27th Technical Convention 2019

The 4th Industrial Revolution ("4IR") | *Building the Power Utility of the Future, Today*

Electrical Master Planning for the 4th Industrial Revolution

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Change is inevitable

"Change is no longer something that happens, but rather something that's happening. As such, the greatest threat to your future success is confidence and certainty. The future belongs to those who embrace uncertainty, and act fast." – Richard Mulholland

The 4th Industrial Revolution

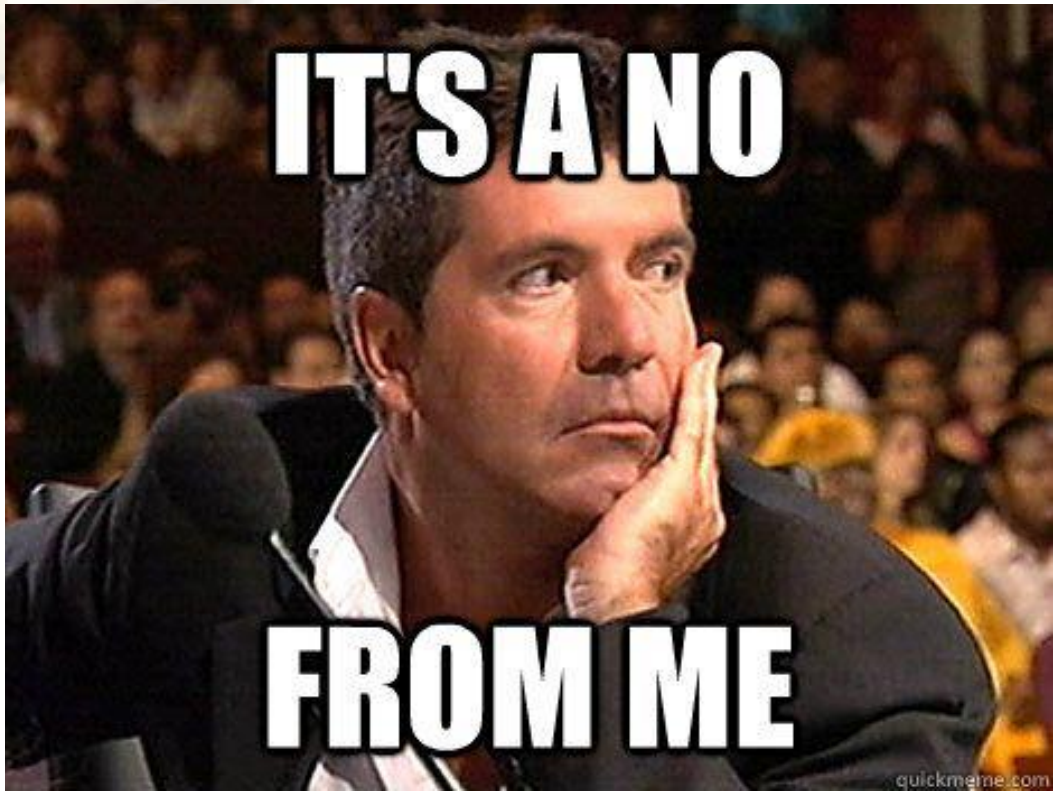
- Smart cities driven by 4th IR
- Communication, big data, Internet of Things (IoT), grid self healing
- Power system of the future is interactive – advanced distribution management system (ADMS)
- Distributed Generation sees consumers turn into prosumers
- Smart metering allows for more accurate consumption & demand statistics

Data & Systems

Current Master Planning Tools & Systems

Integration?

Are we ready to plan & operate the power system of the future?



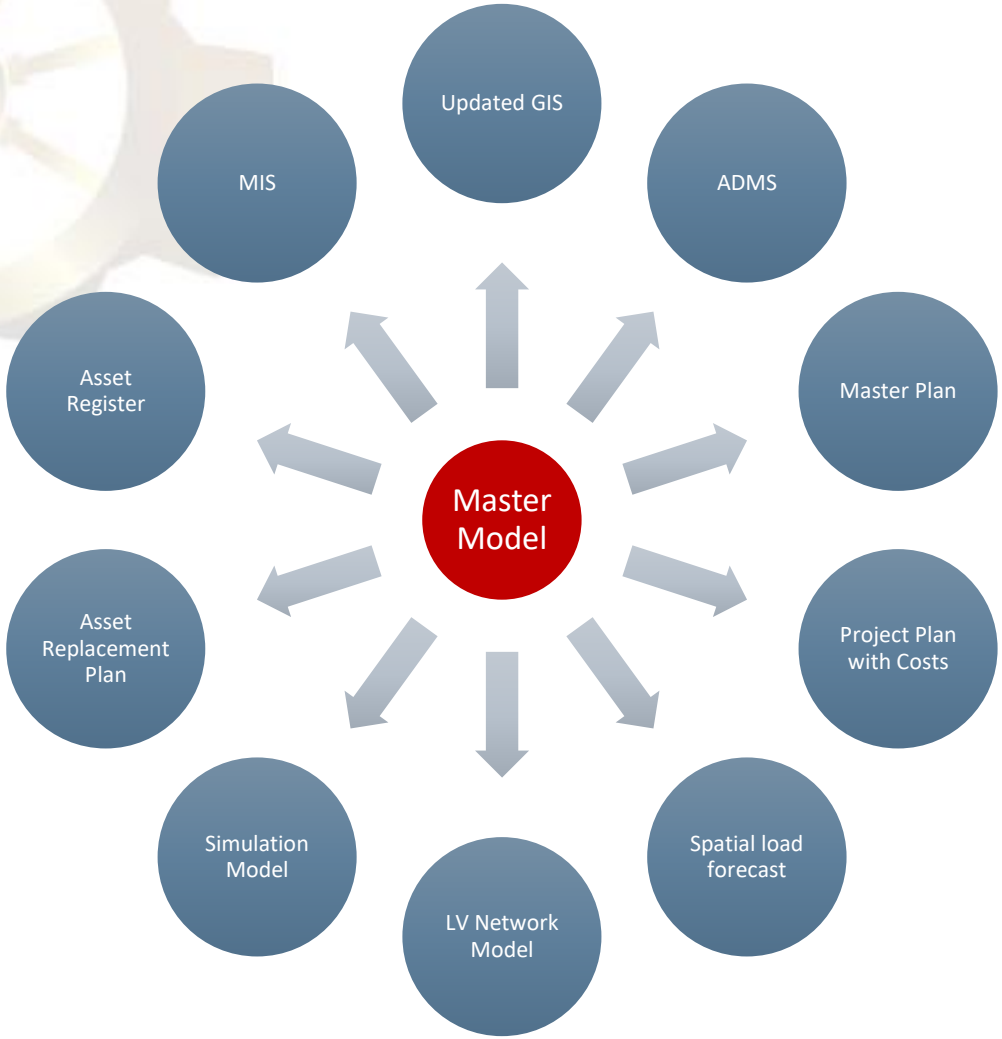
Why not?

- System integration – data exchange haphazard at best
- What is the master data set?
- Master Planning currently only done up to MV (at best)
- Fastest changing part of the network is at customer side – LV network
- Smart Grid or 4th IR power system needs:
  - Observability
  - Controllability
  - Which gives self healing benefits

4th IR Master Planning

- Master model to ensure a master data set as well as smoother system integration
- Sets foundation for Observability part of ADMS
- Consider brown fields and not just greenfields growth - densification
- Asset replacement of ageing and failing infrastructure
- More granular load forecasting – the load is changing!
- Updates of MPs now required more often as more and more data becomes available
- How do we fund the future?

The Advanced GIS Master Model



Asset Management Planning

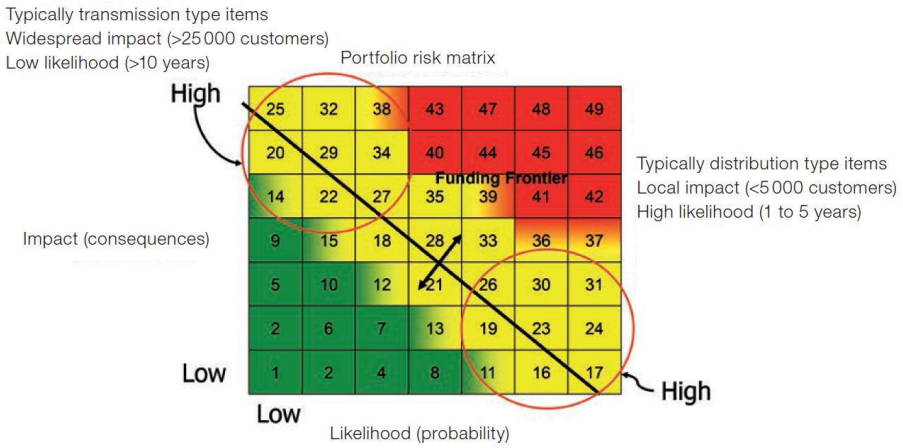
- SA utilities have aged networks which are maintained reactively for the most part
- Limited budgets for:
  - Asset creation
  - Asset operation & maintenance
  - Asset replacement, renewal or refurbishment

HAVE

NEED

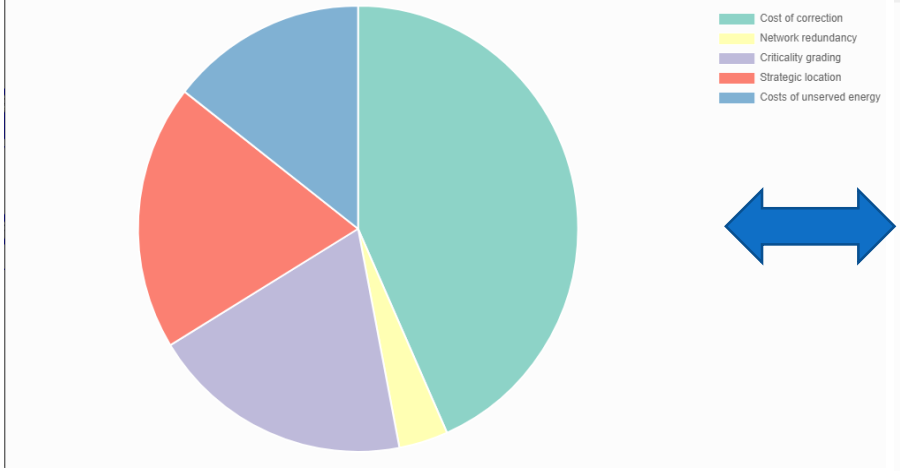
Asset Replacement Prioritization

- Risk scoring to rank assets in terms of replacement prioritization
- Likelihood of failure vs Consequence of failure
- ARP Score = LoF x CoF
- Likelihood of failure
  - Age vs Catalogue life
  - Loading
  - Transformer oil test results
  - Faults & failures
- Consequence of failure
  - HV vs MV vs LV - Cost of unserved energy
  - Customers it serves – Hospitals, Industrial, Commercial



Asset Replacement Prioritization

Importance of Consequence of Failure Factors



Consequence of Failure (ElecMVTransformer-CU_166388)

#	Factor	Score	Weight (%)	Value
CF_01	Criticality grading	0.8/5	20.00	0.0320
CF_02	Network redundancy	0.3/5	10.00	0.0060
CF_03	Costs of unserved energy	0.6/5	20.00	0.0240
CF_04	Strategic location	0.8/5	20.00	0.0320
CF_05	Cost of correction	1.2/5	30.00	0.0720

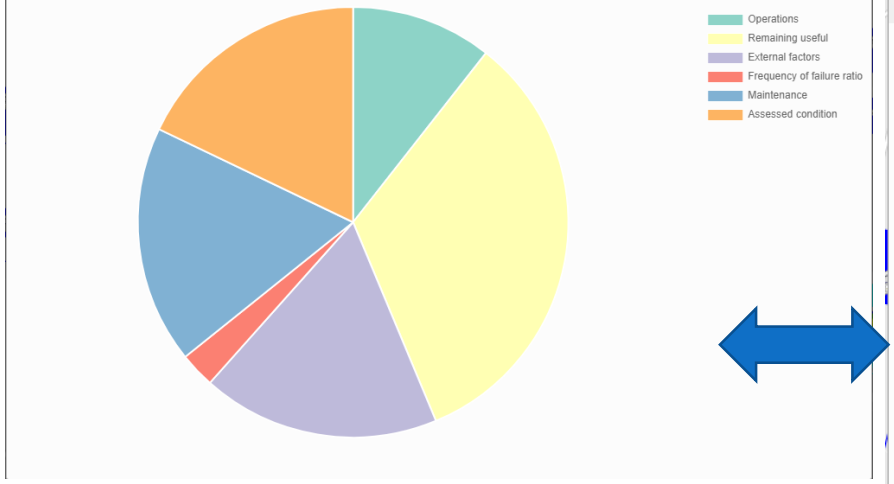
Value = Score x Weight

CF Score = Σ Value
= 3.180 out of 5

Correction Percentage = 25 % x CG + 3 x (1 - 25 %)

Close

Importance of Likelihood of Failure Factors



Likelihood of Failure (ElecMVTransformer-CU_166388)

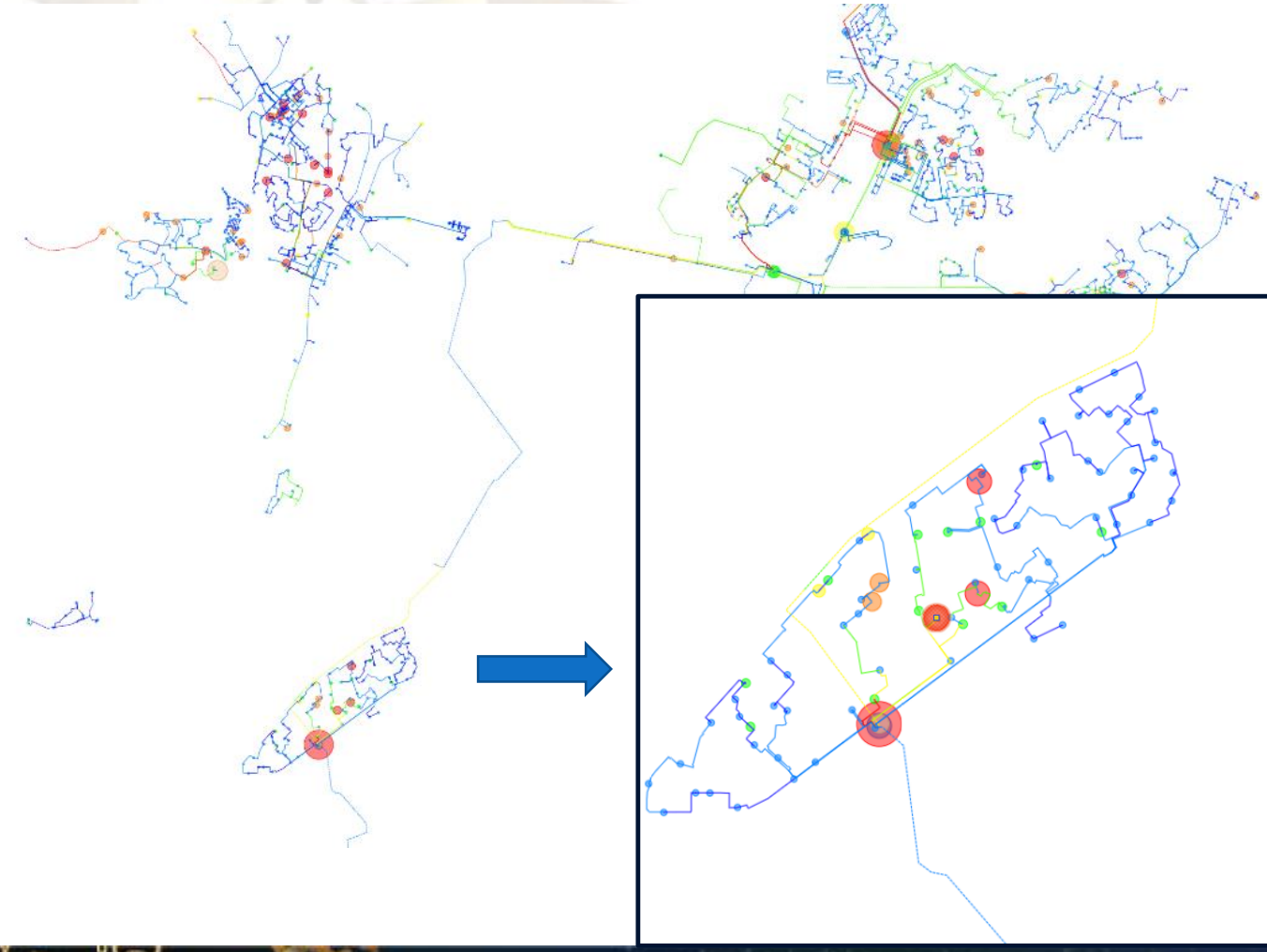
#	Factor	Score	Weight (%)	Value
LF_01	Remaining useful	0.5/5	25.00	0.0250
LF_02	Operations	0.2/5	20.00	0.0080
LF_03	Maintenance	0.45/5	15.00	0.0135
LF_04	Assessed condition	0.45/5	15.00	0.0135
LF_05	Frequency of failure ratio	0.1/5	10.00	0.0020
LF_06	External factors	0.45/5	15.00	0.0135

Value = Score x Weight

LF Score = Σ Value
= 2.150 out of 5

Close

Asset Replacement Prioritization

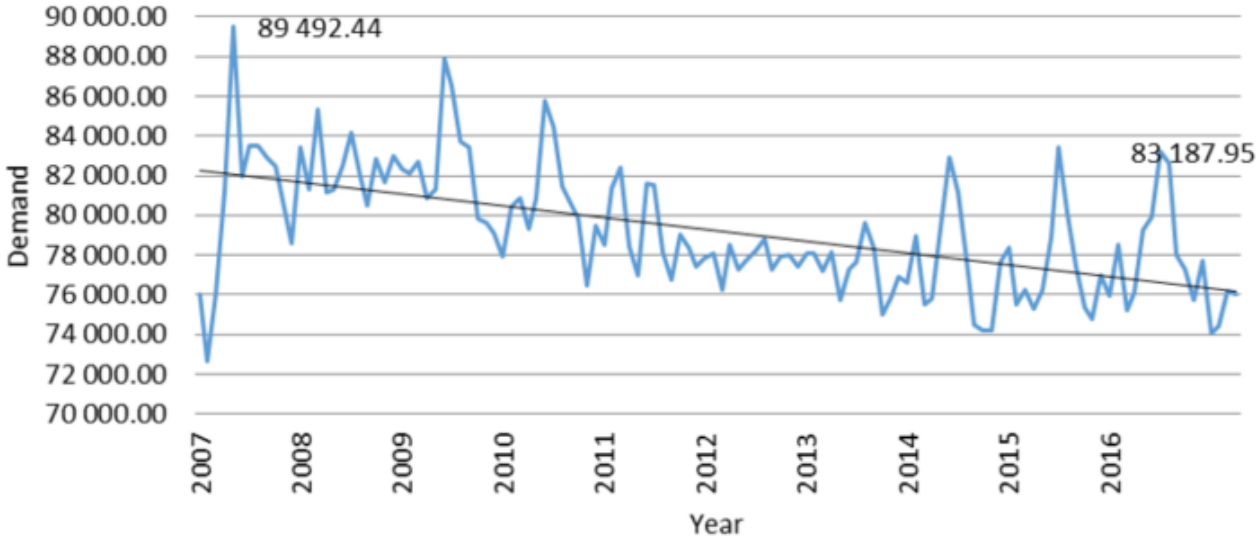


Layout | Default Layout

Field	Value
AM_Criticality_Confidence...	3.00
AM_Utilisation_Grading	3.00
AM_Performance_Grading	5.00
AM_Performance_Gradin...	5.00
PRLoading	5.00
PRCompFail	3.00
PROilLev	3.00
PRFreqFail	1.00
PRVehAcc	3.00
PRVanThe	5.00
PRLightning	3.00
PRManDef	1.00
PRNetRed	3.00
PRCostUnserEne	3.00
PRCostCorr	3.00
PRAge	42.00
PRRUL	4.00
PRStratLoc	3.00
PRCond	3.00
PRCritic	4.00
Comments	
UserNr	CU_165101
ReplCost	194,538.72
LF_Total	3.20
LF_Perc	85.71
CF_Total	3.05
CF_Perc	30.77
RP	9.76
RP_Perc	93.64

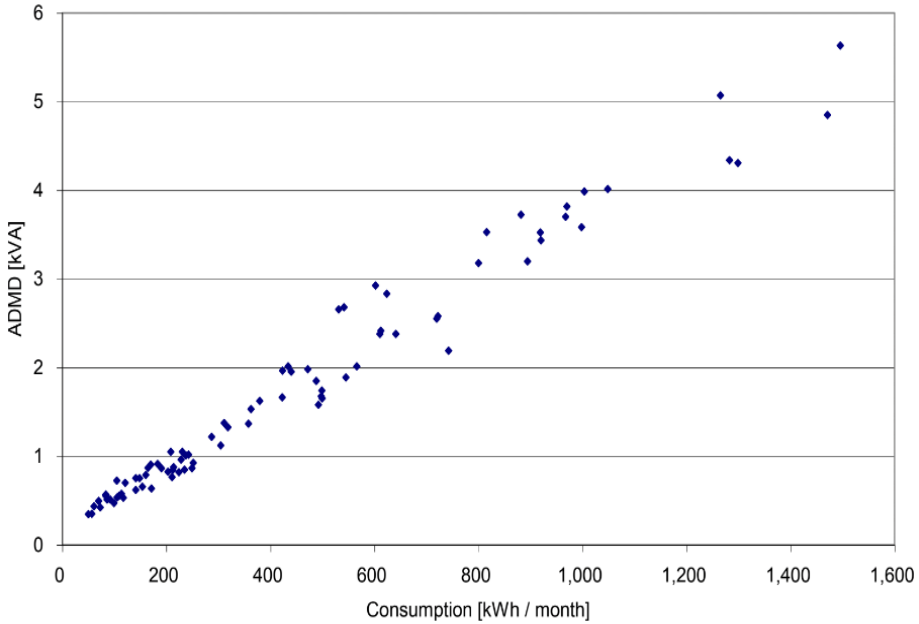
Load Modelling

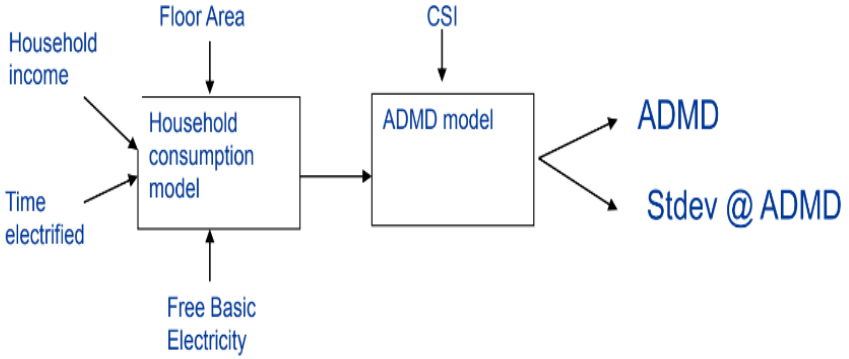
- Consumer behavior has changed – EEDSM, load-shedding, electricity pricing, DG/SSEG
- Growth vs decline
- Necessitates a renewed look at load modelling and forecasting



Load Modelling

Energy consumption (unknown) → How? → MD & ADMD (unknown)





(with thanks to Dr. Schalk Heunis, Mr Marcus Dekenah)

Load Modelling

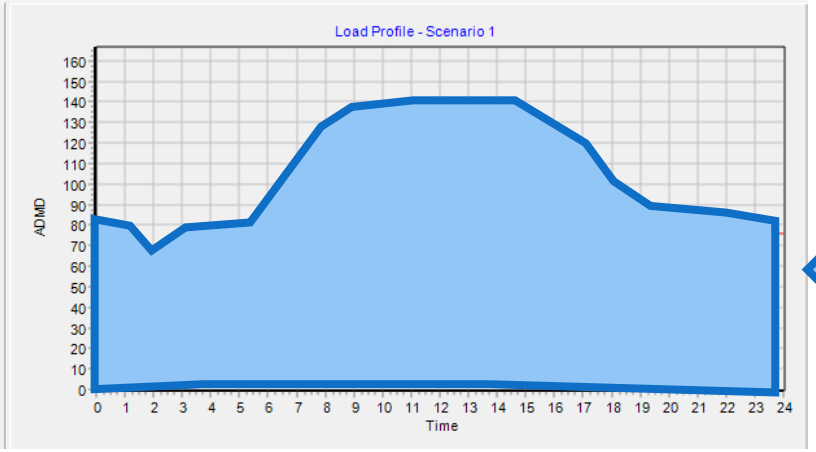
Energy consumption (known) —How?→ MD & ADMD (unknown)

- Load data problem – not readily available downstream of HV/MV substation
- Energy consumption data is readily available through Utility treasury database
- Want to ‘predict’ MDs and ADMDs from energy consumption

Load Profile - Scenario 1

File Scenarios

Time	ADMD
0.00	76.04
1.00	74.71
2.00	65.37
3.00	73.38
4.00	73.38
5.00	74.71
6.00	85.38
7.00	105.39
8.00	121.40
9.00	126.74
10.00	129.41
11.00	132.08
12.00	132.08
13.00	132.08
14.00	133.41
15.00	132.08
16.00	125.41
17.00	112.06

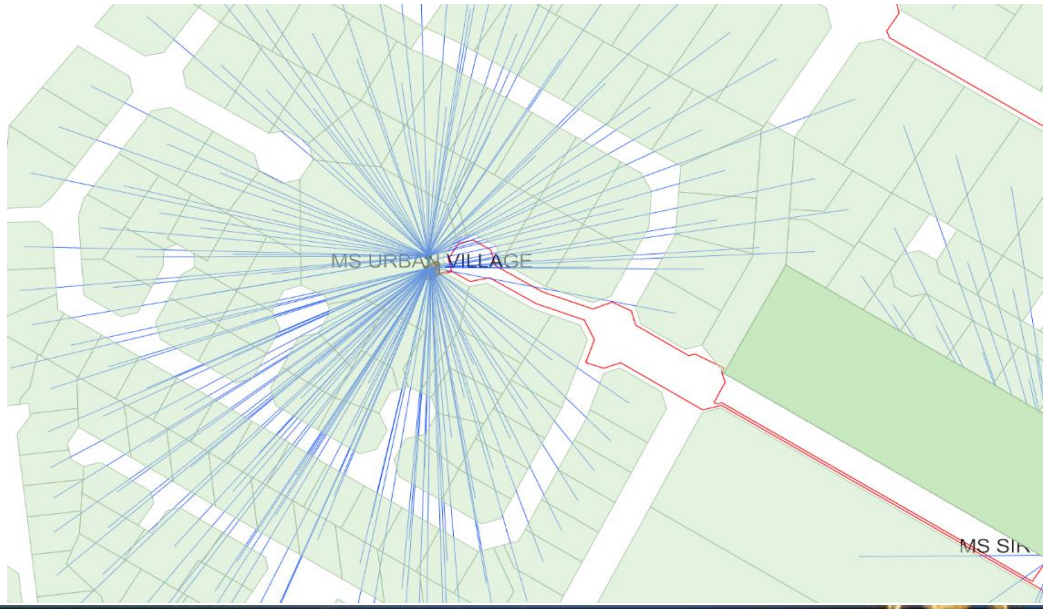


Area under curve is $kVAh = \frac{kWh}{PF}$

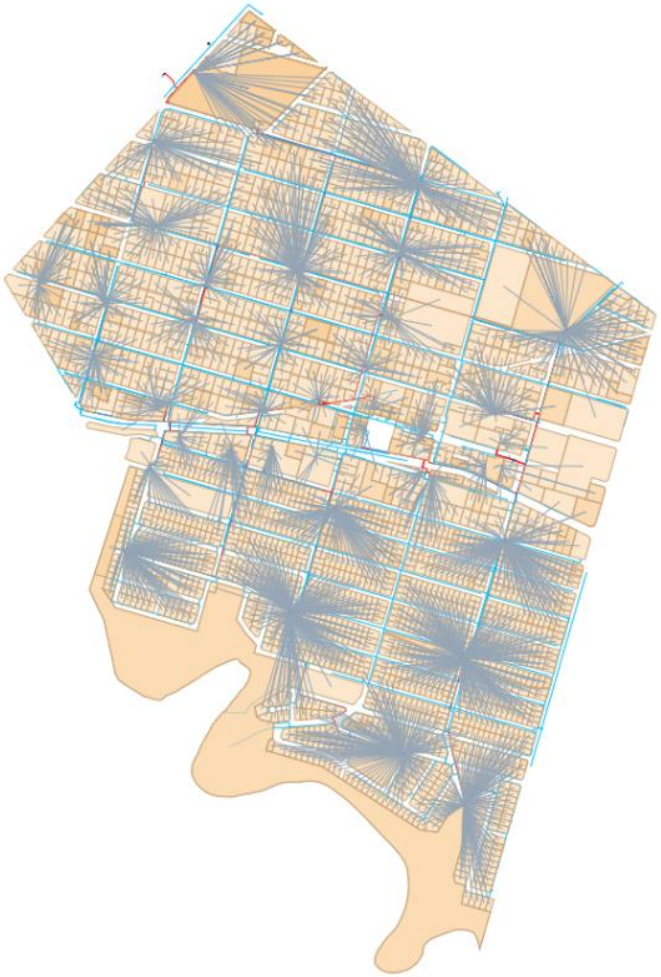
Load Modelling

Working Principle:

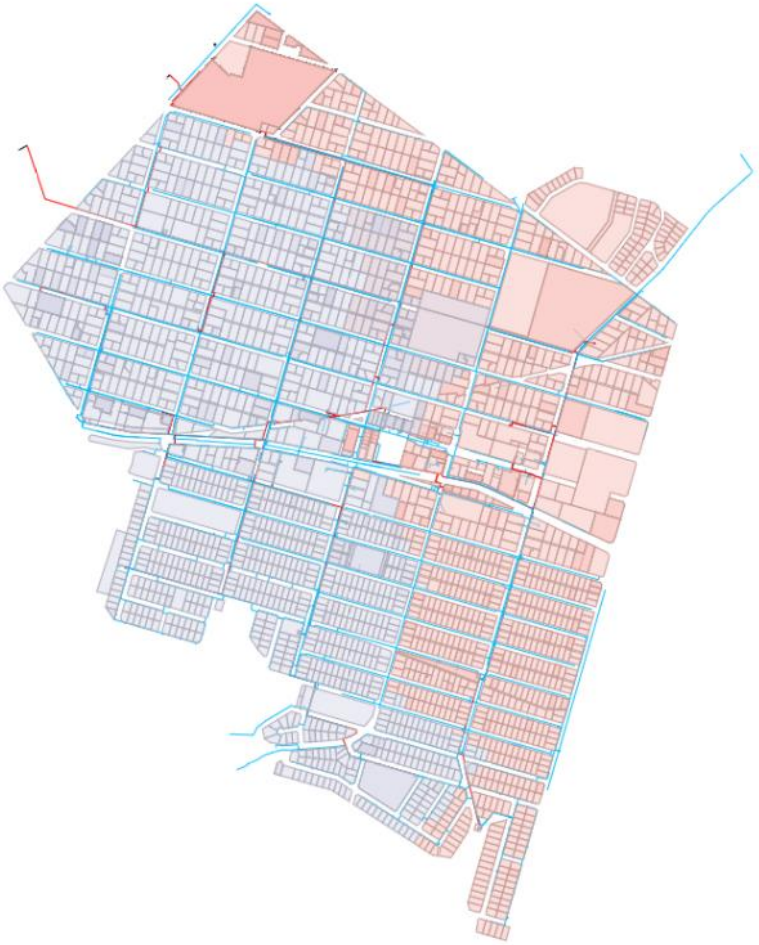
- Consumption & land-use of each stand is imported into the master model via spatial billing system analyser
- Spatially tie stand to closest LV kiosk/minisub/substation etc. (model dependent)
- Get per-stand consumption, ADMD and roll up
- Kiosk- → transformer- → distribution- →substation zones
- Bottom-up approach from stand to substation

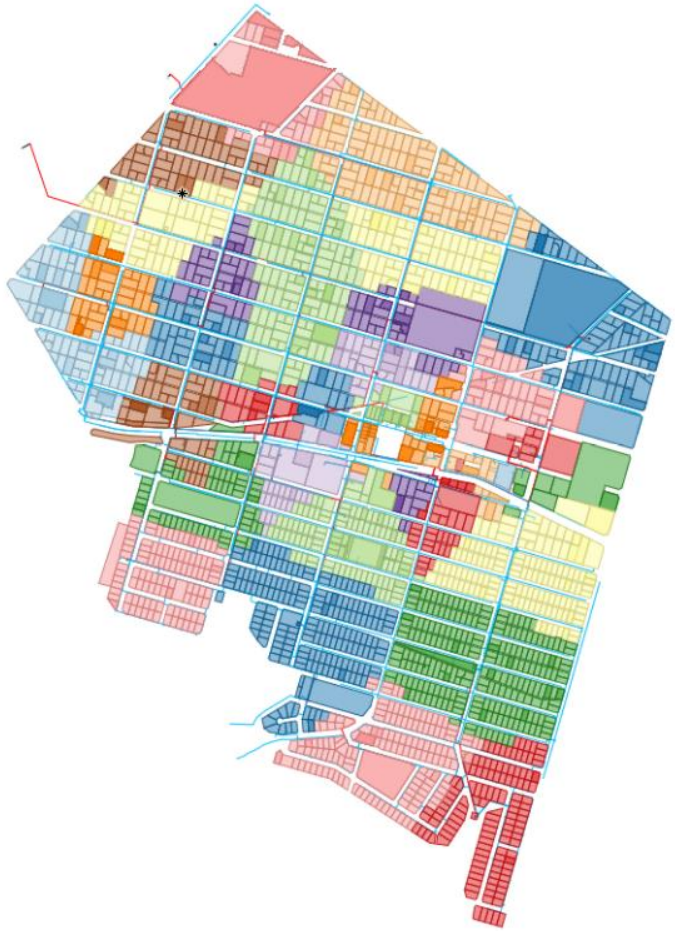


Load Modelling



Load Modelling





Load Modelling

GM_0009398 - Scenario 1

Scenario: Scenario 1

Power Factor: 0.82
Load Factor: 0.79
Total AADC : 179235.80

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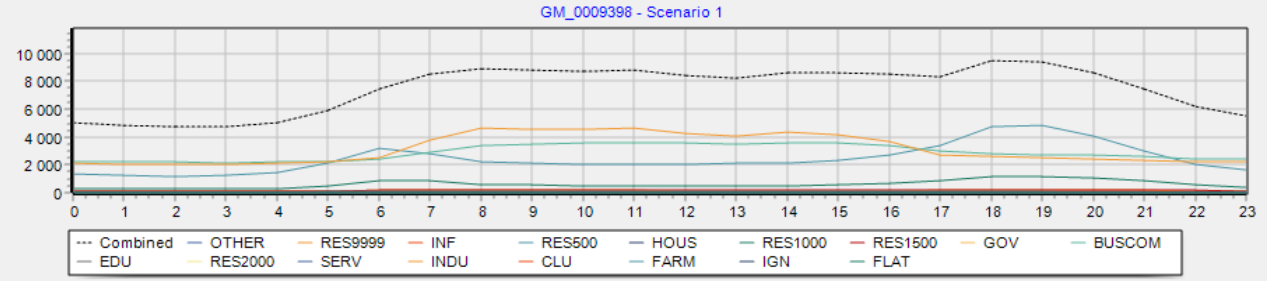
Profile	Count	AADC	MD	ADMD
Combined	8,666	179,235.80	11,606.84	1.34
OTHER	84	1,342.53	99.93	1.19
RES9999	139	3,463.34	204.33	1.47
INF	27	0.00	0.00	0.00
RES500	6,226	58,411.26	4,811.47	0.77
HOUS	14	73.04	4.38	0.31
RES1000	1,146	14,616.94	1,162.84	1.01
RES1500	305	4,047.73	227.27	0.75
GOV	8	232.85	14.68	1.83
BUSCOM	355	47,790.76	3,623.16	10.21
EDU	20	1,020.89	68.08	3.40
RES2000	34	483.30	34.92	1.03
SERV	28	12.27	0.79	0.03
INDU	237	47,451.00	4,653.69	19.64
CLU	1	0.00	0.00	0.00
FARM	5	29.28	1.79	0.36
IGN	34	86.17	6.60	0.19
FLAT	3	174.43	0.00	0.00

Time	AADCpu	MD
0	0.43	5,021.03
1	0.41	4,797.75
2	0.41	4,711.86
3	0.41	4,750.95
4	0.43	5,016.75
5	0.50	5,857.64
6	0.64	7,440.62
7	0.74	8,531.71
8	0.76	8,865.58
9	0.75	8,762.35
10	0.75	8,692.92
11	0.75	8,760.37
12	0.73	8,459.33
13	0.71	8,243.76
14	0.74	8,571.34
15	0.74	8,615.40
16	0.74	8,543.92
17	0.71	8,287.61
18	0.81	9,436.91
19	0.81	9,400.89
20	0.74	8,595.76
21	0.64	7,406.29
22	0.53	6,196.38
23	0.48	5,518.58



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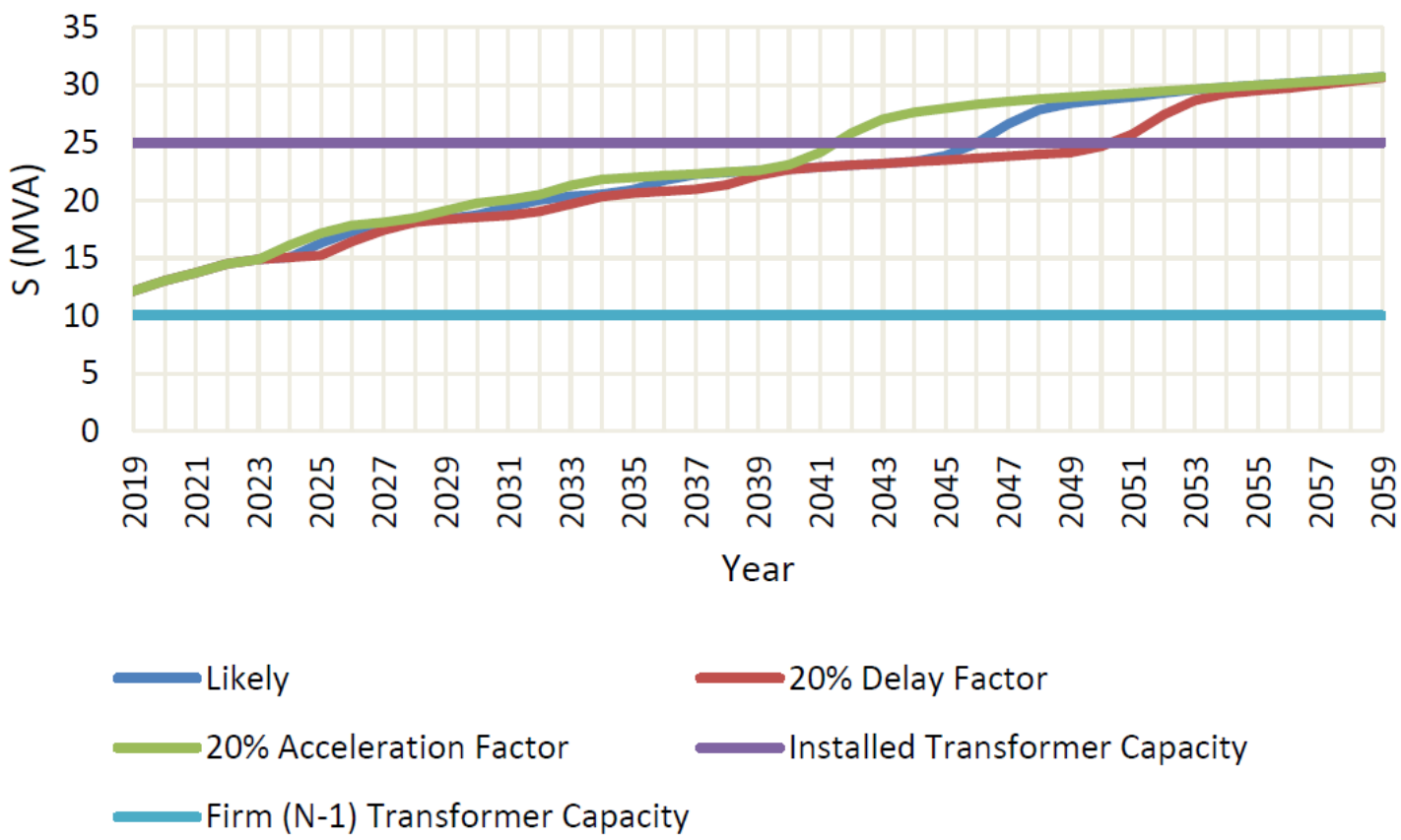
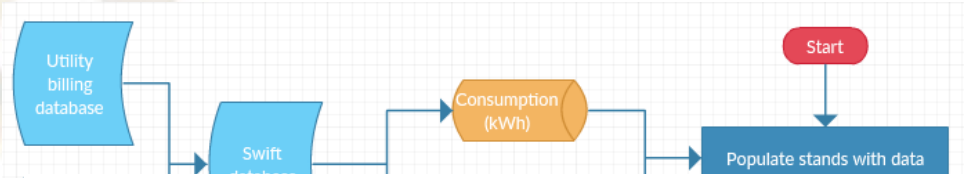
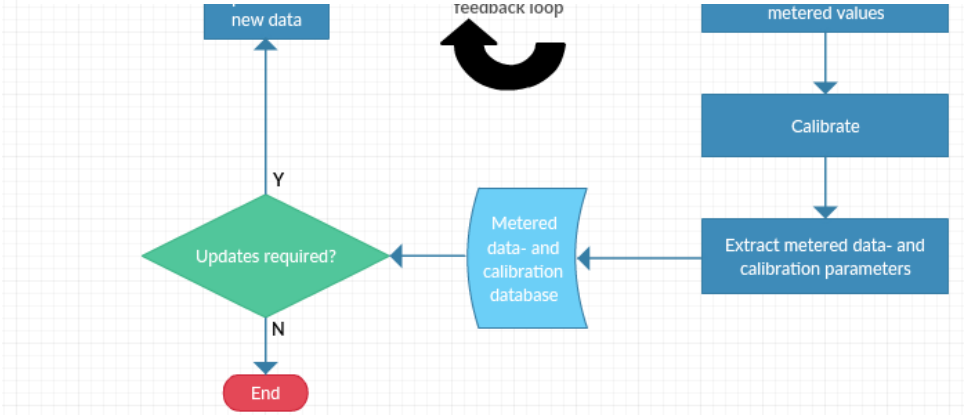


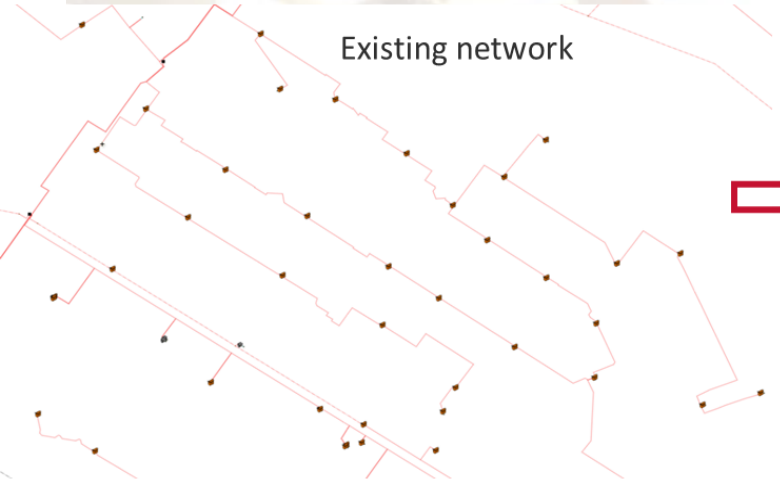
Load Modelling

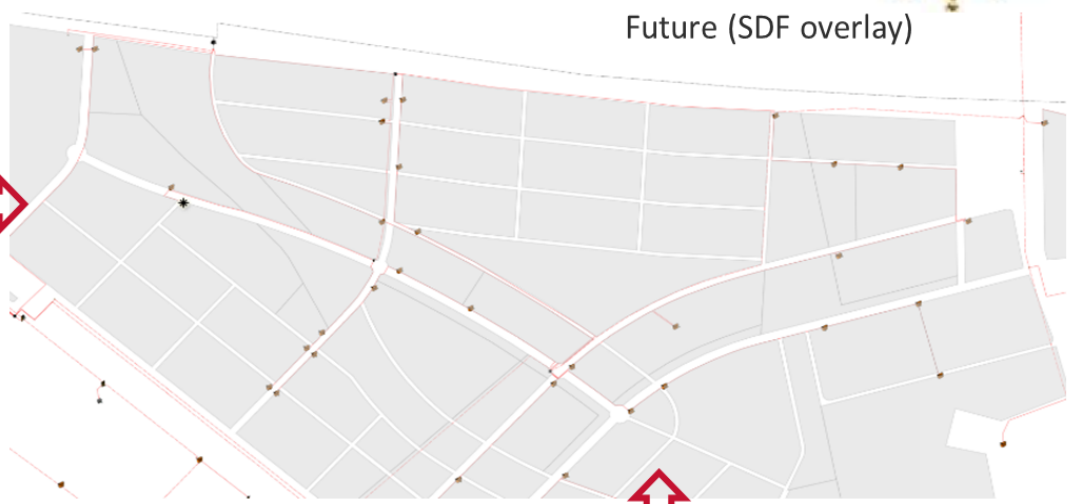


MACHINE LEARNING?

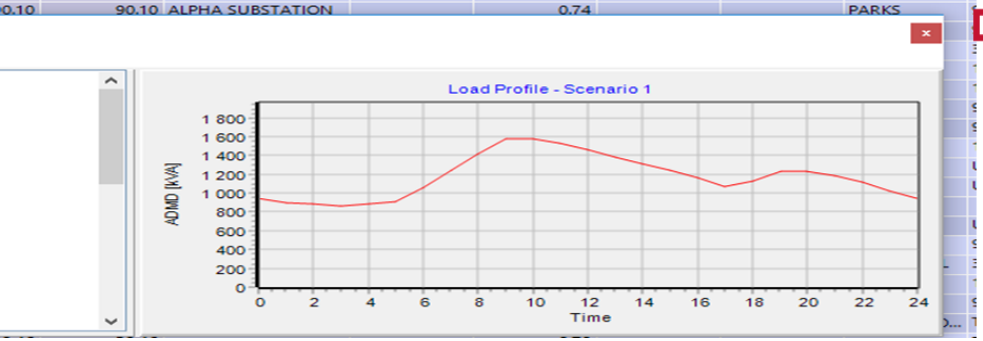


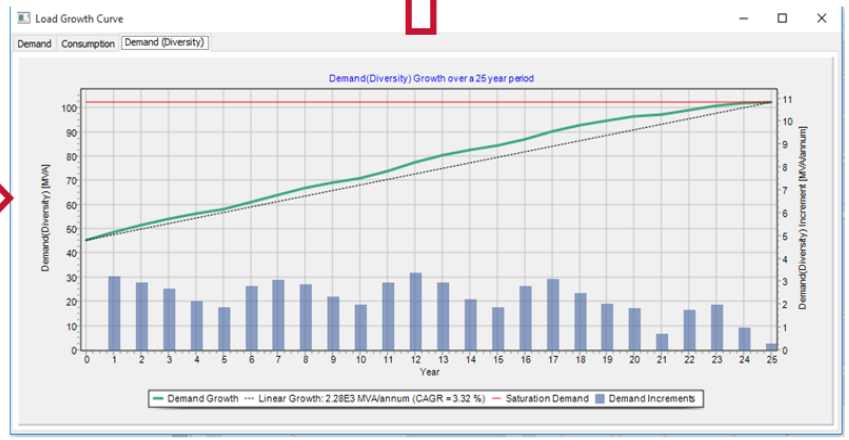
The Integrated Master Plan





AADC Scenario5 [kWh]	Demand Zones	Future Demand Zones	Load Factor	Load Factor Category	Adjust Factor	Land Use Category
100.00	DELTA SUBSTATION		0.50			
395.30	ALPHA SUBSTATION		0.50			FARM_AH
254.06	ALPHA SUBSTATION		0.52			EDUCATION
90.10	ALPHA SUBSTATION		0.74			PARKS

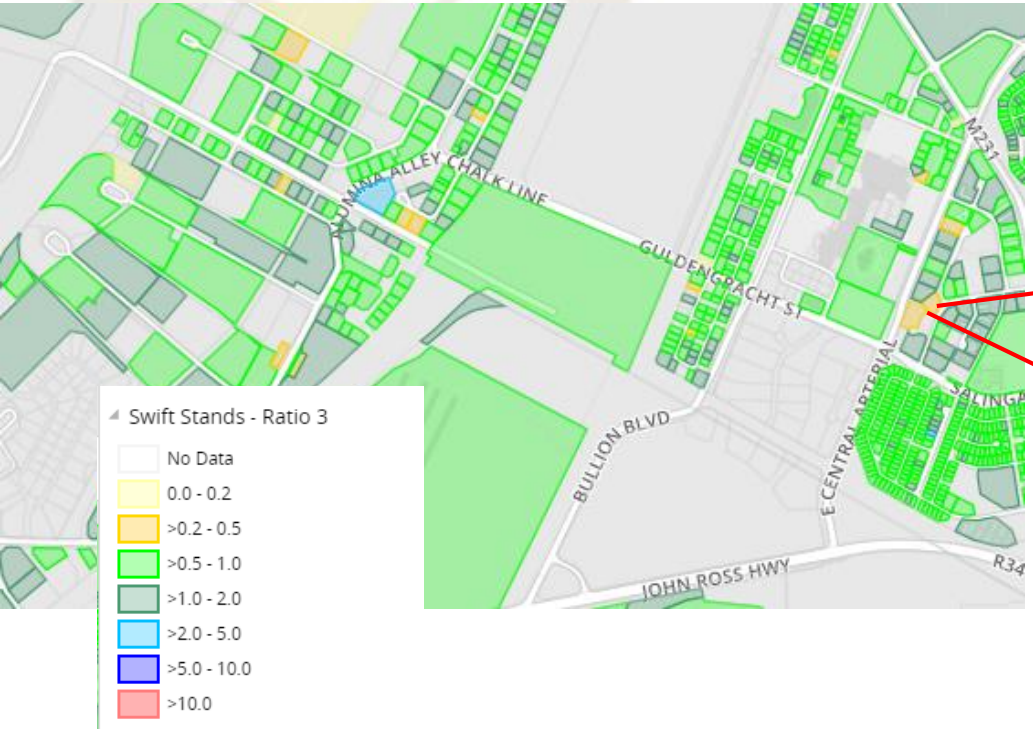




Funding the future

- Capital expenditure plan – but the future sees declining revenues
- Utilities losing revenue due to:
  - EEDSM & Less energy usage
  - High non technical losses
  - DG/SSEG – solar PV, batteries, electric vehicles etc.
- Revenue enhancement & revenue prediction needed
- Load & Energy forecast needs to tie into the tariff & revenue forecasting of the utility – same underlying data set!
- Require stricter control of losses within system – need visibility

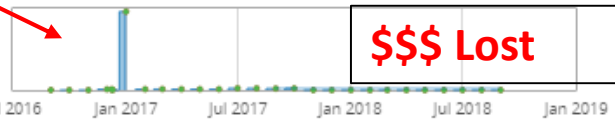
Funding the future



Electricity use

Electricity Reading (kWh)

Electricity Reading (kVA)



$$$ Lost

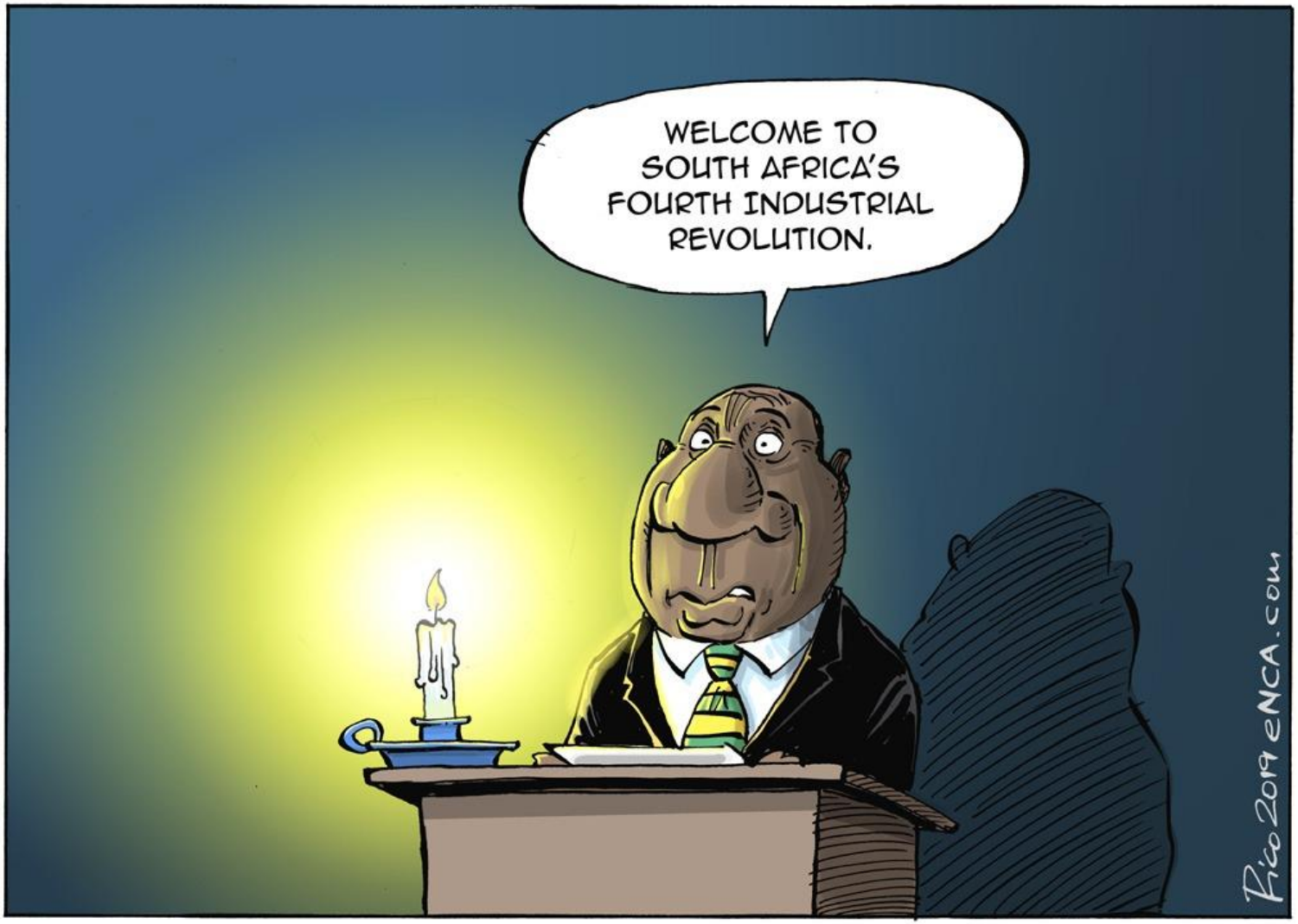
Stand Metered Consumption (AADC) (kWh/d)	34 330.38
Stand Metered Consumption (TWD) (kWh/yr)	12530589
Metered/Estimated/Calculated	Metered
Electricity Balance Group	Billed
Large Consumer	Yes
Vacant Stand	No
Number of Electricity Connections	3
Number of Electricity Meters	3
Stand 1 Month Ratio	0.17
Stand 3 Month Ratio	0.17
Stand Last Consumption (kWh)	5 768.00

Conclusion

- The 4th IR will require greater observability of data and system integration
- Advanced GIS Master Model is key for the future
- Greatest change on LV network – need visibility
- Asset replacement prioritization has to be done due to limited budgets and largely ageing assets
- Load modelling changing due to changing behavior of customers
- Utility billing systems can inform the load modelling exercise
- Revenue & tariff analysis for current and future system is key to ensure future is sustainable

Conclusion

- Integration of IOT device data into data set
- System estimation with live modelling & simulations
- Use mathematical constraint models to calibrate kwh to kVA to usage pattern
- Machine learning to enhance the outcomes of asset replacement scoring & ranking
- Using weather maps, micro & macro economic data sets on granular level to inform forecasting of load for both short and long term
- The possibilities are in fact endless!



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Association of Municipal Electricity Utilities (Southern Africa) Est 1915 AMEU

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