



Ekistica

Translate. Create. Deliver

Renewable Power and Energy
Fractions Revisited: Insights
from ARENA's RAR Portfolio

ARENA & EKISTICA

ARENA: Australian Renewable Energy Agency

Created in 2012

Current budget ~AU\$1B, 80%
grant funding, 20% Innovation
Fund with CEFC

ROI: Knowledge Sharing,
Innovation, Market Impact

EKISTICA: WHO WE ARE

Ekistica is the leading advisory
and technical consultancy firm in
regional and remote Australia.

WHAT WE DO

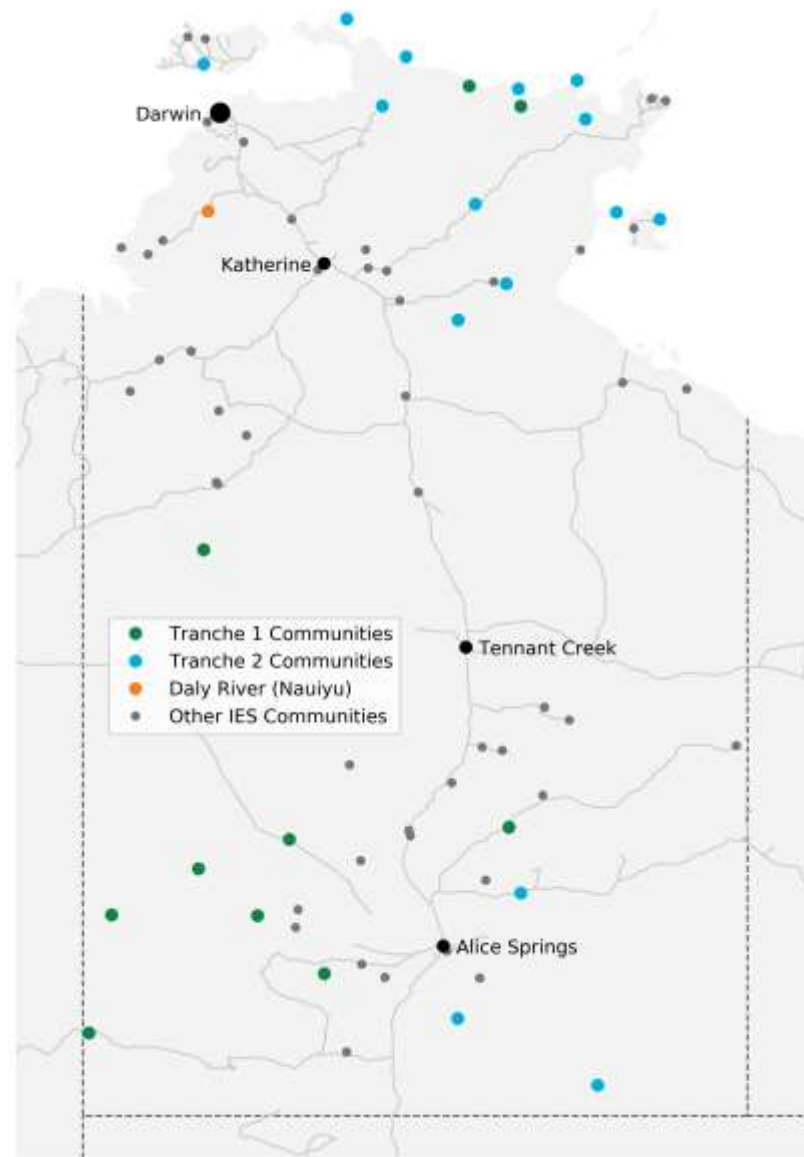
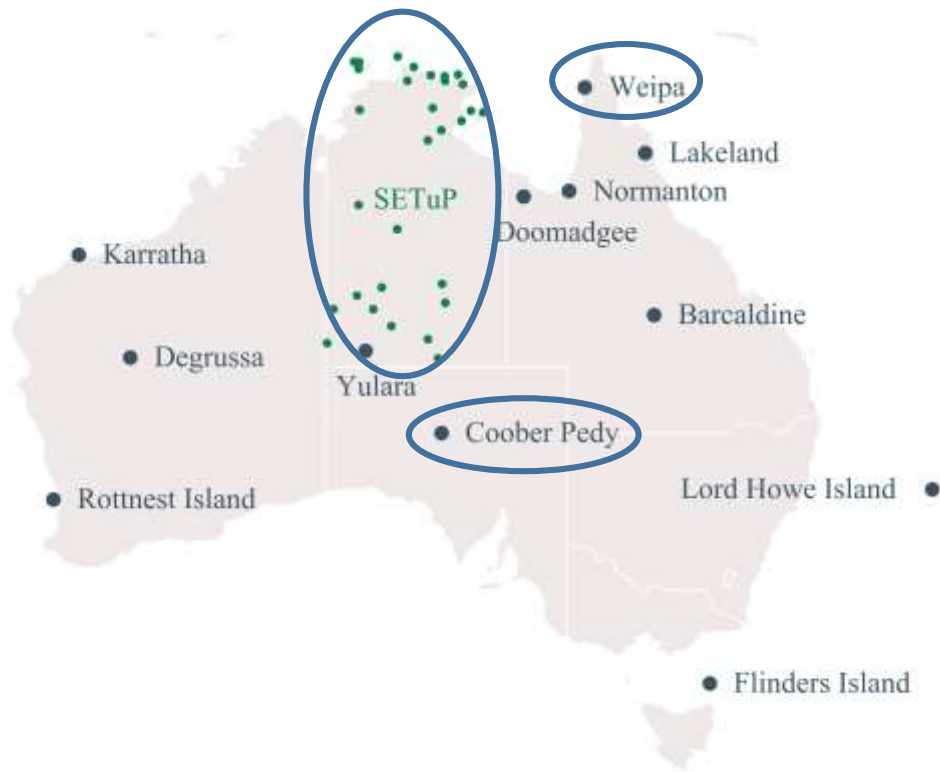
Translate: Advisory

Create: Technical consultancy

Deliver: Project delivery

EKISTICA is ARENA's Knowledge Sharing and Data Handling partner for the
Regional Australia's Renewables (RAR) and Large-Scale Solar (LSS) projects.

ARENA-FUNDED RAR PROJECTS DISCUSSED



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Project	PV capacity [kW _{DC}]	Wind capacity [kW]	Target REF _{year}	Data used	Enabling technologies
Weipa ¹	1,700	-	~2%	Jan – Dec 2017	None
Docker River ²	100	-	15%	Jan – Sep 2018	None
Lajamanu ²	400	-	15%	Jan – Sep 2018	LLD
Maningrida ²	800	-	15%	Jan – Sep 2018	LLD
Yuendumu ²	500	-	15%	Jan – Sep 2018	None
Daly River ²	1,000	-	≥50%	May – Sep 2018	BESS
Cooper Pedy ¹	1,342	4,100	>70%	Mar – Aug 2018	BESS, dynamic resistor, diesel UPS (DUPS), dynamic control system

¹: These projects are owned and operated by EDL (Energy Developments Limited).

²: These projects are part of NT SETuP (Northern Territory Solar Energy Transformation Program), owned and operated by Power and Water Corporation.

LLD: Low-load diesel generator; BESS: Battery Energy Storage System

WHY? START: COMPLEXITY SUBSTITUTION

Complexity: fuel savings in RAR portfolio due to RE addition ⇒ different projects
⇒ Same basis for comparison: P_{ren} & E_{ren} to load

~~Penetration: Power, Capacity or Energy? Ratio of P_{PV} to P_{load} ? RE Contribution?~~

RPF: instantaneous power fraction (similar to normalised efficiency η_N)

$$RPF = \frac{P_{ren}}{P_{load}} = \frac{P_{Ren}}{P_{Ren} + P_{fossil} + P_{store} + P_{dsm} + P_{transfer}} \quad [\%] \leq 100\%$$

REF: fraction of energy (similar to Performance Ratio PR)

$$REF_{year} = \frac{\sum_i E_{Ren,i}}{\sum_i E_{load,i}} = \frac{E_{Ren,y}}{E_{Ren,y} + E_{fossil,y} + E_{store,y} + E_{dsm,y} + P_{transfer,y}} \quad [\%] \leq 100\%$$

RPF and REF: provide additional clarity (language, consistent terms, self-defining) regarding amount & actual impact of VRE on the grid
⇒ Consistent way to **compare RAR projects to initial estimates + consistent terminology + new insights made possible**

APPLICATIONS OF RPF & REF

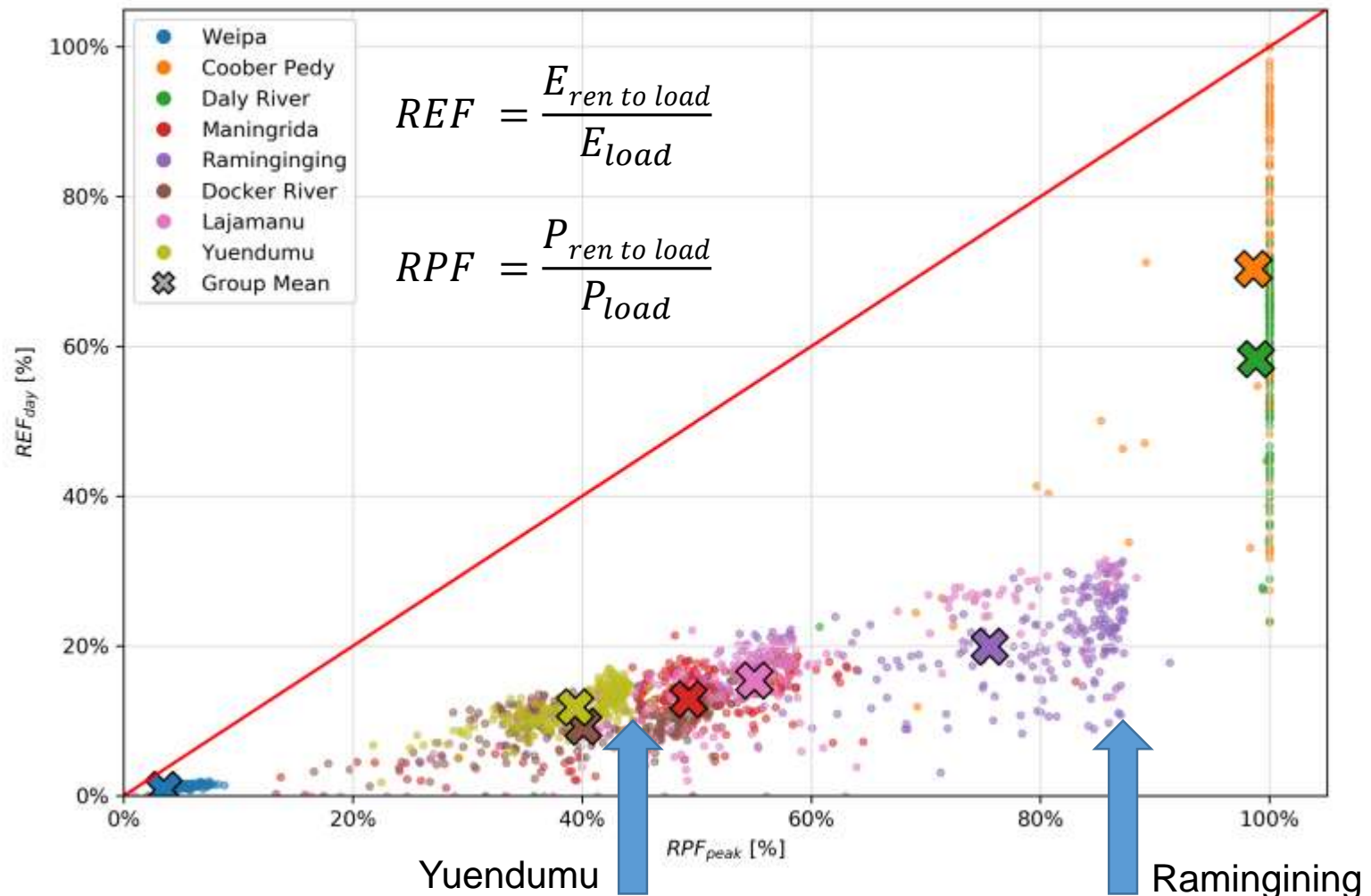
- 1. Daily peak RPF versus the daily REF**
⇒ challenge (RPF) for grid operator to reach target (REF)
- 2. Renewable Energy Fraction duration curves**
⇒ insights of REF over the year, comparison of sites & technologies
- 3. (Seasonality:**
⇒ Visualising & understanding seasonality in load, generation and combined)
- 4. Total system efficiency η_{total} :**
⇒ Black-box view & benefits of increasing REF_{year}
- 5. Uncertainties with higher RPF and REF values:**
⇒ How certain is the destination?

RPF_{peak} versus REF_{day}

Red line: system operates at RPF continuously (theoretical max)

High REF in day: much higher RPF (or demand shift..)

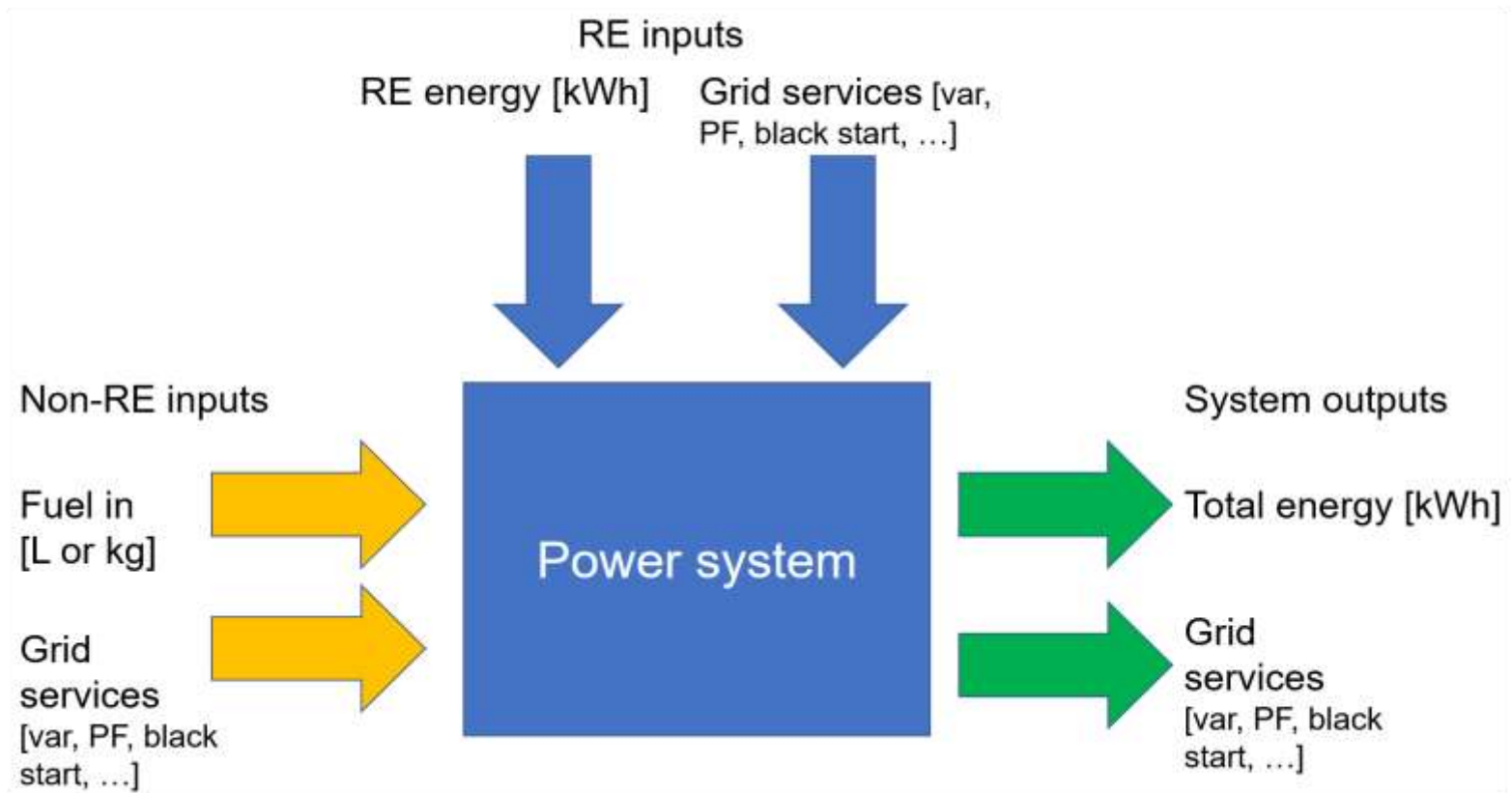
Individual system curtailment (RPF_{peak} ceiling) can be identified



BLACK BOX VIEW: η_{total}

Don't care what occurs inside the black box, just fuel in, kWh & services out
Hybridising to get system to *do more*, per L of fuel used

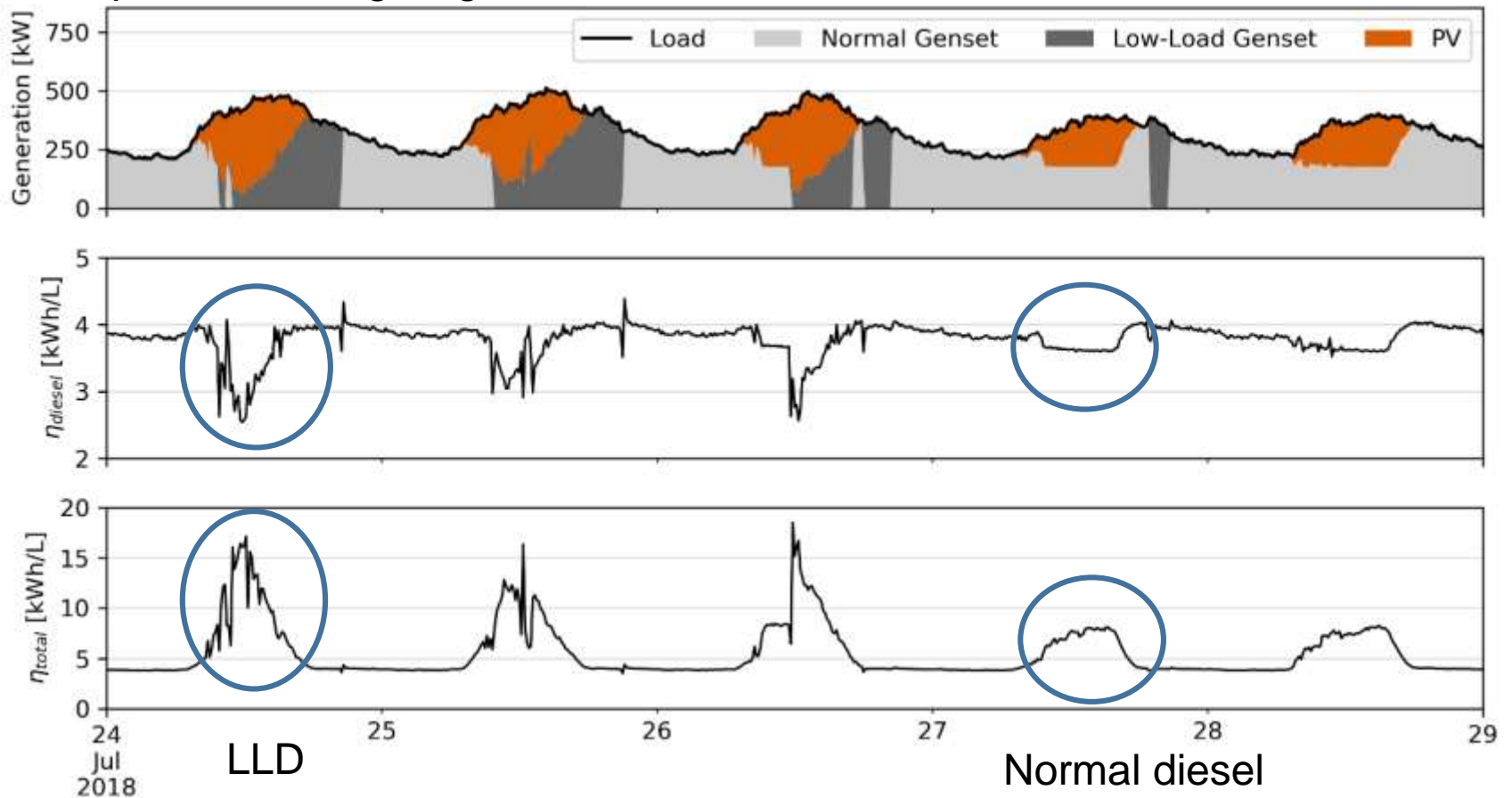
$$\eta_{total} = \frac{E_{total}}{Fuel_{total}} = \frac{\eta_{diesel}}{1 - REF} \left[\frac{kWh}{L} \right]$$



BLACK BOX VIEW: η_{total}

η_{total} increases while η_{diesel} declines: overall benefits, split incentives?
⇒ non-VRE profitability per kWh...

Example for Ramingining



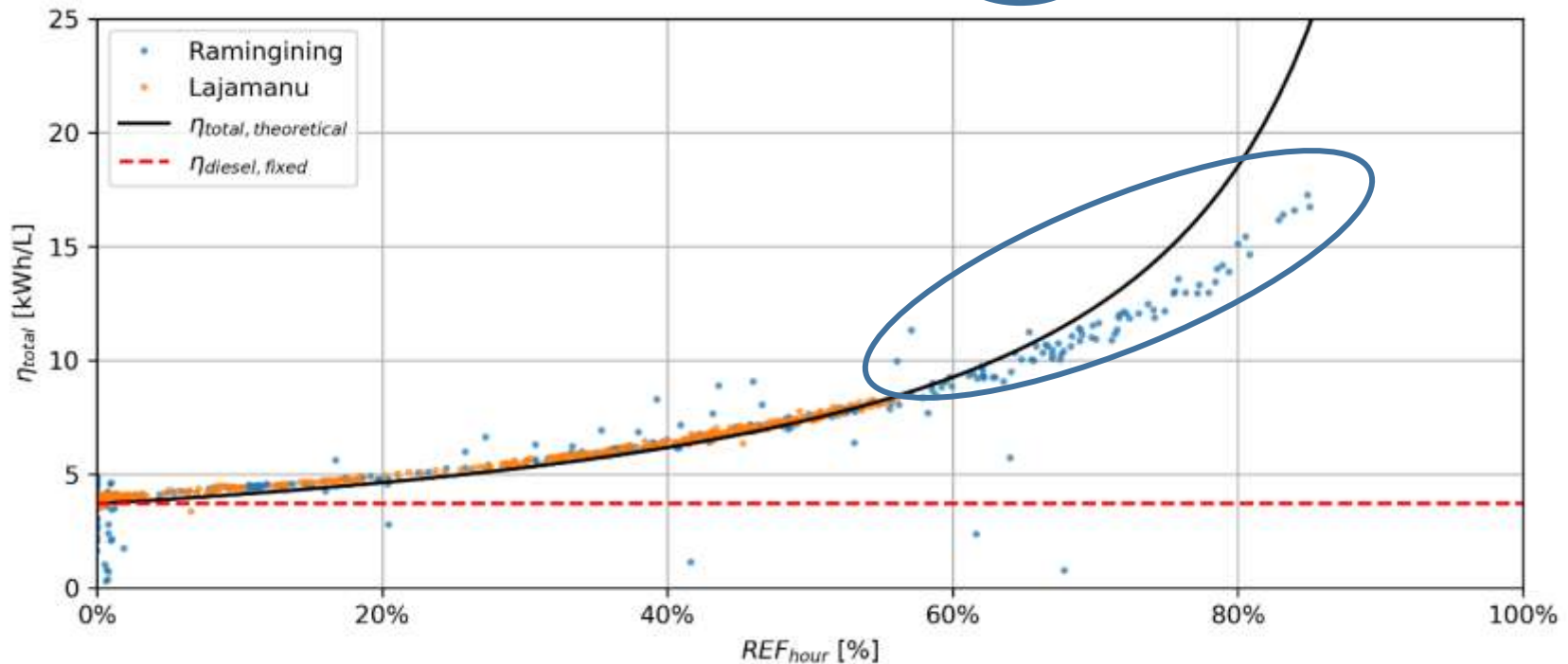
BLACK BOX VIEW: η_{total}

Increasing REF: **1:1 fossil fuel displacement not always true!**

⇒ Limit to fuel displacement **while the generator is on** (fixed + variable fuel consumption as function of net load on genset). ⇒ Benefit of grid-forming BESS

⇒ Change in η_{total} ($\Delta\eta_{total}$): important consideration for **modelling assumptions**, also **uncertainty increases**

$$\eta_{total} = \frac{E_{total}}{Fuel_{total}} = \frac{\eta_{diesel} \left[\frac{kWh}{L} \right]}{1 - REF}$$



SUMMARY - CONCLUSIONS

- RPF and REF very useful metrics to show & identify system performance and behaviour – illustrated by ARENA-funded RAR projects
- RPF_{peak} vs REF_{day} scatter plots: peak in day vs final result
- REF duration curves:
 - show transition for increasing REF values
 - **Grid-forming** storage very useful – turn off generators
- REF or RPF: illustrate and deduce seasonality in load, generation or both

$$\eta_{total} = \frac{E_{total}}{Fuel_{total}} = \frac{\eta_{diesel}}{1 - REF} \left[\frac{kWh}{L} \right]$$

- Total system efficiency (black box view): benefit initially follows hyperbolic growth curve, but benefits decline unless generator can be turned off: fixed + variable fuel consumption
⇒ **1:1 displacement does not always hold for high REF values!**
- Uncertainties and fossil fuel displacement need further work for improved financial model certainty

Challenge to you: which RPF and REF correspond to “low”, “medium”, “high” RE *penetration*?



THANK YOU
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SEASONALITY

... or a different way to look at absolute vs relative values

What causes high peak RPF (& REF_{hour}) values? Not always generation

