

PV Diesel 101

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Powerwater Remote Operations/ACEP

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Abstract

An introduction to PV Diesel Systems including principles of operation for medium and high penetration systems.



SETuP

► Happy

Overview

This talk covers:

- ▶ Electricity, PV, Diesel, Control.
- ▶ How PV/Diesel Systems can be applied in isolated grids.



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There will be another chat about that, this is why and how not what..

"There had been certain difficulties during the expedition and afterwards, There was no use denying it, I had simply told the story from my own point of view, as honestly as I could" - Tenzing Norgay.



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 - ▶ Pv = Photo Voltaic, Gen = Generator, Load = Load, ...
 - ▶ P = power, Q = reactive power, I = current

So what is:

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- ▶ PvSetP, Gen2I3



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- ▶ See also Ackermann for Wind Diesel Hybrid Systems.



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Dill Alert: never confuse peak with average or kW and kWh!



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- ▶ **Frequency (Hz)**, typically ranging from 49 to 51Hz. (cycles per second for the boffins).
- ▶ **Voltage (V)**, typically 430V, for the hydro analogy this is height.
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- ▶ **Reactive Power (vars)**, regulates the voltage, similar to kW it must balance:
$$\text{GenQ} = \text{LoadQ}$$

Note that:

- ▶ If (GenP or $\text{PvP} > \text{LoadP}$) then F increases.
- ▶ And vice versa
- ▶ Similarly for Q and V .



PV good days and bad days



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- ▶ **Step Load:** the capability to take a single immediate increase in load. Typically:
$$\text{StepP} < \text{SpinP}$$



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- ▶ **Setpoint control:** can be used to control output of devices but we need a mixture of Droop and Isochronous in order to balance the system.



No Penetration PV

- ▶ Start and stop diesel in order to keep:
 $\text{SpinP} > \text{SpinMinPPa}$
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Dill Alert: Lets replace Station X with 2 x 1MW containerised sets where load varies from 500..1400 kW



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Dill Alert: PV varies once every minute for data sampled once every minute
- ▶ A bad cloud event typically takes 10s, e.g.
 1. Wind speed at 1000m = 5m/s
 2. Field is 50m across.
 3. Result is obvious, i.e. PV variability depends on wind speed.
- ▶ Low Penetration is limited to 10..20% (spinning reserve).

Dill Alert: Design a power system where we keep 30kW of Spinning Reserve and try to install 60kW of PV.



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3. So control: $GenMaxP$ and $PvSetP$ in order to meet 1 and 2.



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- ▶ Finally: if min loading is 40% the maximum penetration is 60% sif the loads match the generators.



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- ▶ Inevitable in Medium Penetration Systems.
- ▶ We need to minimize spill by:
 - ▶ Appropriate Generator sizing.
 - ▶ Controlling load profiles.
- ▶ Note that most of the cost of the PV in is in the mobilisation, i.e. its $X + Y * K$ not $Y * K$.



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- ▶ Load dump
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Examples are available from WA, AQ, AK, MY, ID, etc.

But its not off the shelf for larger systems.



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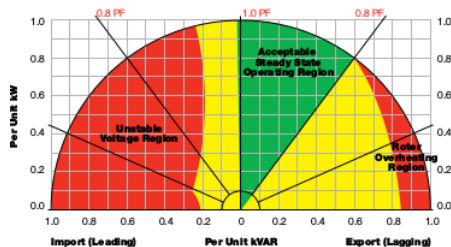


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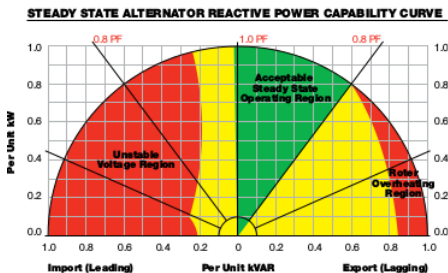
STEADY STATE ALTERNATOR REACTIVE POWER CAPABILITY CURVE



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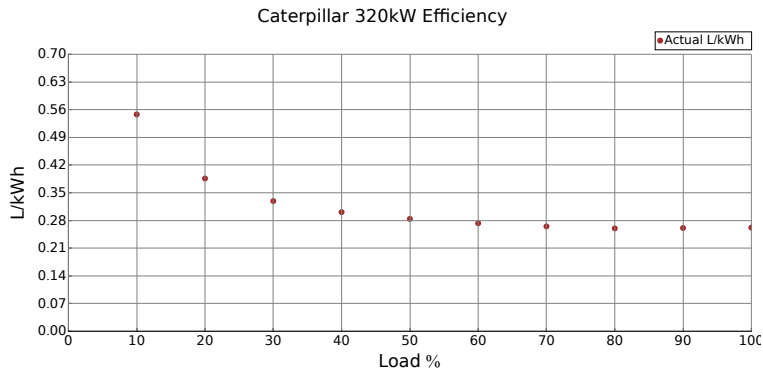
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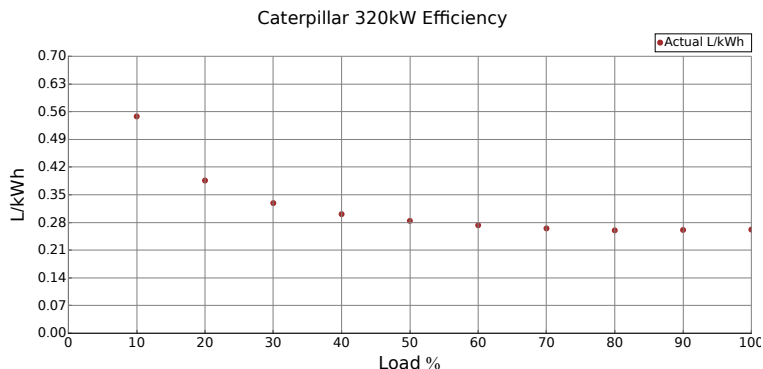
Dill Alert: At low loads my powerfactor is bad, panic



Fuel Efficiency



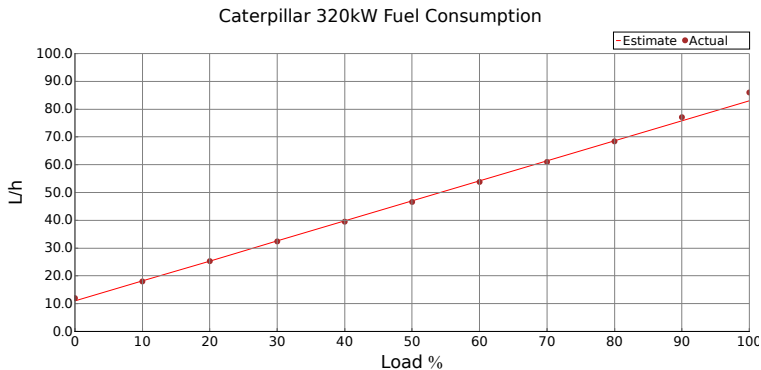
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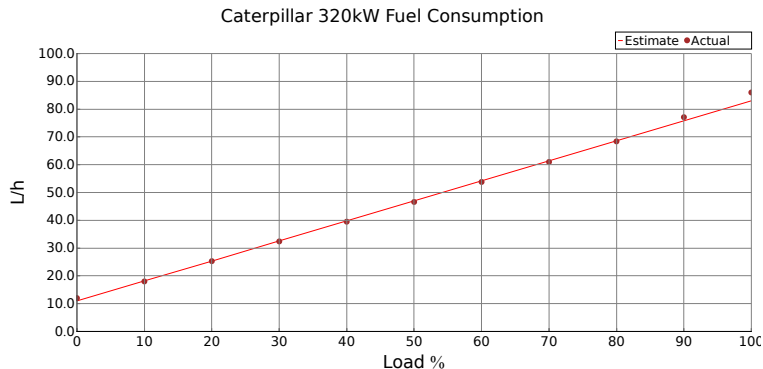
Dill Alert: So clearly we need to run diesels at around 80% load so they are efficient



Fuel Consumption



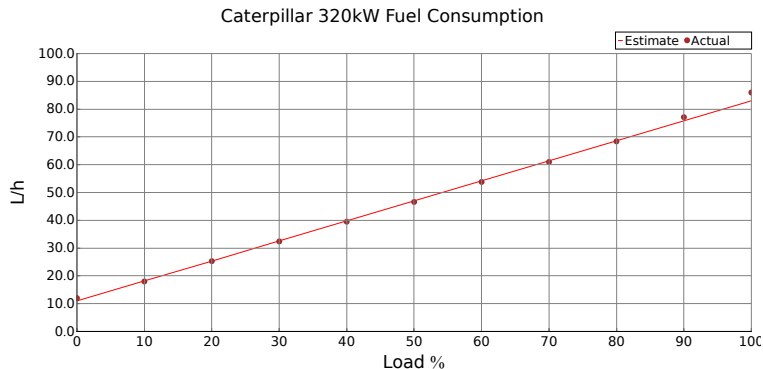
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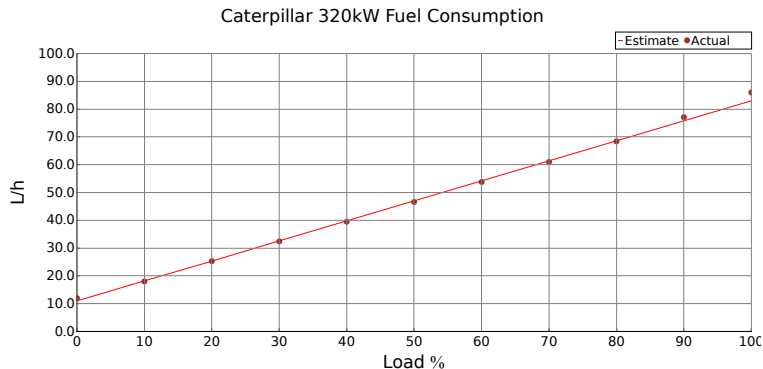
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- ▶ So there is a cost for spinning and a cost for generating.
- ▶ So every bit of PV saves fuel, running a smaller generator saves fuel.



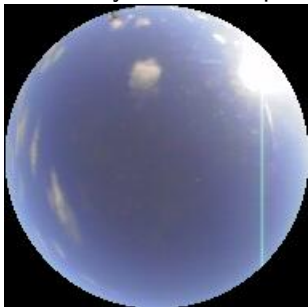
Sky Camera Forecasting

Use a SkyCamera to predict cloud over the next 2 minutes:



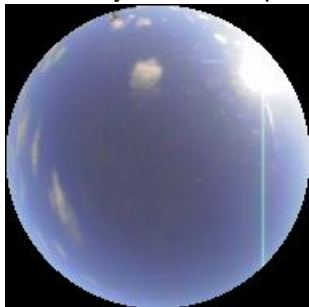
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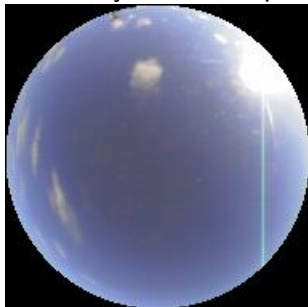


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Then start the next diesel when the cloud comes.



Demand Management

Control LoadP so we can turn off some load, perhaps using:

Green Power Point power iff there is excess green power.

Brown Power Point we assure power but there might be an outage for 2 minutes whilst we start a diesel.

Red Power Point always on.

The key thing is we need two way control and measurement.

See [Saturn South](#)



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neither is survival - W. Edwards Deming*

