems difficult & expensive
  - Programme approach -> standardisation, basis for building of local infrastructure & capabilities

Non technical issues in hybrid systems

- **Dilemma of wind diesel:**
  - Needs: Local
  - Requirements: Utility
  - Financing: Donors, International
  - Technology: Foreign
- **Lack af a market break-through**
  - Chicken and egg problem
    - no market - no technology
    - no technology - no market
    - (and therefore no confidence at decision makers)
- **Need for a programme approach**

Experience & capabilities Denmark I

- **WD Programme at Risø since 1984**
- **SR&R (simple, robust & reliable concept)**
- **Testing and documentation**
- **Assistance to manufacturers & donors**
  - Vestas, Gaia, Vestesen
  - Danida, WB etc (Cape Verde and other projects)
- **International networking**
  - NREL Village power programme, Alaska conferences etc.
  - IEA WD Annex XIII, IEC JCG 62257
  - EU DERLab NoE
- **Analysis methodologies & tools (IPSYS)**
- **Guidelines & strategies (Isolated Systems project)**

Måling på vind-diesel anlæg

- **Der er gennemført målinger på 3 prototype anlæg (Danvest, Vestesen A/S, Vestas A/S)**
- **Formålet har været både at dokumentere funktion og elkvalitet**
- **Der er udviklet procedure til at vurdere den samlede system performance**

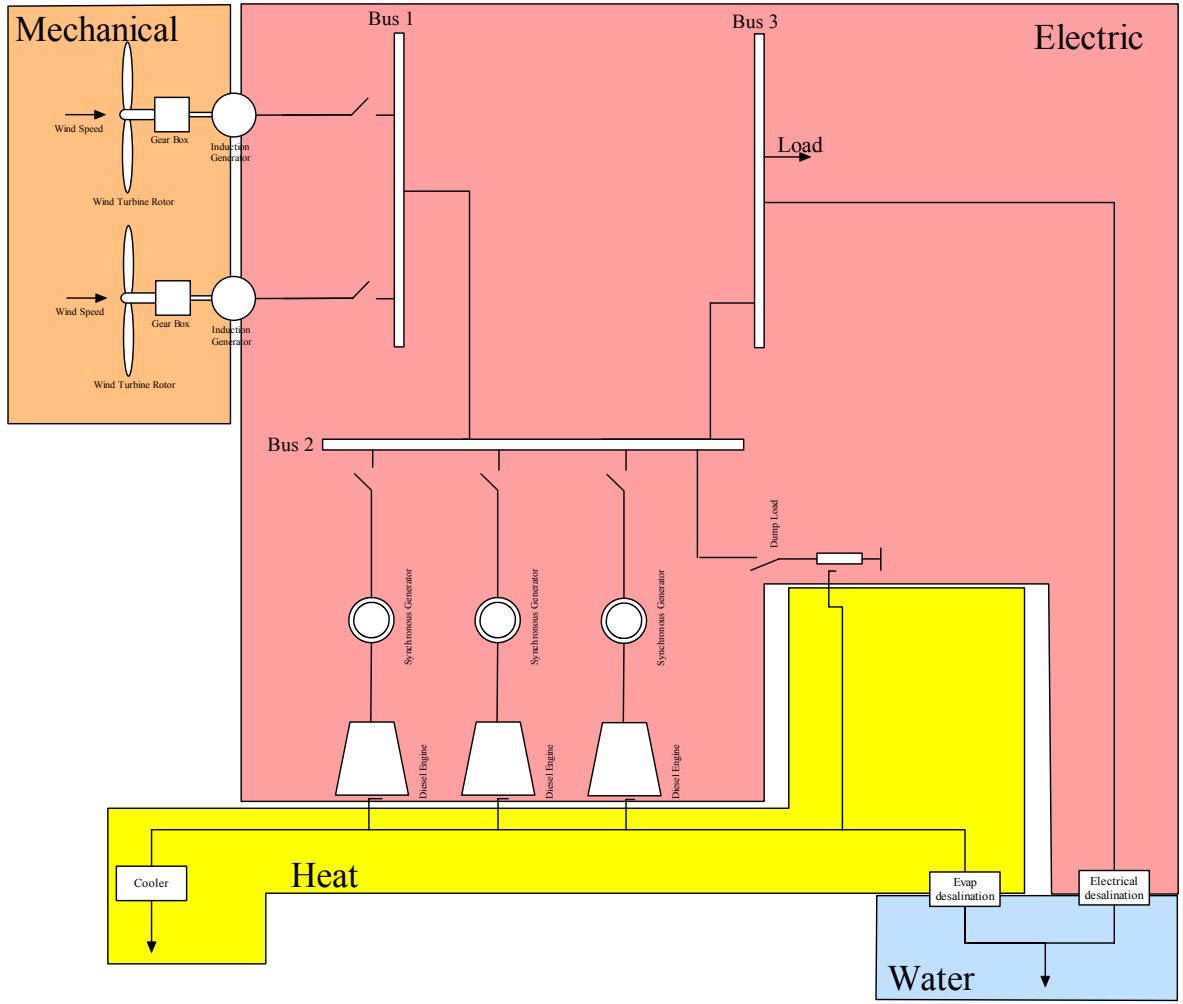
Vestas system i Bønnerup Strand
juni 2005

Gaia-projekt

- Den eksisterende 11kW Gaia mølle er opstillet i mere end 100 eksemplarer og har en god driftsstatistik.
- Den egner sig til brug også i mindre, isolerede elforsyningssystemer
- Der er gennemført et udviklingsprojekt sammen med industripartnere for at dokumentere dens opførsel i mindre systemer samt videreudvikle den til brug i små systemer uden anden produktion såkaldt stand-alone
- Der er lavet en prototype af stand-alone systemet som er blevet testet på Risø
- Resultaterne viser at den egner sig fint til brug i mindre systemer i standard udgaven
- Stand-alone prototypen styrer et isoleret net fint som eneste elproducerende enhed men prototypen skal produktionsmodnes

IPSYS – system performance simulation tool

- Different domains are explicitly modelled including feedback between them
- Flexible modelling of system components and configuration
- Controllers are modelled close to reality and can be easily exchanged



Experience: European Case I

- **EU development**
  - RD&D support through 15 years
  - Many projects >100
  - Support for technology development, modelling/design, demonstration and dissemination
  - Demonstration (prototype) plants especially on Greek islands and the Canary Islands
  - Particular focus on production of fresh water
  - No market support
  - No particular involvement of national/local authorities
  - National support schemes for RE e.g. Greece can open market
  - Number of applications in Europe are quite limited

Experience: European Case II

- **Manufacturers/suppliers**
  - Vergnet
    - Simple no-storage system
    - Taking advantage of the passive mechanism of their wind turbines
    - Experience from several systems e.g. La Desirade
  - SMA regelesysteme
    - Promoter of complex integrated systems applying batteries
    - Focus on optimal control
    - Experience from several systems
    - Long term performance of batteries not known
  - Enercon
    - Involved in many EU-projects
    - Stand-alone or hybrid systems
    - Taking advantage of the power electronics in their wind turbine
    - Strategic collaboration with Powercorp, AUS
    - Still limited experience with hybrid systems

Experience: European Case III

- Turbowind
  - Small manufacturer
  - Promoting simple systems without storage
  - Installation of 1 system in Kenya
- Vestas
  - Experience with high penetration systems on islands
  - Has developed a wind diesel system prototype
  - Has “high penetration kit incl. dump load”
- DanVest Energy
  - Promoting system without storage
  - Emphasis on diesel part of the system
  - Usage of waste heat and surplus power for e.g. fresh water production
  - Experience from 1 prototype
- Gaia
  - Small system based on household wind turbine

Experience: USA & Canada I

- **Alaska**
  - Kotzebue
    - Local utility involvement
    - Simple system (no storage, no power electronics)
  - St. Paul Island
    - Project with IREQ (Hydro Quebec) and Northern Power Systems
- **Canada**
  - Long time involvement of IREQ (Hydro Quebec), Atlantic Wind Test Site and Island Technologies Inc.
  - Activities in the North and North West
- **USA**
  - NREL village power program
    - Important framework for creating an environment for market and technology development

Experience: USA & Canada II

- **Manufacturers/suppliers**
  - AOC / EWS
    - No storage systems applying the AOC 50kW wind turbine
  - Northern Power Systems
    - Experience with several installations also in rough climates (cold)
    - Systems with rotary converter
  - PowerCorp (Canadian subsidiary of Australian PowerCorp
    - More than 30 systems installed in Australia
    - Several patented supporting units & concepts

Experience: Rest of the World

- **Australia**
  - Denham project
  - Esperance project
- **South-East Asia**
  - Lots of interest
  - Still few systems
  - Typically small systems
- **Russia**
  - National programme for application of wind diesel technology
  - Plans for a Wind Diesel Centre
- **Manufacturers/suppliers**
  - Powercorp/Enercon
    - Has developed an integrated system without storage
    - Prototype system (Denham)

Experience: Cape Verde I

Republic of Cape Verde *Based on information from ELECTRA*

Location	Installation	Implementor	Donor/Investor	Working
Ponta d'Agua - Praia	2x55 kW Vestas - grid	INIT	UNSO/Danida	No
Assomada - Santiago	1x55kW Bonus - W/D	INIT	UNSO/Danida	No
Tarrafal - Santia	1x30 kW Lagerwey W/D	MDR	Holland	No
Mt. R. Juliao - Mindelo	10x30 kW Aeroman - grid	ELECTRA	Germany/KfW	20%
Santa Maria - Sal	1x75 kW Vestas - W/D	Morabeza Hotel	Morabeza Hotel	Yes
Palmeira - Sal	2x300 kW NTK - W farm	ELECTRA	Danida/Cape Verde	Yes
Mt. Montona - Mindelo	3x300 kW NTK - W farm	ELECTRA	Danida/Cape Verde	Yes *)
Mt. S. Felipe - Praia	3x300 kW NTK - W farm	ELECTRA	Danida/Cape Verde	Yes
Brava	1x150 NTK - W/D	Municipality	Germany/GTZ/Danida	Yes
Boa Vista	5x15 kW Vergnet - W farm	Municipality	France	Yes **)
Matão - Santiago	1x15 kW Vergnet - W/B	INERG	France	Yes

**) One temporarily down with gearbox problems; **) Performace to be enhanced by improved rotor*

Island systems energy penetration 14%, power penetration 35% without problems

Experience: Cape Verde II

- **Small systems**
  - several systems of prototype nature
  - Several not successful due to lack of skill of maintenance staff and immature technology
  - At least one successful: SR&R system, skilled operator, commercial system
  - Still activity in the area with new installations
- **Larger systems**
  - High penetration systems (14% annual energy coverage)
  - Grid connected wind turbines on diesel grids
  - No extra equipment
  - Satisfactory operating experience
  - Satisfactory power quality
  - In the process of increasing the installed capacity and the penetration level

Recommendations

- Have realistic expectations and adequate requirements
- Choose simple systems or proved systems
- Replicate and build O&M infrastructure
- Stepwise improvement of technology

- Because systems have to work!

Conclusions

- Development of Wind Diesel Systems have taken place for more than 15 years
- Many prototypes have been installed
- Many configurations have been implemented and are being implemented
- There has not been many replications
- There is no consensus on configurations
- Technology is still immature
- Still no real market needed to mature technology

- SR&R systems have low technological risk and know-how exist on design and implementation
- Best results have been obtained when a cautious approach have been taken