



USDA-ARS

**Conservation
& Production
Research
Laboratory**

**Bushland,
Texas**



Wind/Diesel Research at USDA

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Mechanical Hybrid

- DESCRIPTION
 - Water pump powered by wind turbine and diesel engine. A mechanical over-running clutch was used to synchronize the speed of the two mechanical inputs.
- RESULTS
 - Fuel savings for the system was low because the engine had to run all the time.
- DATES
 - Tests conducted 1980 to 1985

WIND TURBINE

WIND ASSIST DIRECT

DISC BRAKE

RIGHT ANGLE
SPEED INCREASER

STARTING
MOTOR

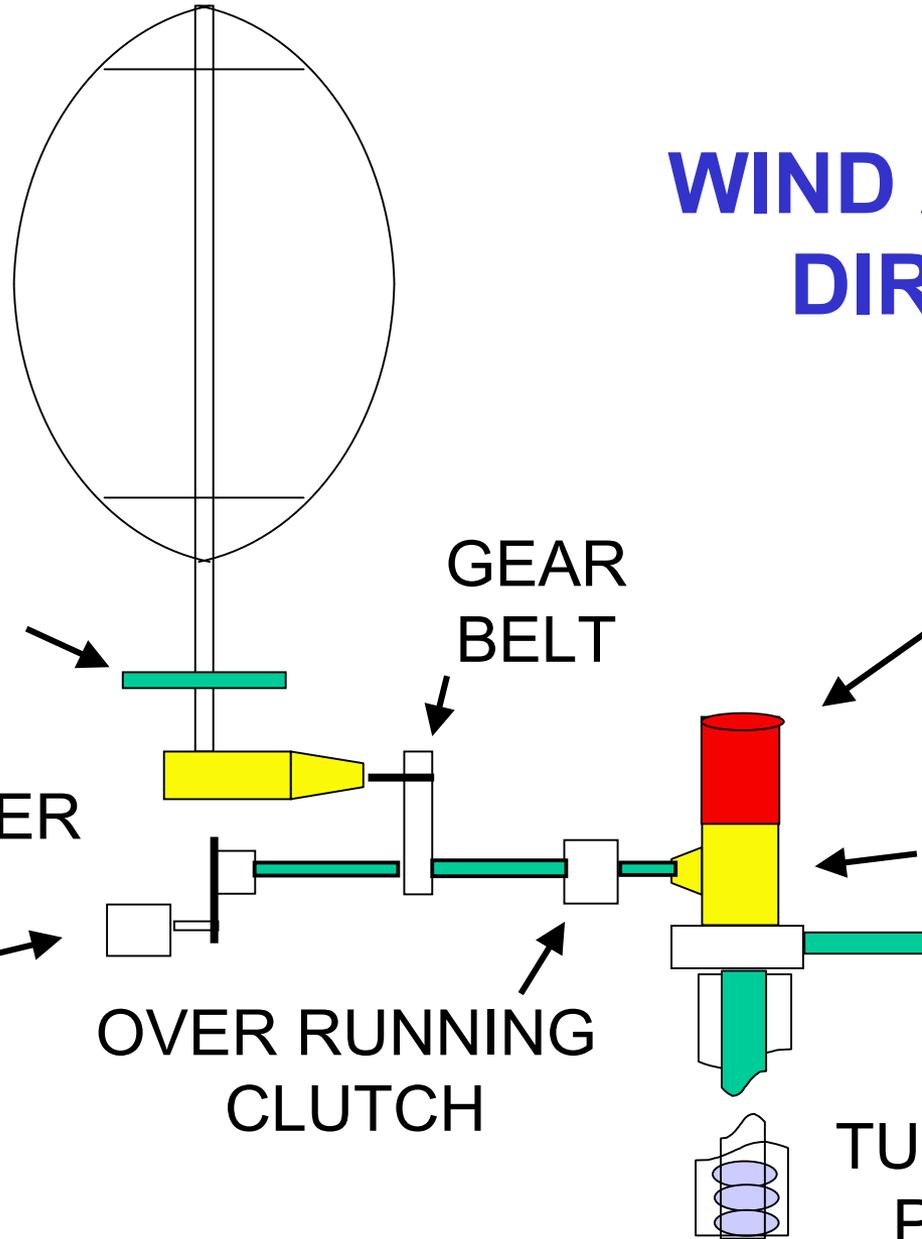
GEAR
BELT

ELECTRIC
MOTOR

DUAL DRIVE
GEAR HEAD

OVER RUNNING
CLUTCH

TURBINE
PUMP





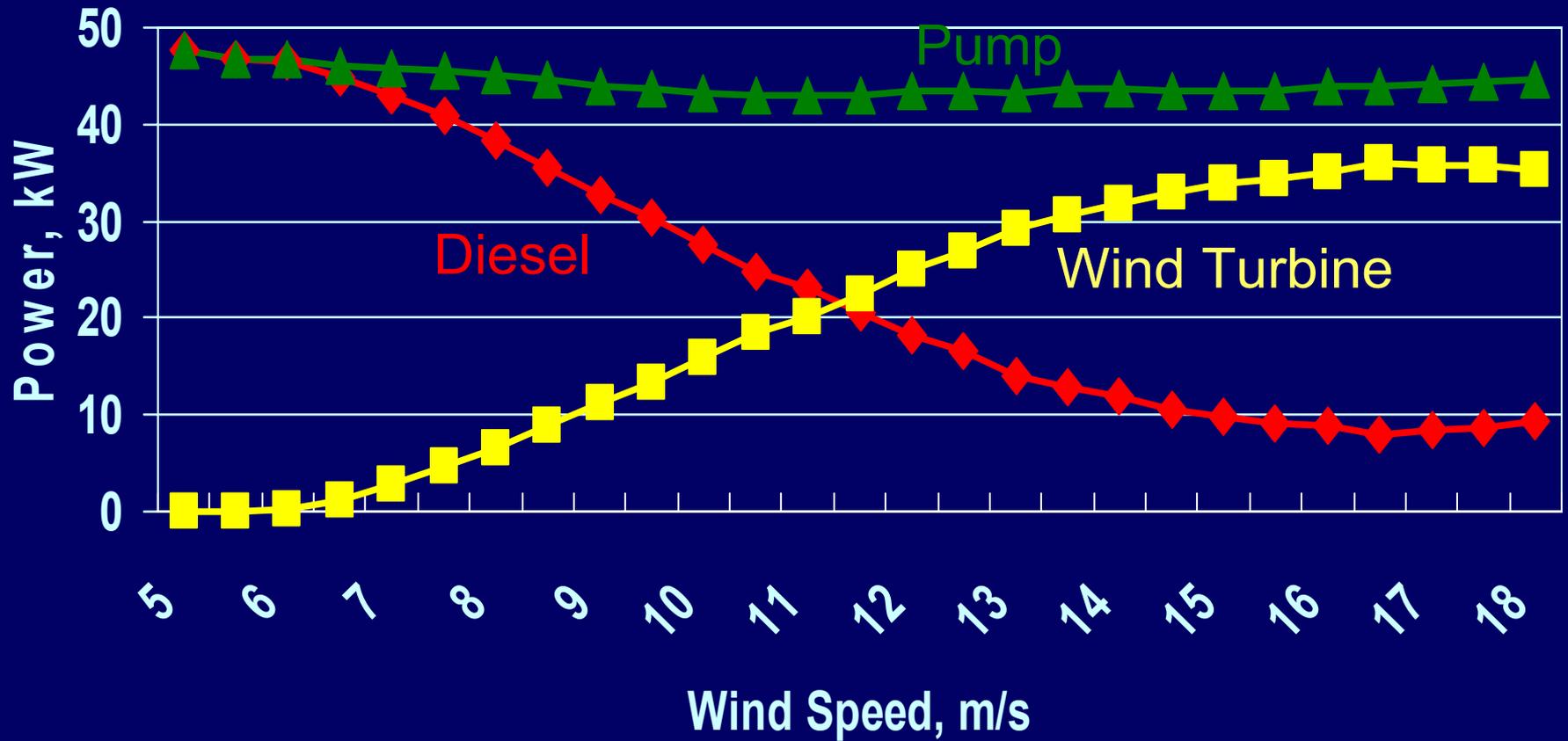
WIND ASSISTED DIRECT

**VAWT 50 KW
ELECTRIC, 56 kW**



**VAWT 40 KW
DIESEL, 56 kW**

Mechanical Wind/Diesel



Small Electric Grid

- DESCRIPTION

- A single wind turbine (50 kW) and a single diesel generator (40 kW) operated on a grid with motor and resistive loads. System included a balancer load (dump load).

- RESULTS

- Fuel savings for the system was low because the diesel engine had to run all the time. Back-driving of engine was a problem.

- DATES

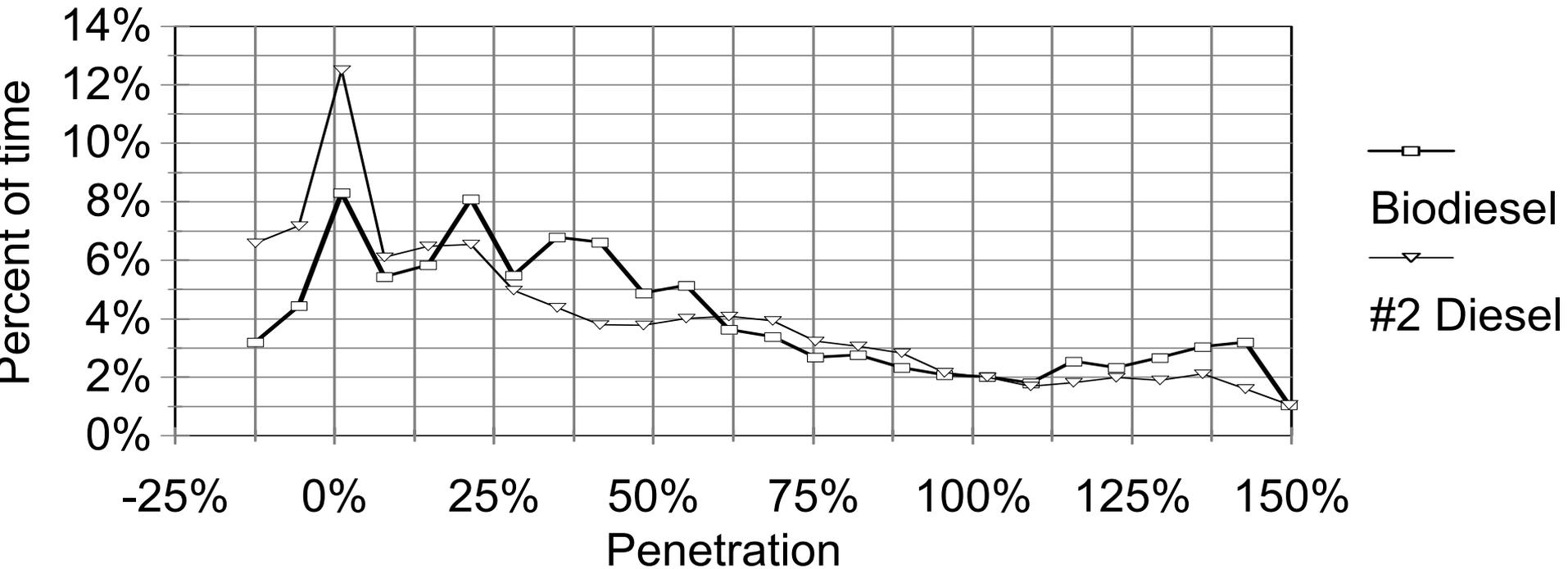
- Tests conducted 1993 to 1997

40 and 50 kW Wind Turbines



Penetration Histogram

Biodiesel & #2 Diesel Tests



Three Engines with No Storage

- DESCRIPTION

- Three 40 kW diesel engines and two wind turbines (40 and 50 kW) were operated on a grid with motor and resistive loads. The system used a synchronous condenser to maintain grid frequency.

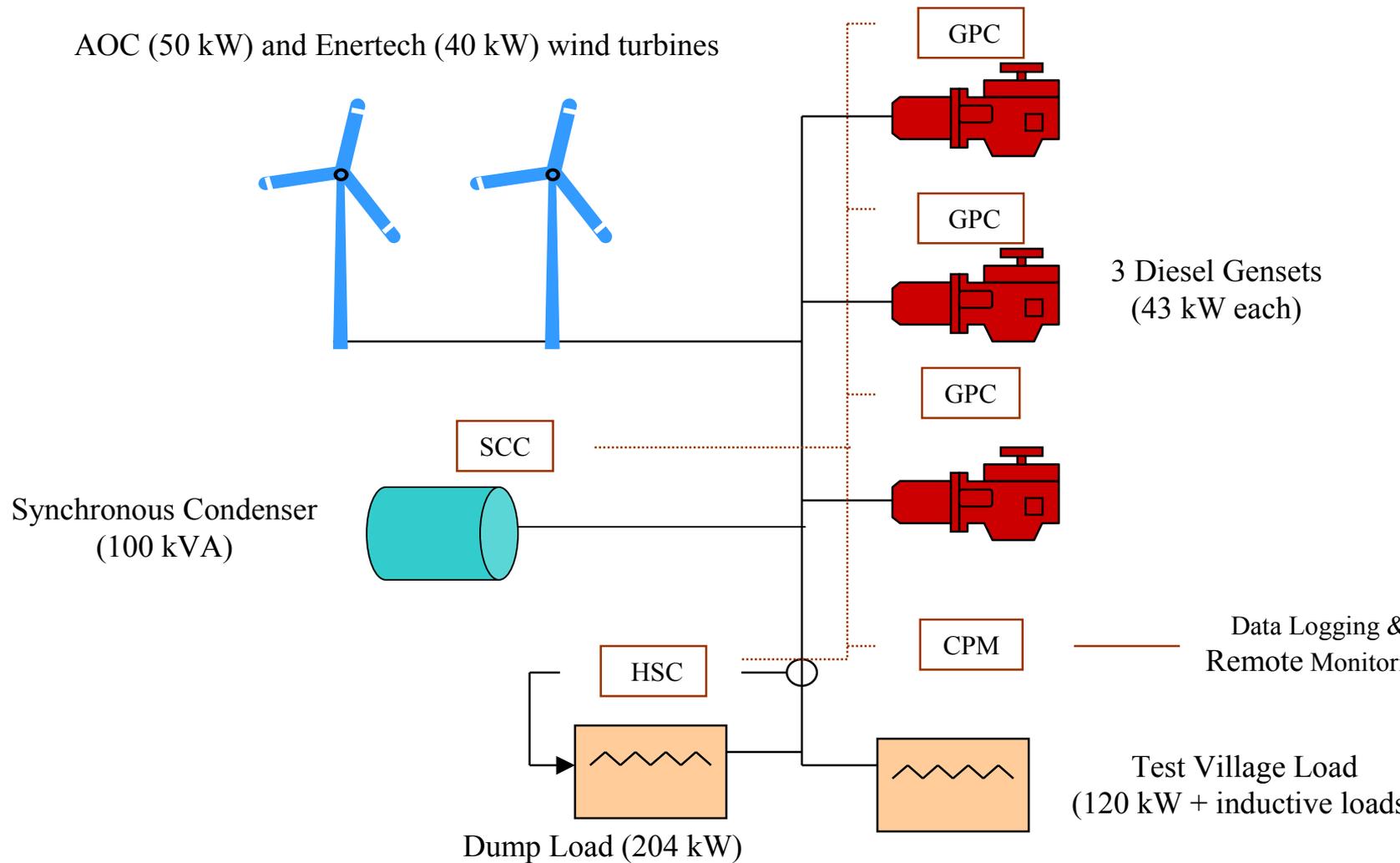
- RESULTS

- Fuel savings for the system averaged 22% and varied between 0 and 52% depending on wind conditions. Reliability goals were not met.

- DATES

- Tests conducted 1998 to 2000

Hybrid System Without Storage



43 kW Diesel Gensets



Resistive and Inductive Loads



Synchronous Condenser



Three Engines with Storage

- DESCRIPTION

- Three 40 kW diesel engines and two wind turbines (40 and 50 kW) were operated on a grid with motor and resistive loads. The system used a rotary converter and batteries to maintain grid frequency.

- RESULTS

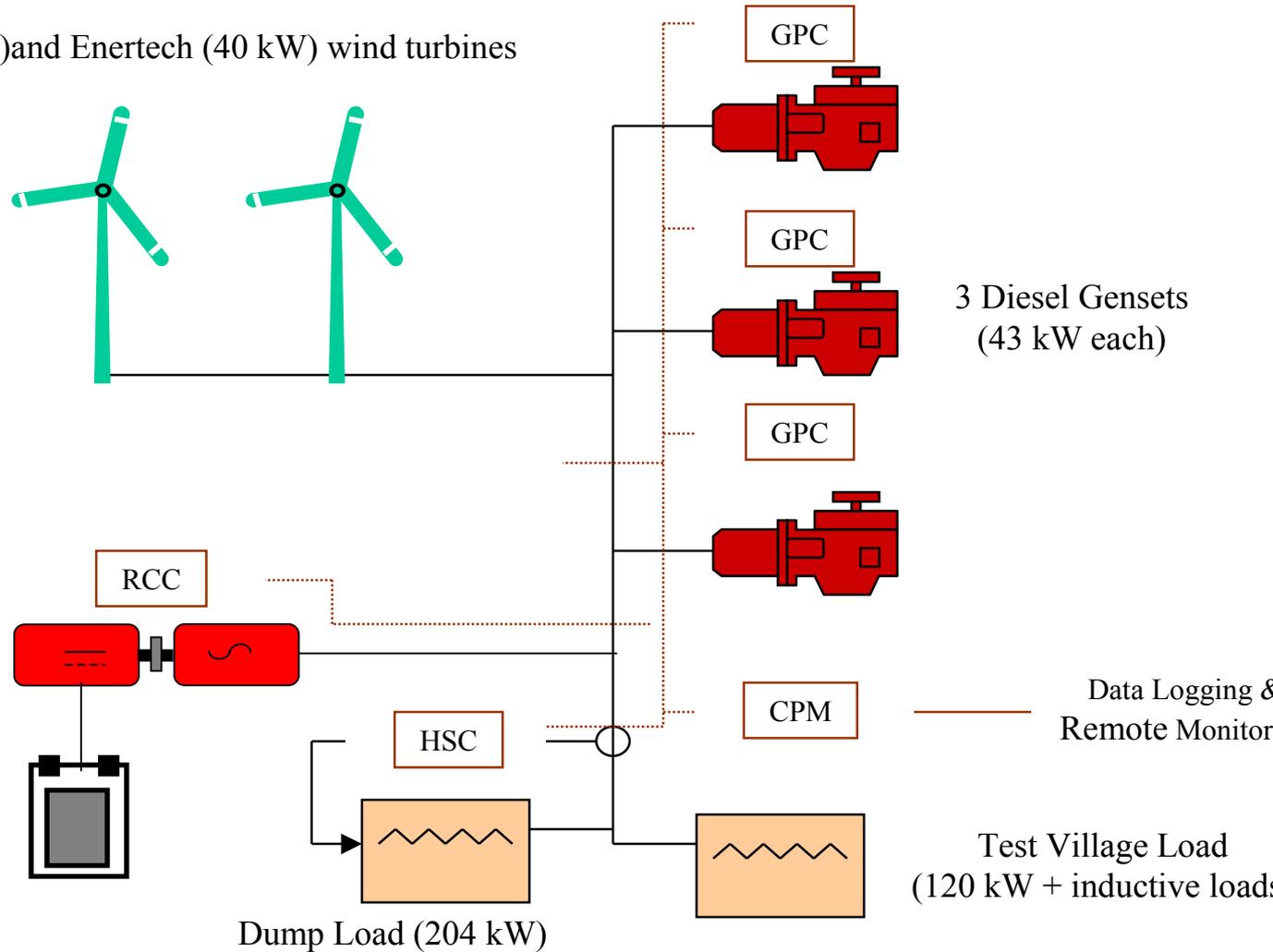
- Fuel efficiency increased from 2.63 kWh/liter for diesel only to 4.01 kWh/liter for wind-diesel without storage to 10.09 kWh/liter for wind-diesel with storage.

- DATES

- Tests conducted 2000 to 2003

Hybrid System With Storage

AOC (50 kW) and Enertech (40 kW) wind turbines



Storage System

• Rotary Converter (100 kW)

• Battery: 110 kW x 10 min

3 Diesel Gensets
(43 kW each)

Data Logging &
Remote Monitor

Test Village Load
(120 kW + inductive loads)

Dump Load (204 kW)

Rotary Converter

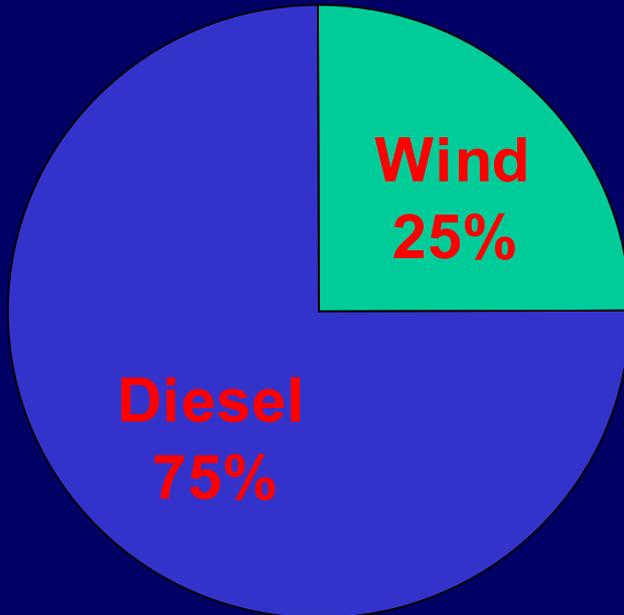


110 kW Battery Storage

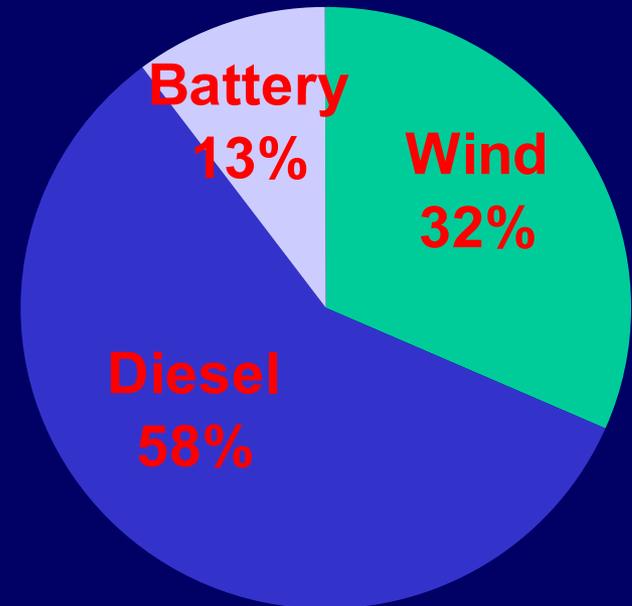


Penetration

**Without
Storage**



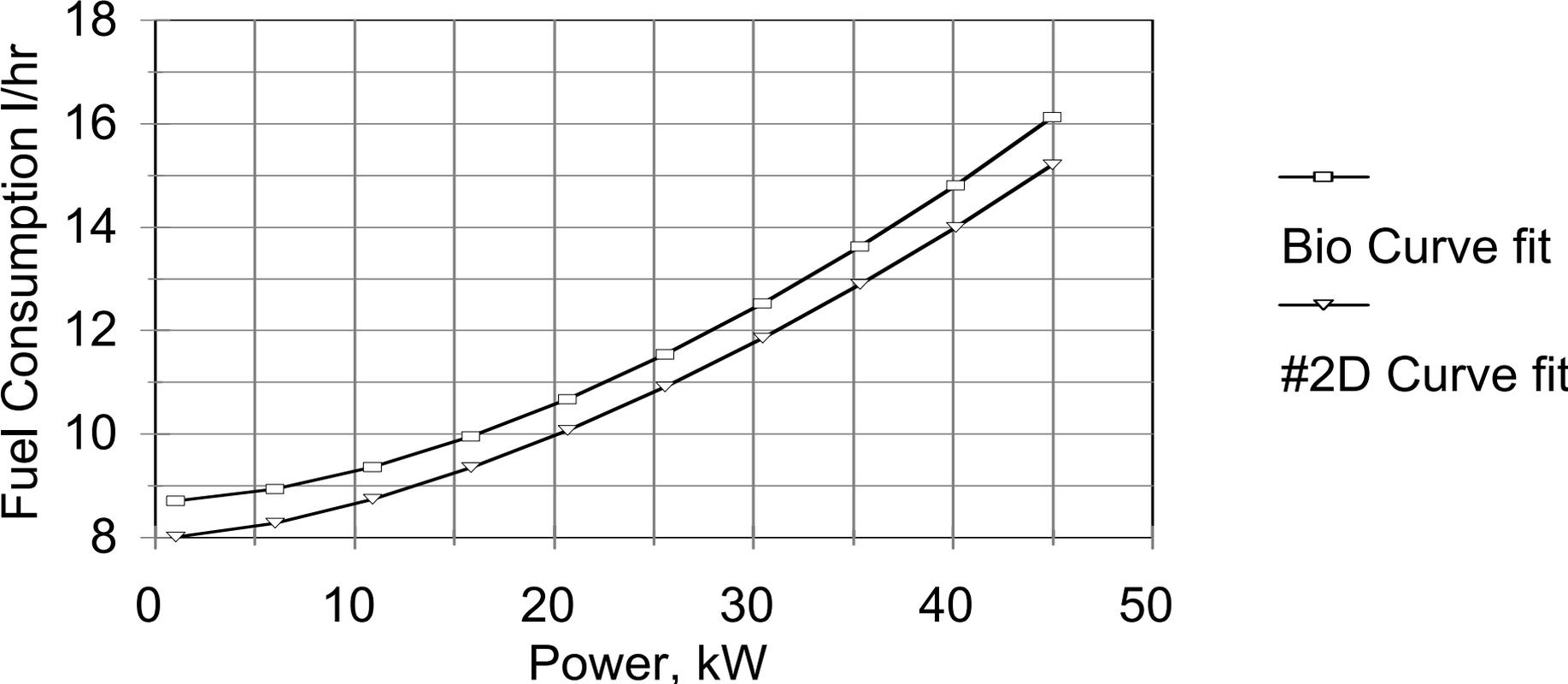
**With
Storage**



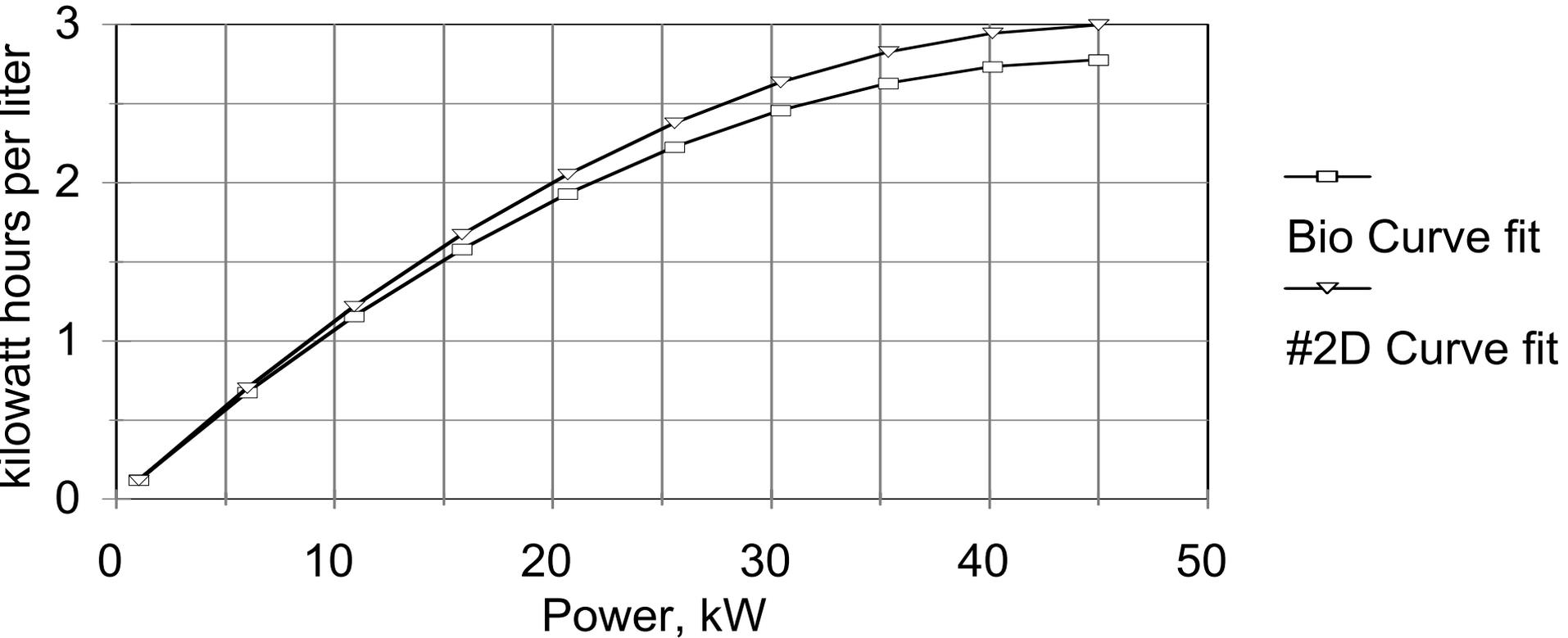
Two Engines and Microturbine Powered by Biodiesel

- DESCRIPTION
 - Two 40 kW diesel engines, a 30 kW microturbine and two wind turbines (40 and 50 kW) will be operated on a grid with motor and resistive loads. The system will use a synchronous condenser to maintain grid frequency.
- EXPECTED RESULTS
 - The system should have less grid frequency variation and the penetration level should increase when microturbine assumes the base load.
- DATES
 - Tests to be conducted 2005 to 2009

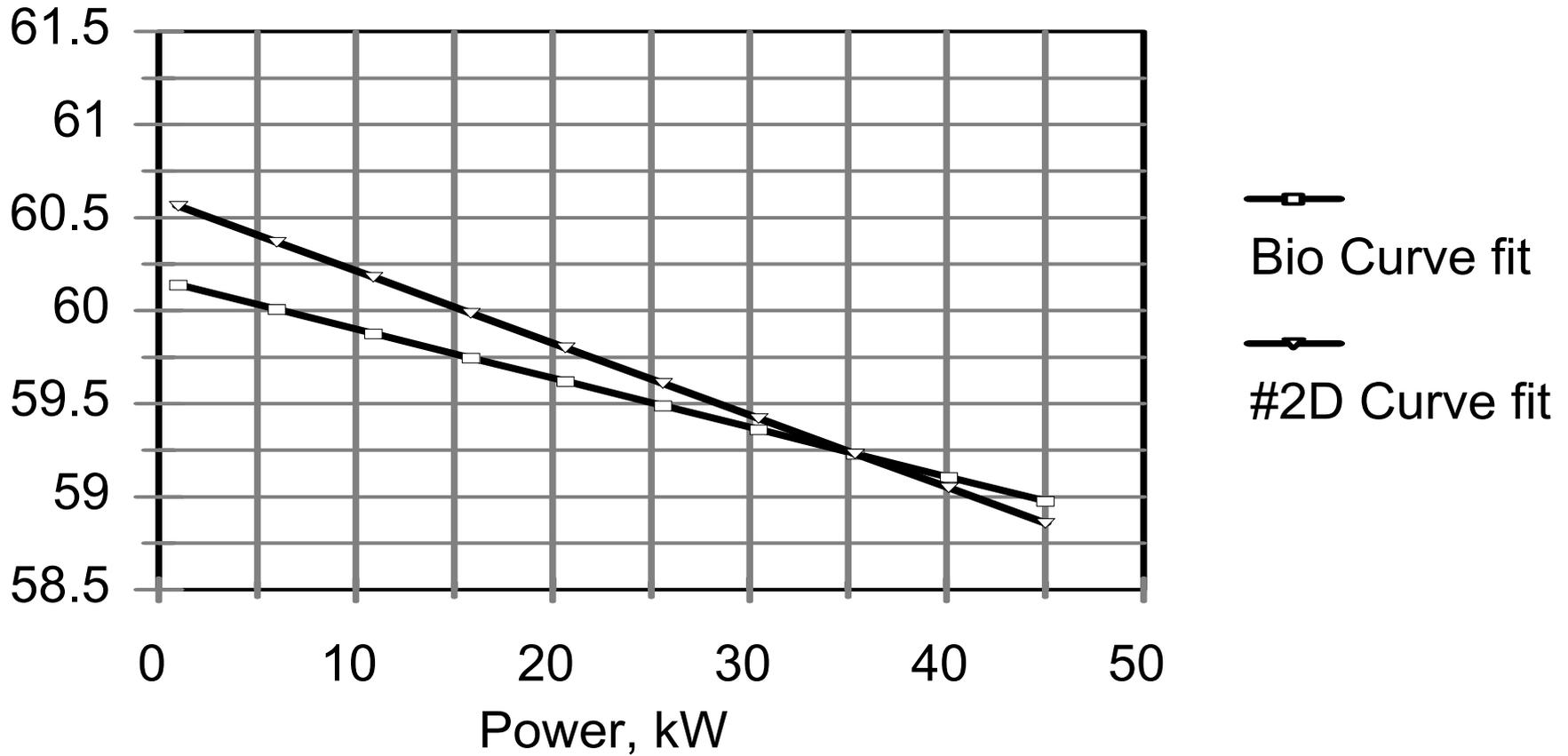
Power vs Fuel Consumption



Generator "Mileage"



CAT 3304PCNA Droop by Fuel



Why Combine Wind and Biodiesel?

- Both fuel sources are renewable.
- Each is a proven technology.
- Fuels are available at points of use.
- Cost of operations are decreasing rather than increasing.

