The cost of power outages to Zambia's manufacturing firms, households and the climate

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The study

National electricity consumption by economic sector, 2014-2018

Sectors	2014		2015		2016		2017		2018	
	GWh	% share	GWh	% share	GWh	% share	GWh	% share	GWh	% share
Mining	5,871	47.3%	6,246	54.5%	5,918	54.5%	6,202	50.9%	6,682	54.8%
Domestic	3,251	26.2%	3,482	30.4%	3,383	31.2%	4,147	34.0%	4,337	35.6%
Finance & property	487	3.9%	517	4.5%	499	4.6%	640	5.2%	714	5.9%
Manufacturing	479	3.9%	**531**	**4.6%**	**470**	**4.3%**	503	**4.1%**	593	**4.9%**
Agriculture	241	1.9%	260	2.3%	228	2.1%	262	2.1%	297	2.4%
Others	99	0.8%	99	0.9%	80	0.7%	87	0.7%	84	0.7%
Trade	107	0.9%	110	1.0%	97	0.9%	110	0.9%	114	0.9%
Energy & water	73	0.6%	89	0.8%	88	0.8%	81	0.7%	69	0.6%
Quarries	62	0.5%	68	0.6%	60	0.5%	118	1.0%	148	1.2%
Transport	31	0.3%	33	0.3%	28	0.3%	32	0.3%	33	0.3%
Construction	1,702	13.7%	15	0.1%	7	0.1%	10	0.1%	11	0.1%
Total	**12,405**	**100%**	**11,450**	**100%**	**10,857**	**100%**	**12,192**	**100%**	**13,080**	**107%**

The study

Manufacturing survey

Survey of 123 large manufacturing firms funded by the **International Growth Centre**

- Stratified by subsector – success
- Geography: Lusaka, Ndola, Kitwe (primary industrial towns)
- April-August 2018

Survey of individuals

Survey of 54 distinct IP addresses

- Restricted to internet users (online)
- Geography: 80% from Lusaka province; 6 of 10 provinces represented
- December 2019 before the announcement of a tariff hike

Issues of interest – manufacturing

1. Months and years firms experienced their worst power outages
2. Whether firms experienced unplanned and planned outages differently
3. Extent of costs incurred as a result of outages
4. Firms' coping strategies
5. Correlations between firm characteristics, costs of power outages, coping mechanisms
6. Willingness to pay a premium on the latest tariff revisions for more reliable electricity after the latest tariff revisions of 1 September 2017
7. Energy use patterns
8. Carbon emissions associated with diesel generation

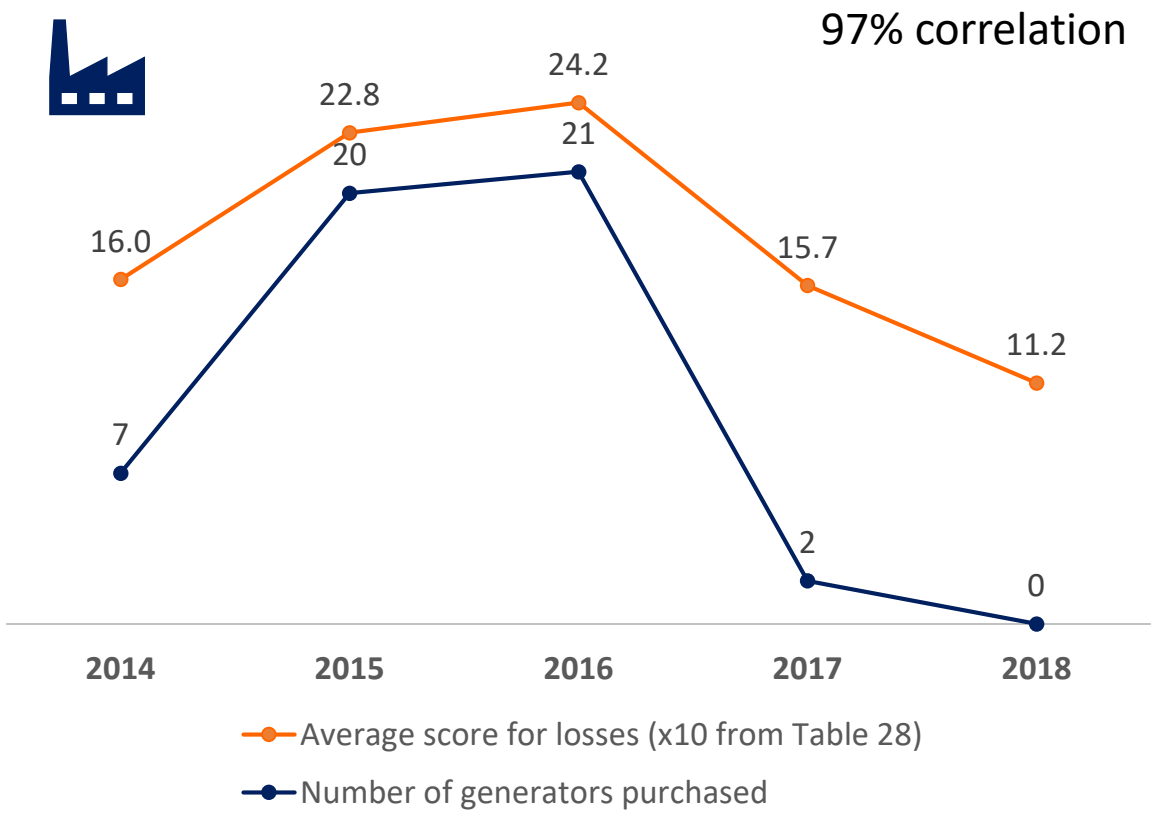
Issues of interest – individuals

1. Years firms experienced their worst power outages
2. Impact of outages
3. Coping strategies
4. Willingness to pay for reliable energy
5. Ubiquity of diesel generation as an intervention

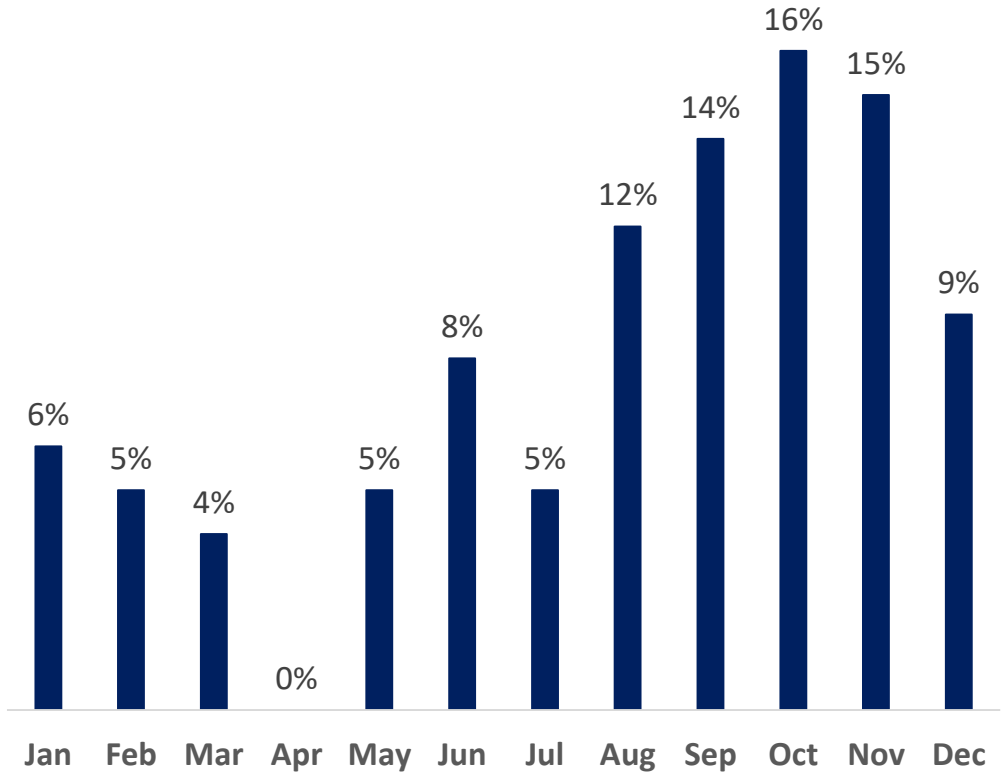
Findings

Periods of worst outages

Years of worst outages & of oldest generators

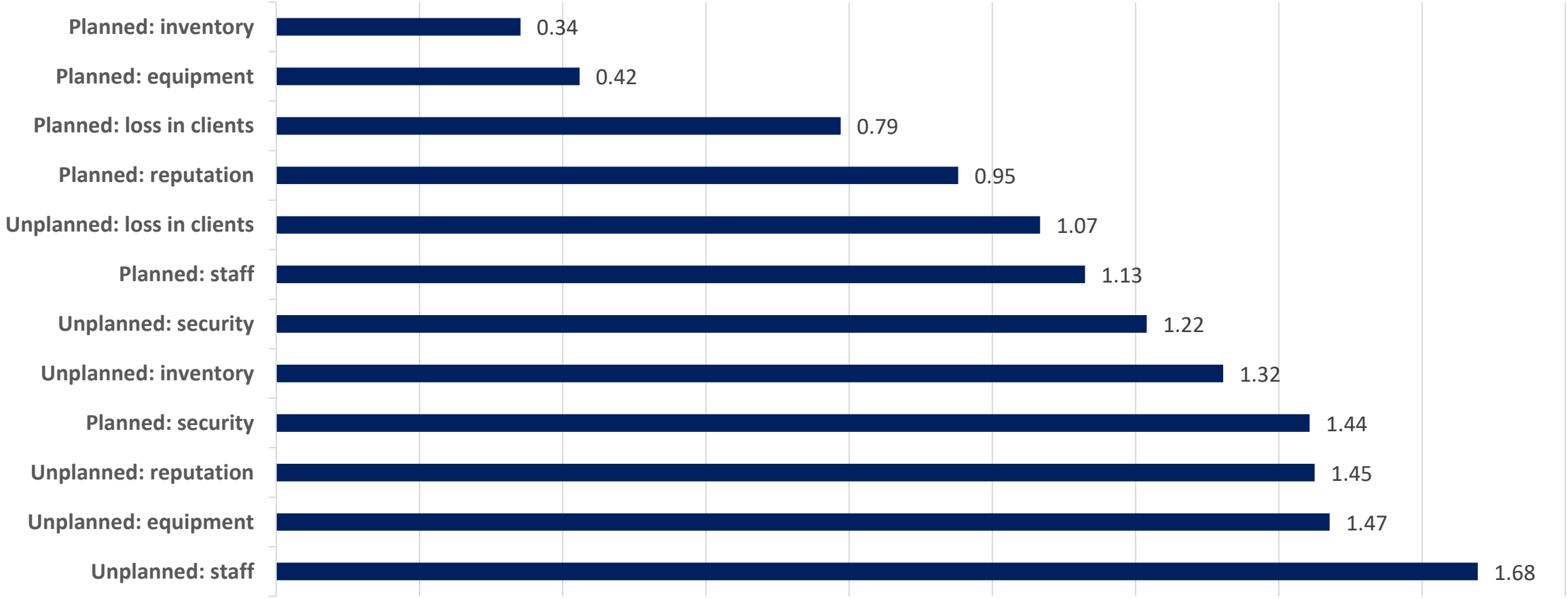


Worst months for power outages



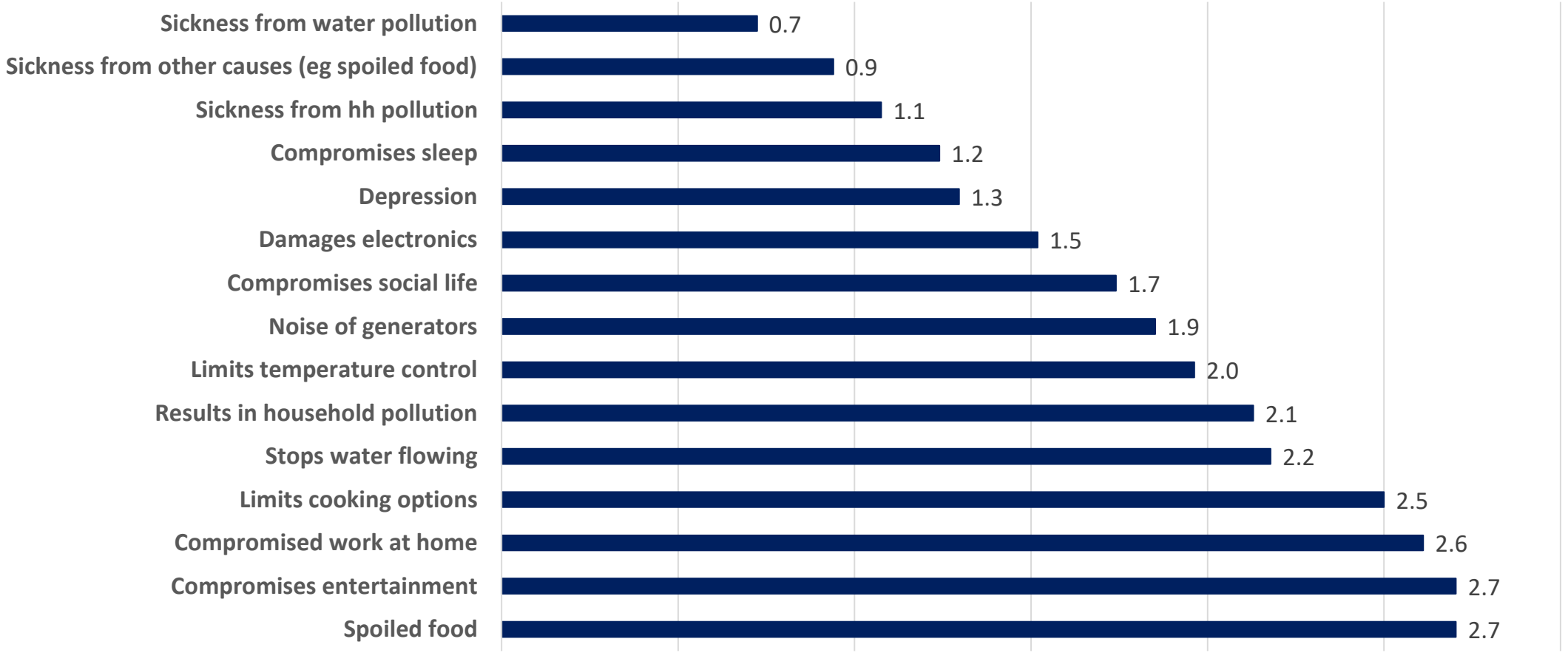
Rank of the costs of outages – firms

Most common & severe cost of power outages (0-4)



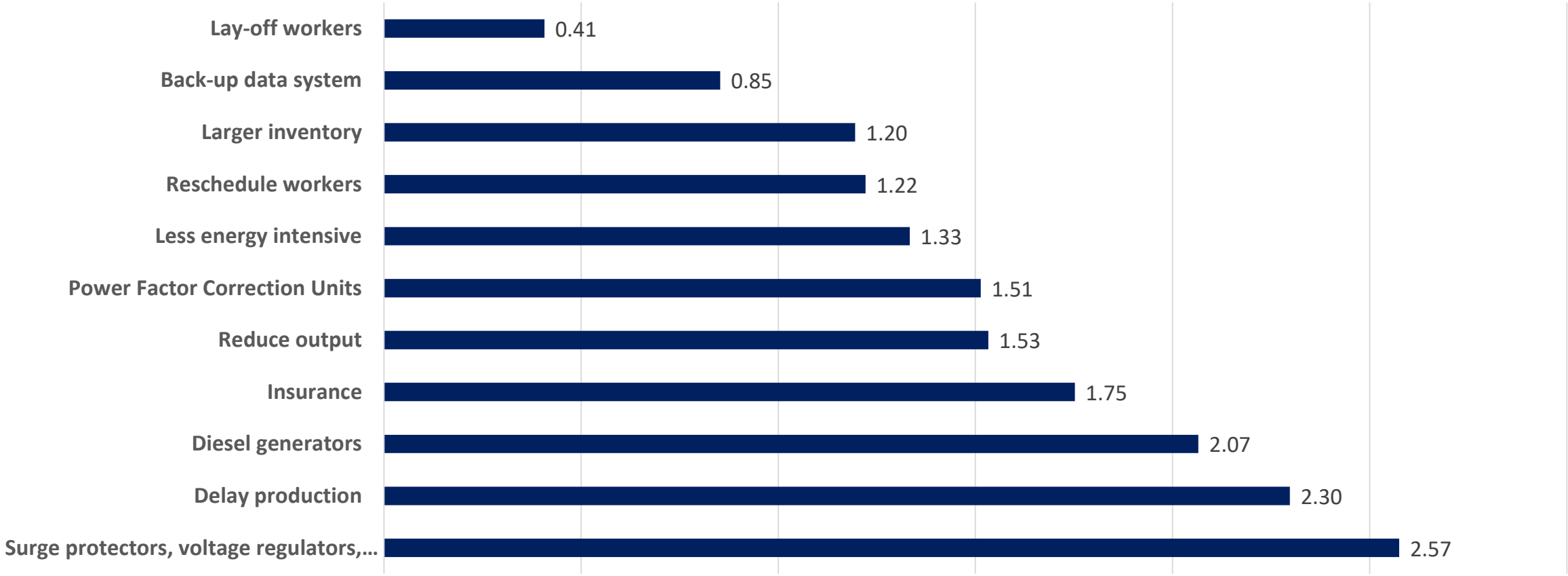
Rank of the costs of outages - individuals

Most popularly scored costs of power outages (0-4)



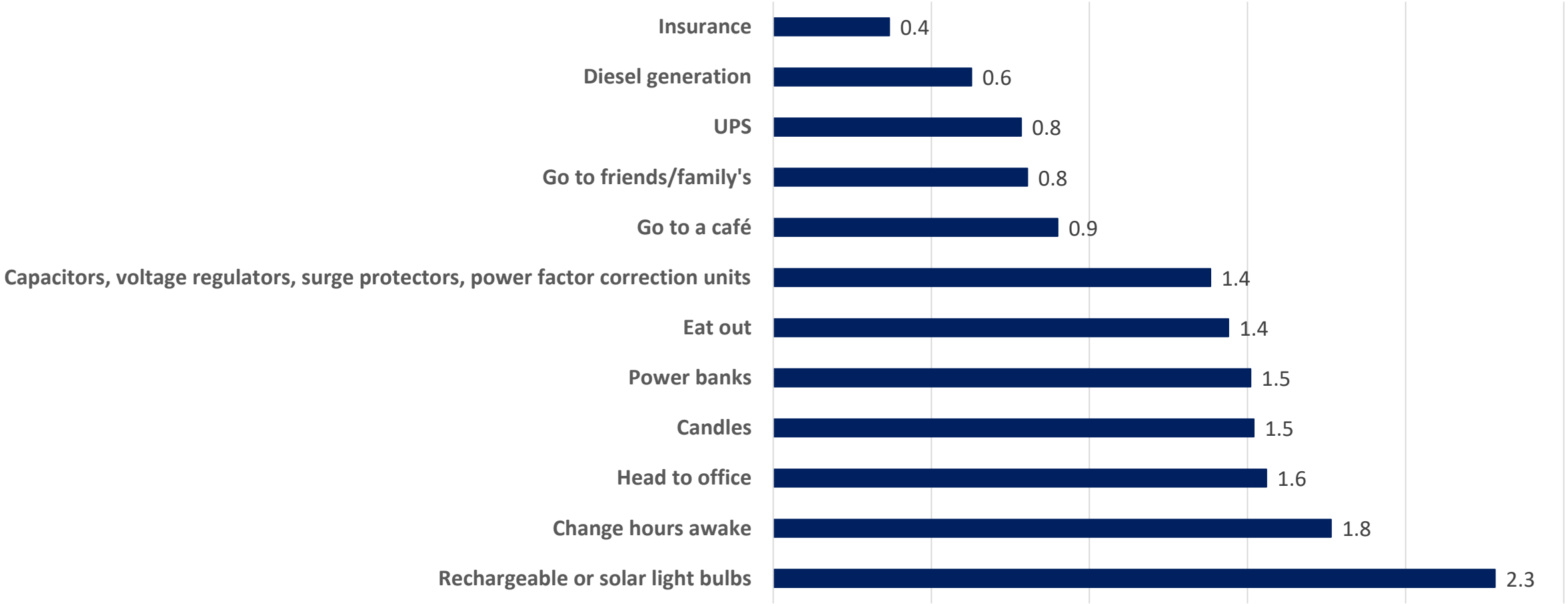
Coping mechanisms – firms

Most popular interventions (0-4)



Coping mechanisms – individuals

Most popular interventions (0-4)



Efficacy of coping mechanisms

- Self-generation contributed to reduced delays*** which resulted in reduced loss in clients***
  - 73% of firms had generators; 93% firms used them
  - Predictors of installed capacity (45% R-sq):
    - **Firm size in terms of employees** (+)***
    - **Production hours per week** (+)*
  - Predictors of generator use (prob > chi sq = 2%):
    - **Exports*** (+)
    - **Basic metals subsector**** (-)
    - **Wood subsector**** (-)
    - **Installed capacity***** (+)

****p<0.01, **p<0.05, ***p<0.1*

Marginal cost of using backup generators

Assumptions: 13 K/USD as of 31 August, 2018
0.29 USD/kWh variable cost of self-generation

Marginal cost of power outages - differential between self-generation and Zesco tariff in 2018

	% of respondents who fall into this category	Marginal cost, USD/kWh	% different from standard 16-300kVA
Maximum demand capacity 16-300kVA	50%		
Standard charge, 6am-6pm		0.263	0%
Off-peak charge, 10pm-6am		0.270	3%
Peak charge, 6-10pm		0.256	-3%
Maximum demand capacity 301-2000kVA	37%		
Standard charge, 6am-6pm		0.267	1%
Off-peak charge, 10pm-6am		0.272	4%
Peak charge, 6-10pm		0.262	-1%
Maximum demand capacity 2001-7,500kVA	13%		
Standard charge, 6am-6pm		0.271	3%
Off-peak charge, 10pm-6am		0.276	5%
Peak charge, 6-10pm		0.267	1%
Maximum demand capacity 7,500+kVA	0%		
Standard charge, 6am-6pm		0.274	4%
Off-peak charge, 10pm-6am		0.278	6%
Peak charge, 6-10pm		0.271	3%

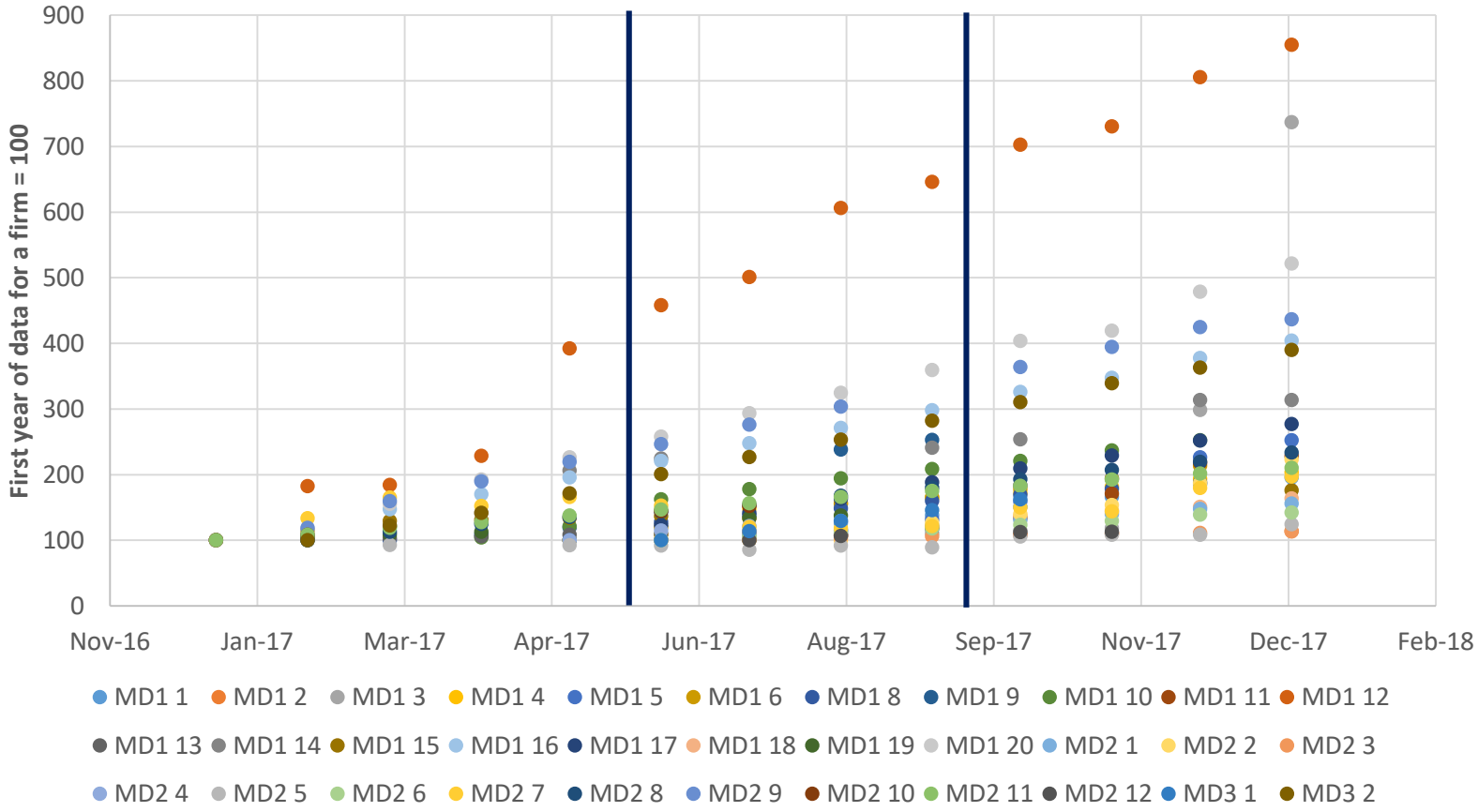
WTP for more reliable electricity - firms

- 25% respondents (2018) said they WOULD be WTP more
  - Likelihood of a firm that exports being willing to pay more was 80%***
  - Food & beverages* (+)
- Those who refused:
  1. 7% satisfied
  2. 13% thought their tariffs were already too high
  3. 2% because there had already been two tariff hikes in 2017
  4. Distrust in ZESCO's ability to deliver

     26% respondents:
     - never received notifications of outages or
     - received inaccurate notifications
  5. Firms perceived that they were subsidising mining companies

Tariffs too low to impact consumption

Peak energy consumption for by 33 MD1, 2 & 3 firms pre & post tariff hikes



WTP for more reliable electricity - individuals

- 63% said they would be willing to pay more
- On average: K 1.4/kWh (USD 0.095/kWh)
  - In contrast to
    - what they were paying:
      - K 0.15/kWh for the first 200kWh/month and
      - K 0.89/kWh for more
    - what they started paying from 1 Jan, 2020:
      - K 0.47/kWh for the first 100kWh/month and
      - K 0.85/kWh for the next 200kWh/month and
      - K 1.94/kWh for more

Predictors of WTP more

(42% R-sq; p > F = 0.02):

- Income (+) ***
- Spoilage of food (+)**
- Cooking limited (+)**

WTP for more reliable electricity - individuals

15. Households currently pay K 0.15/kWh for the first 200kWh/month and K 0.89/kWh on energy consumed after the first 200kWh/month.

Zesco is not charging any customer a cost-recovery tariff, which means it does not have the money to supply more energy.

Bearing in mind that it costs about K 4.2/kWh to run a diesel-generator, if it meant more reliable energy, what is the maximum you would pay:

- ○ K 1.2/kWh on all your household energy consumption?
- ○ K 1.5/kWh on all your household energy consumption?
- ○ K 1.7/kWh on all your household energy consumption?
- ○ Other, K/kWh (state how much in comments)

Comments:

Sacrifices for higher tariffs:

- Use geysers less
- Switch to gas stoves
- Energy saving lights
- Use water boiler less; have people shower within 2 hour periods in the morning & evening

Energy use patterns

- Firms operating >84h/week operated less during off-peak hours; more during peak hours than if they had been operating steadily 24h/day
  - The c. $0.01/kWh difference between peak and off-peak tariffs (compared with Zimbabwe's $0.09/kWh) is not enough to induce alignment of firms' energy use with ZESCO's baseload versus peak-load levelised costs of energy

Carbon emissions from self-generation

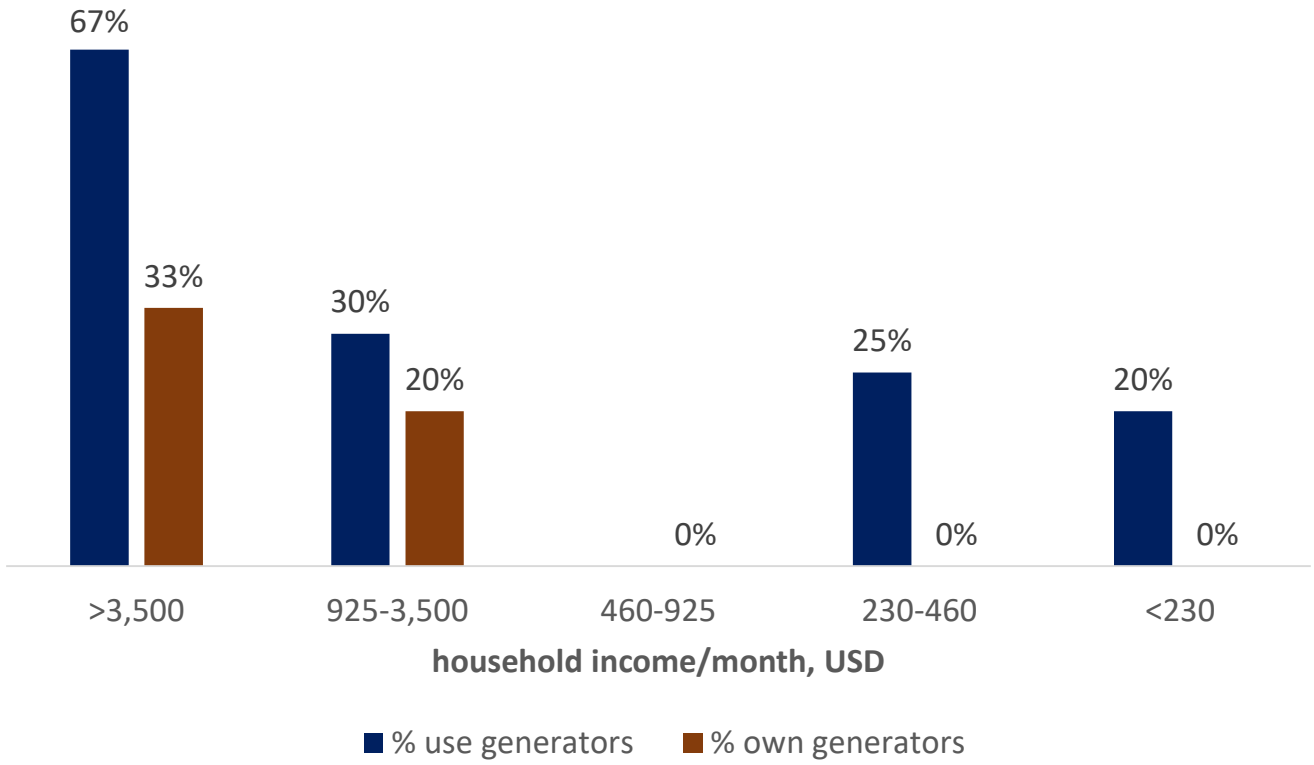
- Generator usage – collected data
  - Fuel used, generator capacity, hours run, MJ released
- Predictors of fuel use & hence emissions 99.9% R-sq:
  - Year (2015 or 2016)*
  - Installed capacity, kVA**
  - Installed capacity, litres*

➔Extrapolated 13,000 tonnes CO_2 for worst month in 2015/16

➔3,400 tonnes in 2017/2018

Carbon emissions from self-generation

Household diesel gen emissions



- Income a statistically significant predictor for ownership & extent to which used
- Possibly north of 200,000 hh use diesel generators*
- Not immediately switched on – wait until sunset, or 2-20 hours
- Not used for prolonged periods – up to 4-8 hours

**Based on assumption of 27% USD 460-925 use generators)*

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