सिद्धिमूलं प्रबन्धनम्
भा. प्र. सं. इन्दौर
IIM INDORE

JIGSAW ACADEMY
a manipalglobal education
investee company

CAPSTONE PROJECT

Revenue optimization strategy by fine-tuning of demand & supply of electricity by using forecasting techniques

Team 10

Batch 6A

1st July 2021

Agenda

- Objective | Assumptions | Source & nature of data
- Approach
- Pre-liminary Analysis
- Analysis
- Conclusion
- Team - Group 10
- Annexures

Caveat:

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Objective | Assumptions | Source and Nature of Data

Objective

The electricity distribution company in this case is by large looking at revenue optimization by managing the demand-supply gap. However this project focuses on the first step which is understanding the demand forecast

For ease of management/understanding, forecasting methodology has been limited to monthly time frame

Assumptions

Continuity of data

Data maintains a trend in future which is similar to immediately preceding data

And that there is a policy continuity that does not affect the demand adversely such as banning of certain industries

Supply position

Since the data is of sensitive nature, therefore, for supply side scenario availability of power is not being considered, also since the focus of this report is on demand

Confidentiality

The data is confidential & sensitive in nature and therefore name of the state, company among other details to be kept anonymous

For project purpose, strategy formulation will be on high level to avoid disclosure of any implicit information

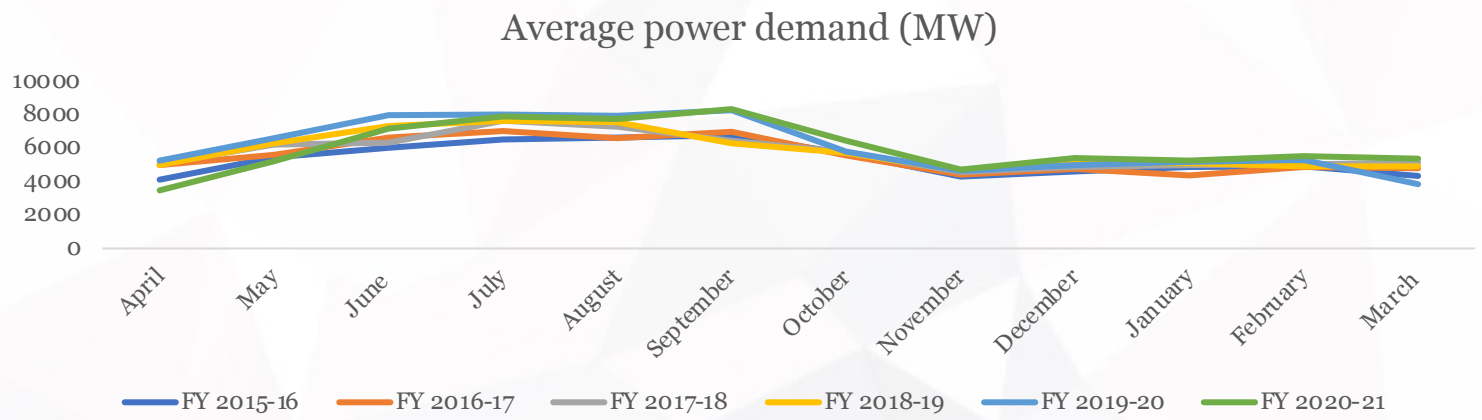
Source and Nature of Data

- The data for demand was collected from State Load Dispatch Center (SLDC) for the state under consideration ("Confidential") for demand and from monthly installed capacity report published by Central Electricity Authority (CEA) for power availability respectively
- The dataset is spread across six (6) years for electricity demand for a State electricity distribution company operating in the Indian landscape
- The dataset captures the electricity demand/consumption at 15 minutes interval from 1 Apr 2015 to 31 Mar 2021. Thus we have 96 observations per day for~1800 days
- It tabulates electricity demand for each time interval of each day and is measured in Mega Watt (MW)
- The original confidential data which cannot be appended to this report consists of one spreadsheet with a table of 96 rows x 1800 columns containing power demand data at 15 minute intervals per day
- The supply data used is the available power (in MW), which is based on the installed capacity of power with different fuel sources such as – thermal, gas, nuclear and renewable

About the data – Demand

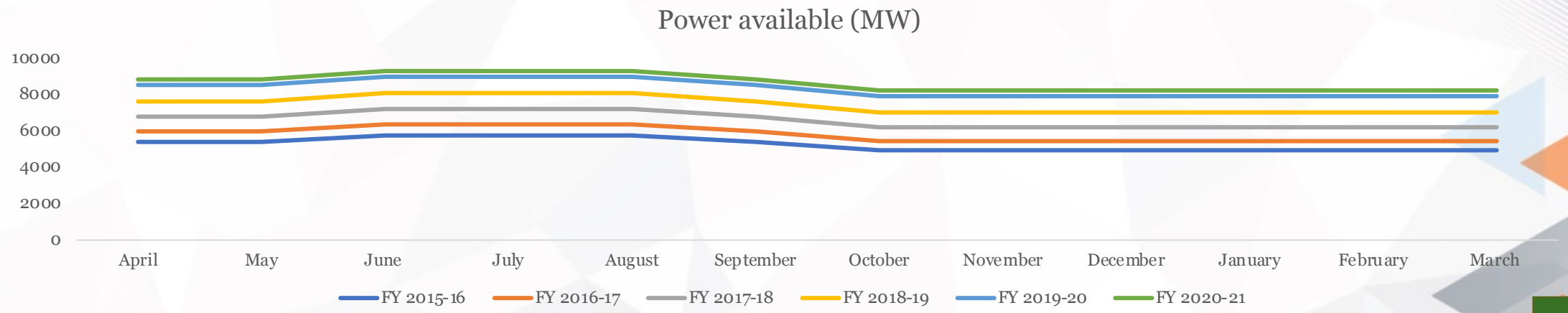
Average power demand (MW)						
Months	FY 2015-16	FY 2016-17	FY 2017-18	FY 2018-19	FY 2019-20	FY 2020-21
April	4110	4996	5040	4965	5239	3471
May	5457	5581	6201	6284	6571	5225
June	6028	6616	6324	7302	7950	7144
July	6506	7016	7629	7624	8020	7884
August	6638	6591	7288	7561	7937	7723
September	6761	6968	6443	6282	8259	8327
October	5665	5563	5734	5717	5787	6424
November	4312	4408	4571	4658	4646	4725
December	4609	4761	4870	5100	4974	5396
January	4849	4363	4988	5094	5190	5253
February	4907	4849	5005	4901	5278	5519
March	4323	4772	5128	4915	3841	5365

- The data here shows the average monthly power consumption demand across 6 years, and the appended graph shows that the data follows a similar pattern across given time periods



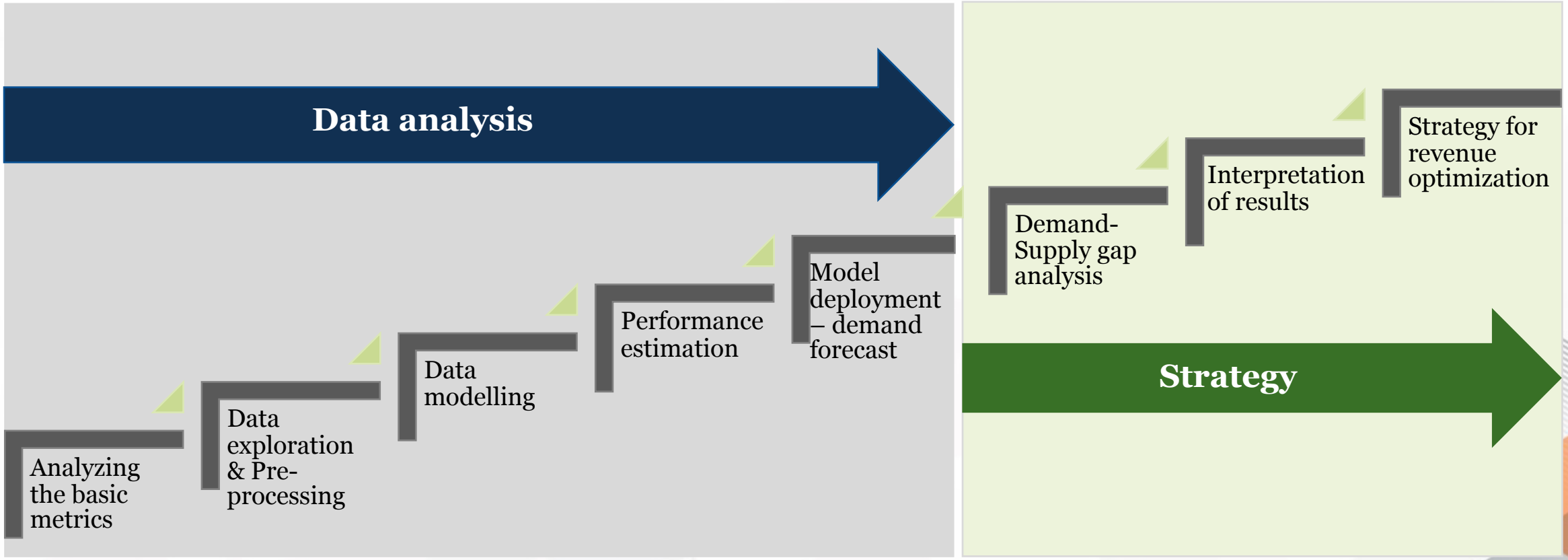
About the data – Supply

Average power available (MW)						
Months	**FY 2015-16**	**FY 2016-17**	**FY 2017-18**	**FY 2018-19**	**FY 2019-20**	**FY 2020-21**
April	5409	5974	6784	7636	8530	8846
May	5409	5974	6784	7636	8530	8846
June	5756	6365	7213	8091	8985	9301
July	5756	6365	7213	8091	8985	9301
August	5756	6365	7213	8091	8985	9301
September	5409	5974	6784	7636	8530	8846
October	4942	5446	6207	7023	7918	8234
November	4942	5446	6207	7023	7918	8234
December	4942	5446	6207	7023	7918	8234
January	4942	5446	6207	7023	7918	8234
February	4942	5446	6207	7023	7918	8234
March	4942	5446	6207	7023	7918	8234



Approach

Approach



Approach

The approach for visualization includes the following:

- Excel charts for preliminary analysis on processed data
- It was observed that monthly, quarterly and yearly representations analyzed in data exploration phase held higher significance, as it helped in aligning the approach with the business objective
- This also gave a better visual representation of trend, seasonality and cyclic nature of data along with presence of shocks to understand the data comprehensively

Approach

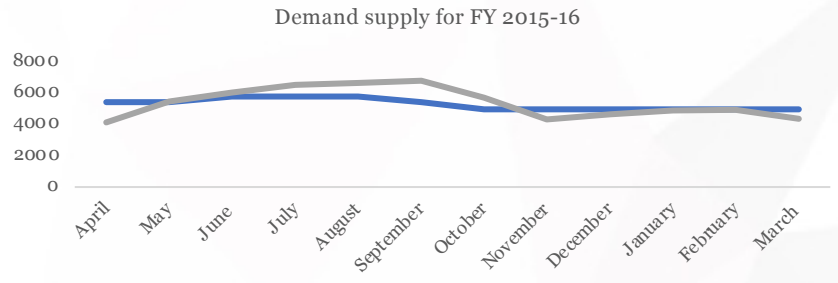
The approach for forecasting includes the following steps:

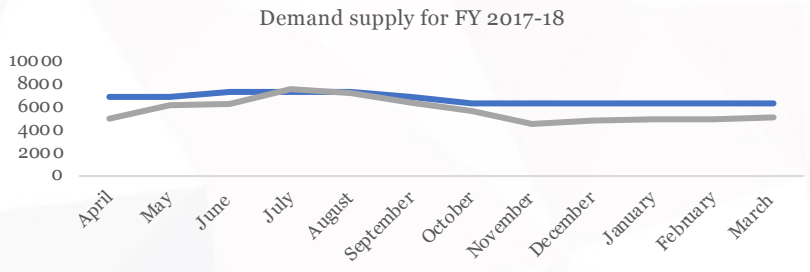
- Analyzing the basic datasets and related matrices
- Data exploration and pre-processing which includes data cleaning and data mining
- Checking for missing values and subsequently addressing the gaps based on the quantum (percentage) of missing values
- Converting the original data of power consumption available to average demand month wise for each of the respective years taken into consideration (based on business requirement)
- Decomposing the data to assess presence/ absence of Time Series Components of – trend, seasonality, cyclicity and random variation
- Testing and comparing different modeling techniques of Holt Winters (double, triple), and ARIMA respectively is based on MAPE

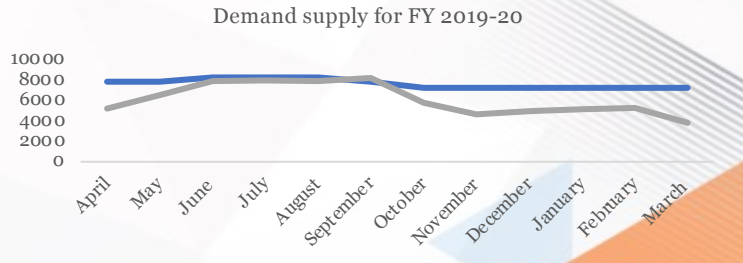
Preliminary Analysis

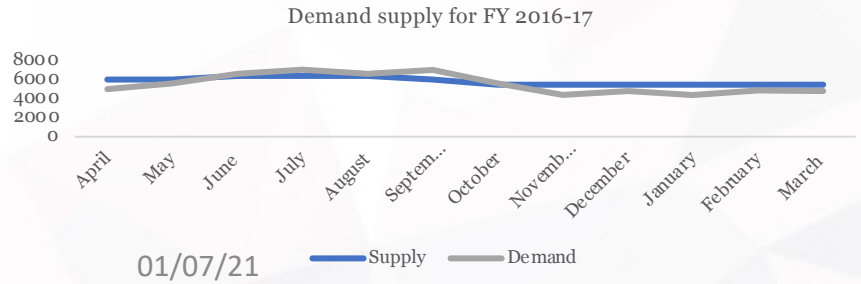
Preliminary Analysis of historical data : Demand – Supply Gap

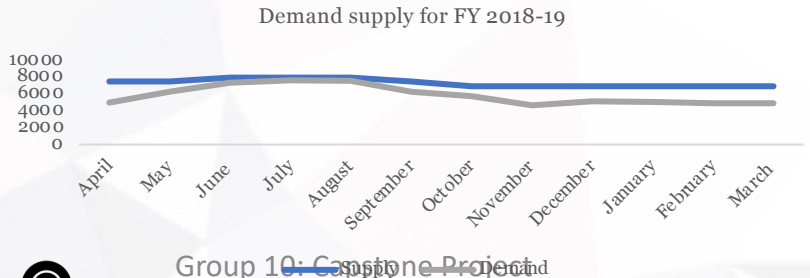
Supply Demand gap (MW)						
Months	FY 2015-16	FY 2016-17	FY 2017-18	FY 2018-19	FY 2019-20	FY 2020-21
April	1299	978	1745	2670	3291	5376
May	(48)	392	583	1352	1959	3622
June	(272)	(250)	889	788	1035	2157
July	(750)	(651)	(415)	466	966	1418
August	(881)	(225)	(75)	529	1049	1578
September	(1352)	(994)	342	1353	271	519
October	(724)	(117)	473	1307	2131	1810
November	630	1038	1636	2365	3272	3509
December	333	685	1337	1923	2944	2838
January	93	1083	1219	1929	2728	2981
February	35	598	1202	2123	2640	2715
March	618	674	1079	2108	4077	2869

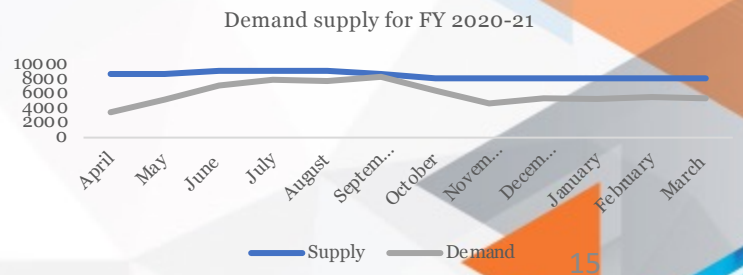




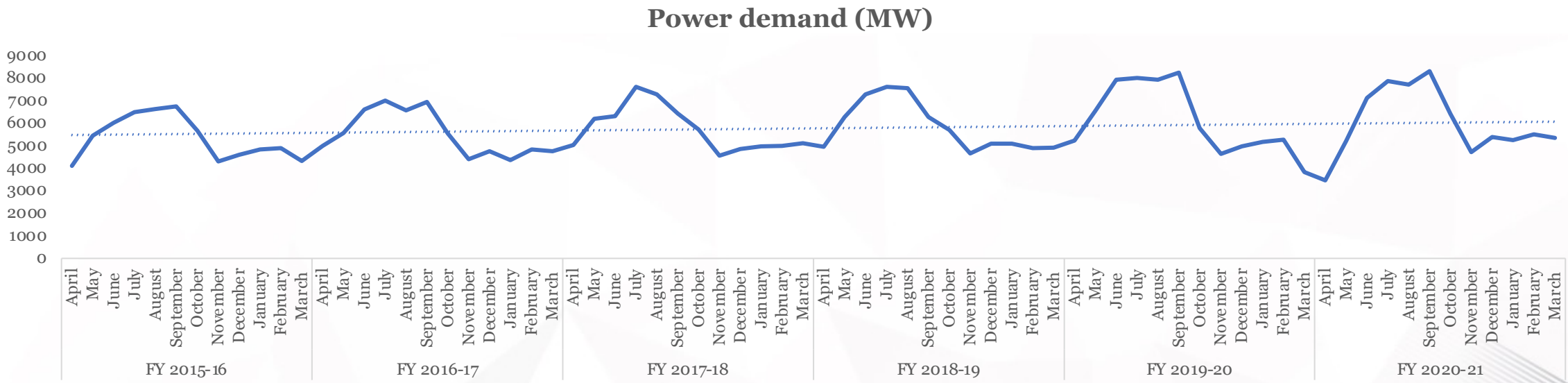






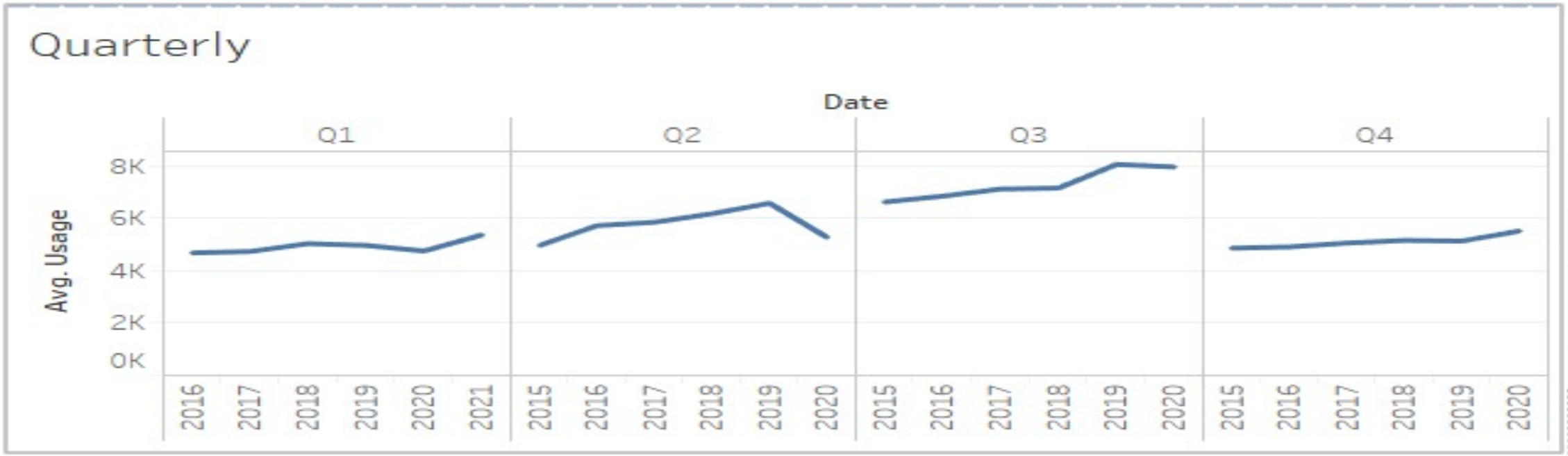


Preliminary analysis



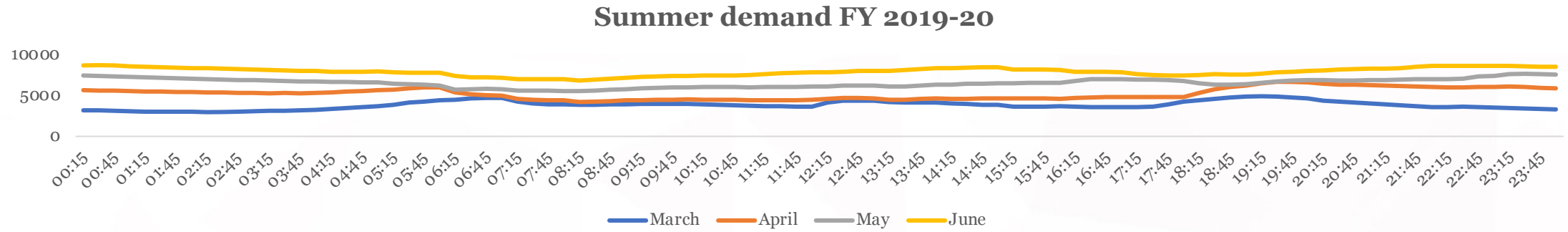
- Based on the preliminary analysis it is observed that :
  - There is a presence of an upward trend in demand/ power consumption year-on-year basis
  - There is a variation in consumption across months, therefore, seasonality can be inferred
  - The pattern is cyclic in nature and can be observed from its occurrence till FY 2019-20. Thereafter, a shock was observed which was highly likely to be a result of the ongoing pandemic

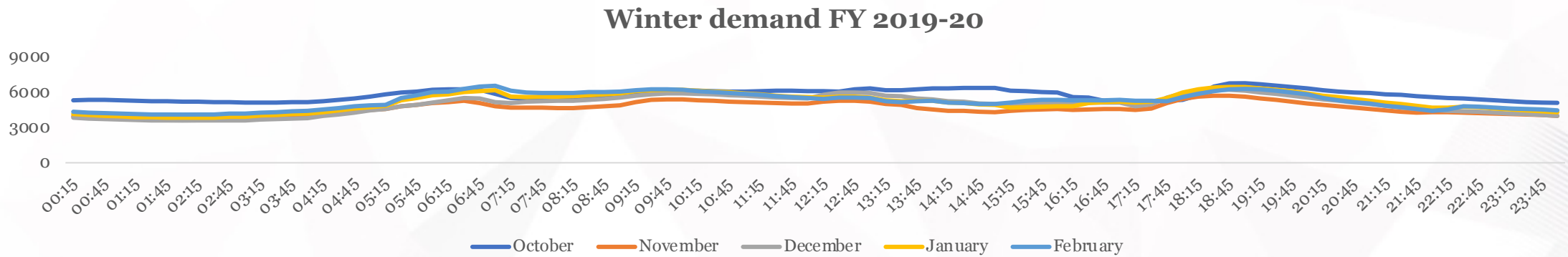
Preliminary analysis

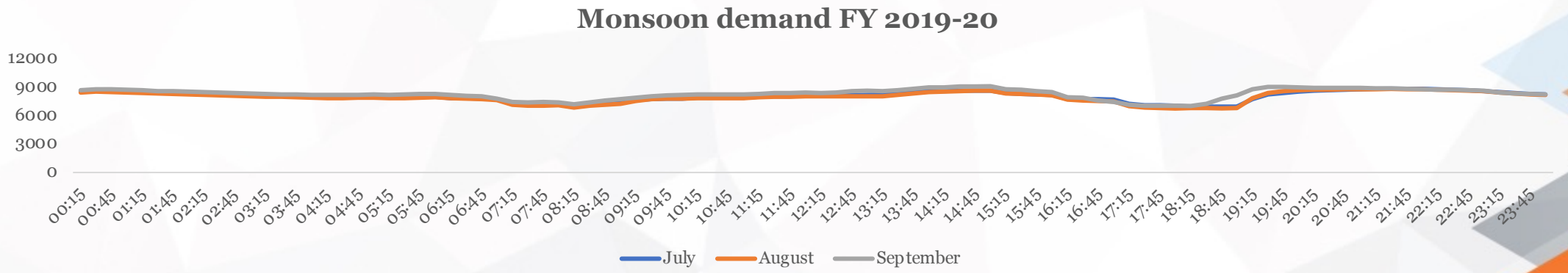


- The quarterly comparison of power demand was made in tableau which essentially tells us that some quarters perform better than the others and vice versa
- This gives us a granular view of seasonality across quarters in initial data exploration stage

Preliminary analysis







Preliminary analysis - Summary

- During preliminary stages of data exploration, we wanted to explore the effect of Seasons of Summer, Monsoon, and Winter on the power consumption

- However such data forecasting may not have been useful as factors such as - shift in seasons according to dates/weekdays/weekends would not give us a clear picture. Hence this was dropped after graphical analysis

- ***After the analysis of the data based on monthly, quarterly and seasonal power consumption, it was observed that forecasting on monthly basis would be better suited with business requirement***

Analysis

Selection of technique

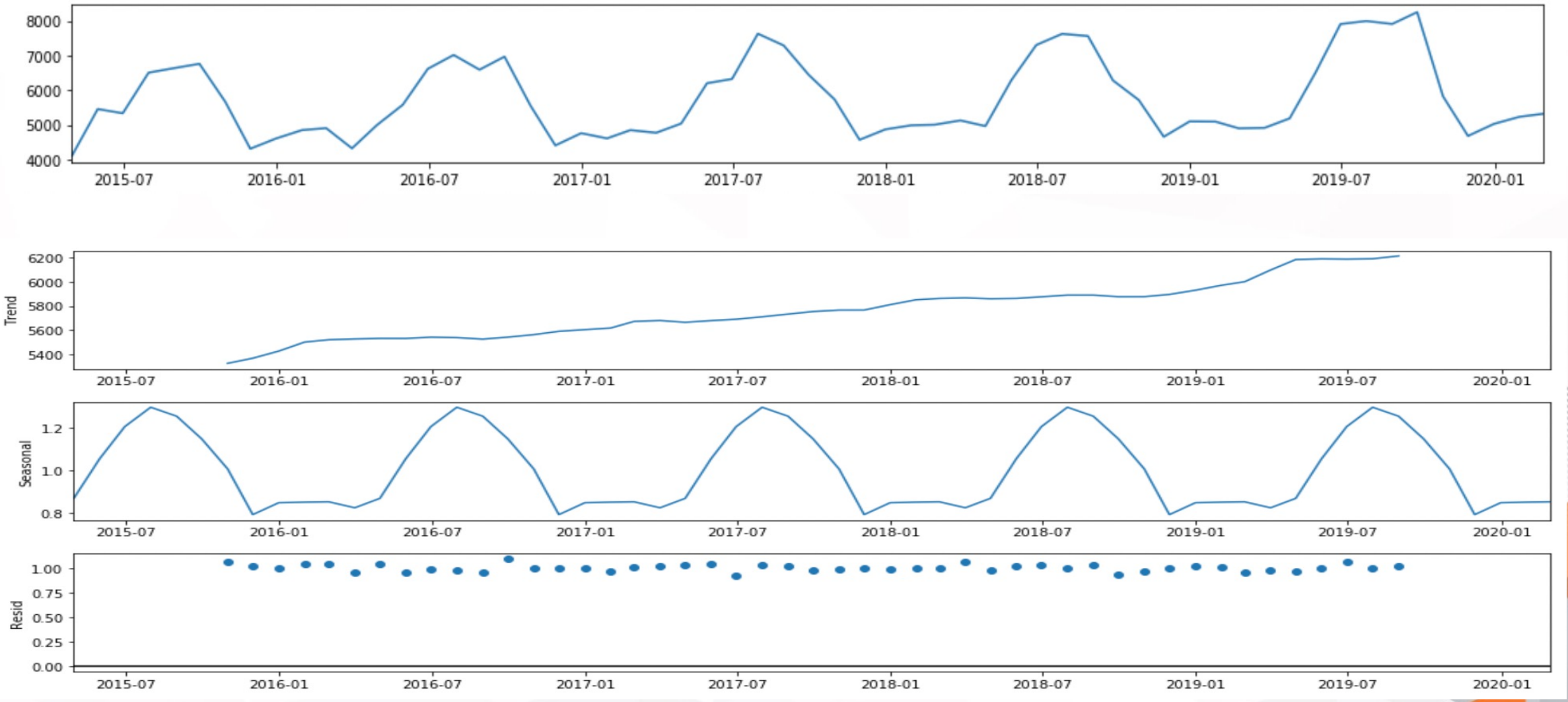
- Since the data in hand is time series data, therefore linear regression technique is not applicable due to absence of any other independent variable other than the data itself

- Therefore, we will be using Time Series based forecasting techniques and comparing them based on their Mean Absolute Percentage Error as a common parameter for the goodness of accuracy check

Time series decomposition

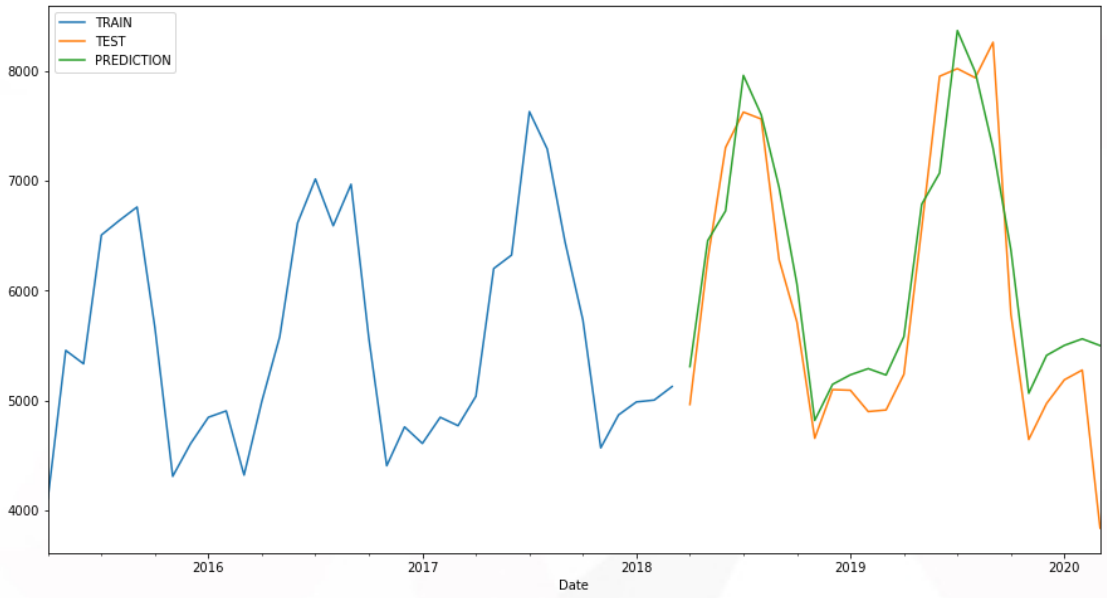
- Decomposition techniques are used to assess presence/ absence of Time Series Components of – trend, seasonality, cyclicity and random variations
- The two decomposition techniques used are Additive and Multiplicative
- Based on the preliminary analysis, the times series graph shows increase in both – the level and amplitude w.r.t. time, which is a property of multiplicative time series as shown in the next slide
- Therefore, we have proceeded with multiplicative time series for further analysis and modeling

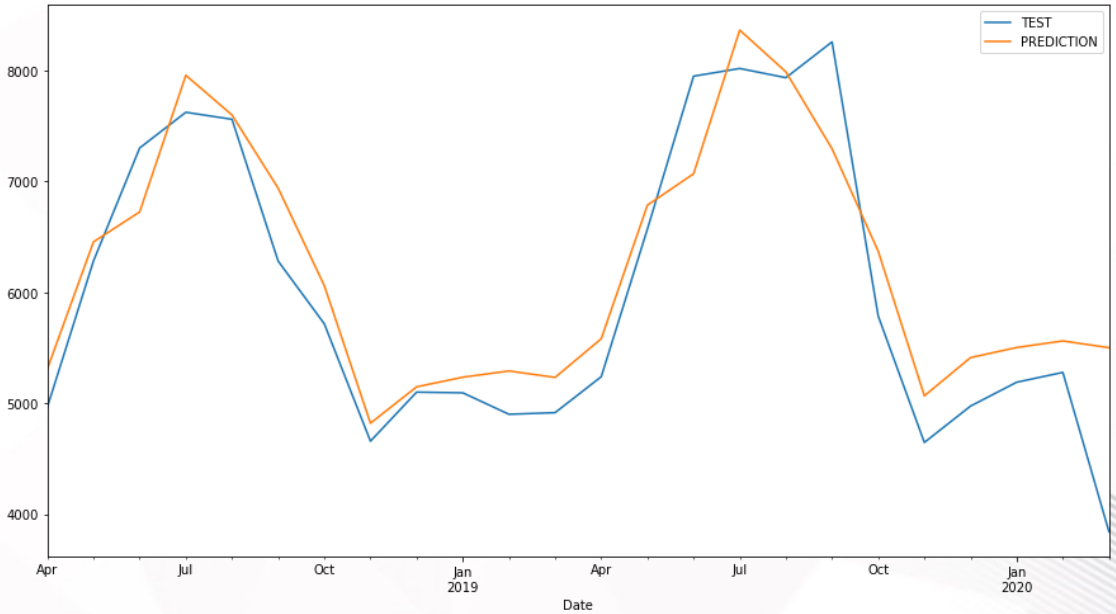
Identification of components – multiplicative decomposition



Forecasting

- **Forecasting using Holt-Winters Triple Exponential Smoothing**





- The dataset was split into training set (from FY 2015-16 to FY 2017-18) and testing set (FY 2018-19 to FY 2019-20)
- Holt Winters Triple Exponential Smoothing was used based on our observation of presence of seasonality in addition to the trend from the decomposition graphs
- The projections appear to be close to actuals during the same period for both the training and testing data sets, which can be attributed to the other factors such as temperature variations, weather, festivities which have not been considered for our analysis

Forecasting

```
Best model:  ARIMA(2,1,0)(0,1,0)[12]
Total fit time: 4.537 seconds
```

SARIMAX Results

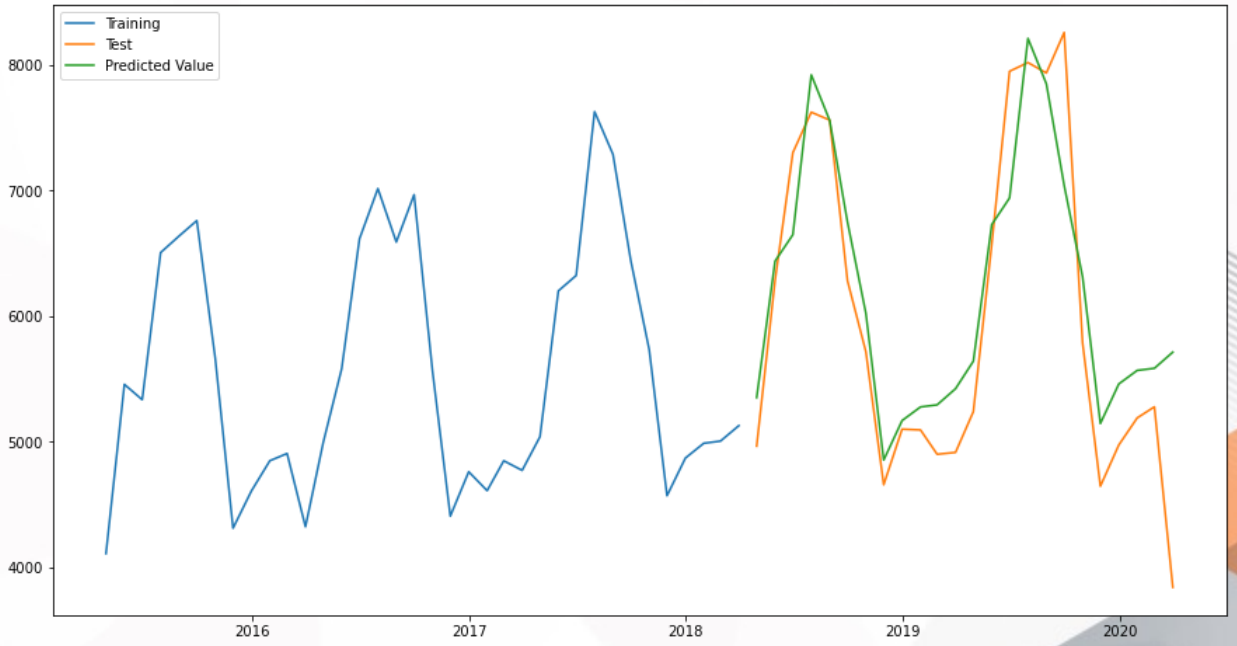
Dep. Variable:	y	**No. Observations:**	36
Model:	SARIMAX(2, 1, 0)x(0, 1, 0, 12)	**Log Likelihood**	-171.200
Date:	Thu, 01 Jul 2021	**AIC**	348.399
Time:	03:00:57	**BIC**	351.806
Sample:	0	**HQIC**	349.256
	- 36		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	-0.8434	0.166	-5.088	0.000	-1.168	-0.519
ar.L2	-0.5614	0.138	-4.076	0.000	-0.831	-0.291
sigma2	1.555e+05	6.95e+04	2.238	0.025	1.93e+04	2.92e+05

Ljung-Box (L1) (Q):	0.05	**Jarque-Bera (JB):**	1.48
Prob(Q):	0.82	**Prob(JB):**	0.48
Heteroskedasticity (H):	0.45	**Skew:**	-0.27
Prob(H) (two-sided):	0.28	**Kurtosis:**	1.88

Forecasting technique using Auto ARIMA

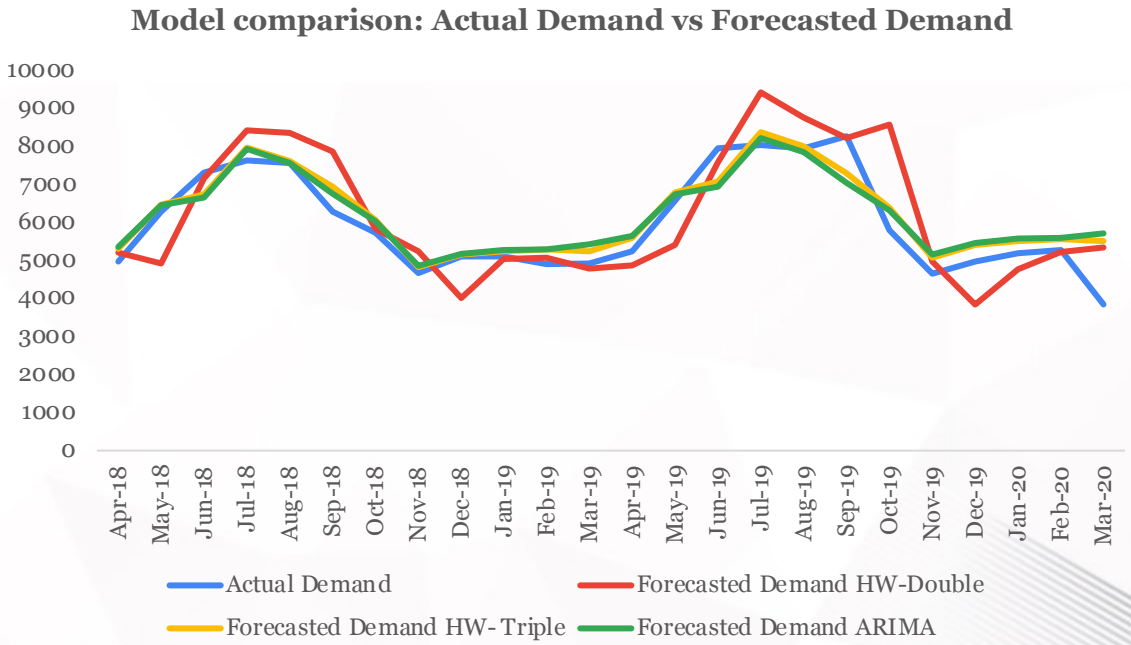
- The Auto ARIMA output shows ARIMA(2,1,0)(0,1,0) [12] as the best model
- Based on the model values for p, d and q are 2, 1 and 0 respectively and the model was run there after



Conclusion

Conclusion

Month	Actual Demand	Forecasted Demand		
		HW-Double	HW- Triple	ARIMA
Apr-18	4965	5200	5310	5352
May-18	6284	4913	6456	6439
Jun-18	7302	7149	6726	6649
Jul-18	7624	8413	7958	7922
Aug-18	7561	8343	7600	7559
Sep-18	6282	7853	6940	6750
Oct-18	5717	5822	6061	6023
Nov-18	4658	5240	4820	4854
Dec-18	5100	4014	5148	5169
Jan-19	5094	5032	5235	5277
Feb-19	4901	5065	5291	5294
Mar-19	4915	4788	5233	5422
Apr-19	5239	4870	5582	5641
May-19	6571	5404	6786	6729
Jun-19	7950	7567	7070	6941
Jul-19	8020	9412	8366	8212
Aug-19	7937	8743	7989	7850
Sep-19	8259	8217	7295	7042
Oct-19	5787	8570	6371	6313
Nov-19	4646	4959	5067	5146
Dec-19	4974	3838	5412	5460
Jan-20	5190	4761	5503	5568
Feb-20	5278	5214	5562	5585
Mar-20	3841	5340	5501	5714
MAPE :		**7.53**	**7.27**	**8.16**



- A good value for MAPE is considered to be 10%
- MAPE for all the selected models is observed to be less than 10%
- Therefore, all the models are considered to be a good fit for time series in analysis
- However, as **MAPE for Holt Winters Triple Exponential Smoothing (multiplicative) is observed to be least at 7.27**, hence, this would be the recommended model

Source: https://onlinelibrary.wiley.com/doi/pdf/10.1002/9781119130885.app1

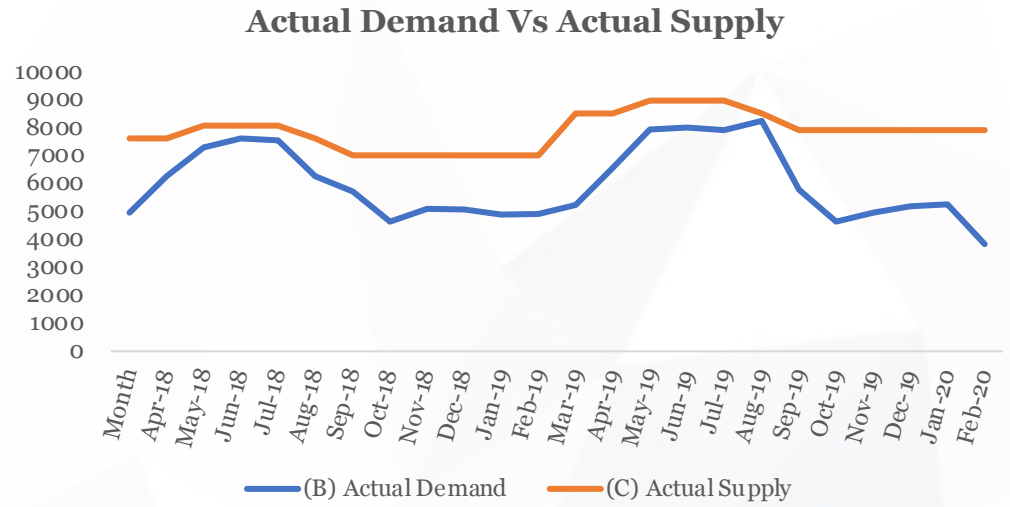
Conclusion

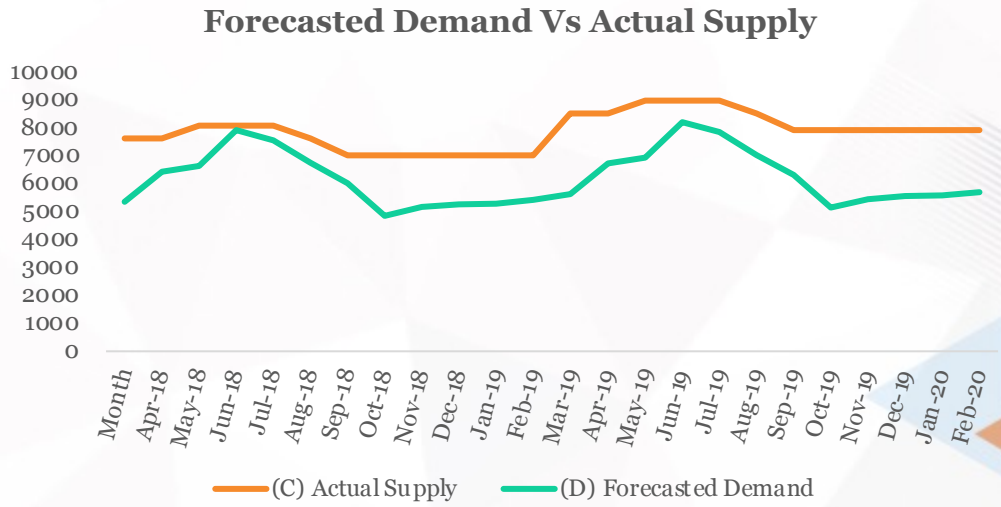
S. No.	Month	(A) Installed Capacity (MW)	(B) Actual Demand	(C) Actual Supply	(D) Forecasted Demand	(E) Difference b/w Actual Supply & Actual Demand	(F) Difference b/w Actual Demand & Forecasted Demand	(G) Difference b/w Actual Supply & Forecasted Demand
1	Apr-18	11202	4965	7636	5352	2671	(387)	2284
2	May-18		6284	7636	6439	1352	(155)	1197
3	Jun-18		7302	8091	6649	789	653	1442
4	Jul-18		7624	8091	7922	467	(298)	169
5	Aug-18		7561	8091	7559	530	2	532
6	Sep-18		6282	7636	6750	1354	(468)	886
7	Oct-18		5717	7023	6023	1306	(306)	1000
8	Nov-18		4658	7023	4854	2365	(196)	2169
9	Dec-18		5100	7023	5169	1923	(69)	1854
10	Jan-19		5094	7023	5277	1929	(183)	1746
11	Feb-19		4901	7023	5294	2122	(393)	1729
12	Mar-19		4915	7023	5422	2108	(507)	1601
13	Apr-19	12676	5239	8530	5641	3291	(402)	2889
14	May-19		6571	8530	6729	1959	(158)	1801
15	Jun-19		7950	8985	6941	1035	1009	2044
16	Jul-19		8020	8985	8212	965	(192)	773
17	Aug-19		7937	8985	7850	1048	87	1135
18	Sep-19		8259	8530	7042	271	1217	1488
19	Oct-19		5787	7918	6313	2131	(526)	1605
20	Nov-19		4646	7918	5146	3272	(500)	2772
21	Dec-19		4974	7918	5460	2944	(486)	2458
22	Jan-20		5190	7918	5568	2728	(378)	2350
23	Feb-20		5278	7918	5585	2640	(307)	2333
24	Mar-20		3841	7918	5714	4077	(1873)	2204

Conclusion

- The objective of the previous data is to draw a relationship between the Actual Demand, Actual Supply and Forecasted Demand (using values obtained from the selected model - Holt Winter's Triple Exponential Smoothing, as a first step to understand the accuracy of the Selected Model

- Once the same is understood, a simple line of recommendation has to be made due to lack of information on breakup of Power Resources as per capacity of individual units

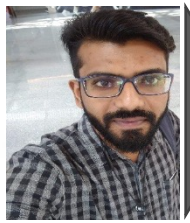




Conclusion

- We have excluded the months for FY 2020-21 as the unprecedented event of pandemic resulted in anomalies and induced a shock in the systems globally
- Using the Holt-Winter's Triple Exponential Smoothing Model (multiplicative), we observed that the Forecasted Demand had the least Mean Absolute Percentage Error amongst other models
- It was observed that the subject state of this analysis has a perpetual **Power Surplus** when compared with the actual demand as well as the Forecasted Demand based on the selected modelling technique as mentioned above
- As a short term measure to optimize the revenue the surplus power available may be traded on energy exchanges
- As a long term strategy stressed power plants or those which have completed their lifespan can be planned to phased out as an addition to this, a shift to power generation from the renewable energy resources could also be aligned to the country's target of 455 GW of Renewable Energy installed capacity by 2030

Our Team – Group 10



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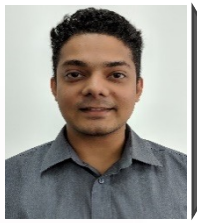

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Annexures

Data – demand side

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	Day 16	Day 17	Day 18	Day 19	Day 20	Day 21	Day 22	Day 23	Day 24	Day 25
Interval 1	2242	2689	2590	2614	2816	2918	3148	2957	3208	3429	3670	3839	4056	4426	4694	4947	4996	4374	4506	4897	4188	4739	5165	5044	5288
Interval 2	2225	2663	2567	2622	2800	2905	3131	2957	3183	3415	3649	3803	4036	4378	4638	4895	4921	4324	4470	4861	4165	4690	5135	5046	5266
Interval 3	2212	2643	2549	2616	2783	2893	3126	2947	3181	3395	3605	3756	3979	4327	4584	4850	4813	4287	4402	4812	4110	4658	5063	4995	5202
Interval 4	2183	2624	2542	2599	2768	2870	3118	2933	3173	3362	3545	3730	3917	4276	4527	4811	4758	4220	4333	4747	4096	4605	5020	4941	5120
Interval 5	2170	2604	2533	2575	2746	2831	3095	2909	3144	3344	3486	3684	3850	4244	4495	4740	4689	4085	4276	4690	4064	4551	4956	4866	5085
Interval 6	2159	2562	2528	2552	2730	2834	3074	2889	3130	3273	3484	3670	3839	4220	4462	4707	4647	4021	4243	4672	4007	4525	4929	4831	5021
Interval 7	2152	2564	2519	2555	2716	2832	3045	2858	3107	3257	3453	3652	3815	4157	4418	4659	4633	3974	4161	4630	3975	4483	4892	4784	4937
Interval 8	2139	2548	2506	2552	2710	2813	3038	2854	3119	3239	3463	3636	3783	4130	4398	4606	4590	3940	4128	4582	3953	4458	4851	4760	4872
Interval 9	2132	2541	2491	2547	2698	2812	3002	2853	3072	3231	3454	3607	3778	4093	4357	4544	4592	3907	4129	4542	3924	4418	4814	4726	4861
Interval 10	2133	2534	2494	2538	2691	2798	2987	2843	3022	3220	3440	3587	3771	4069	4319	4491	4583	3893	4089	4495	3917	4389	4804	4713	4863
Interval 11	2192	2603	2587	2597	2777	2790	2982	2851	3047	3204	3442	3611	3745	4052	4290	4485	4546	3862	4061	4463	3875	4352	4760	4678	4833
Interval 12	2206	2641	2603	2601	2778	2775	2969	2838	3085	3198	3436	3611	3729	4051	4271	4467	4515	3866	4026	4432	3883	4313	4735	4646	4804
Interval 13	2246	2649	2603	2583	2778	2781	2971	2840	3103	3197	3441	3602	3703	4063	4273	4444	4510	3804	3954	4407	3868	4294	4706	4624	4788
Interval 14	2281	2664	2604	2600	2795	2800	2989	2841	3118	3223	3467	3614	3717	4079	4280	4428	4479	3790	3922	4408	3884	4290	4699	4631	4788
Interval 15	2293	2684	2616	2614	2823	2835	3013	2842	3144	3250	3493	3637	3744	4096	4304	4443	4488	3801	3928	4402	3873	4305	4672	4626	4789
Interval 16	2343	2732	2652	2652	2862	2882	3058	2872	3187	3302	3538	3688	3800	4130	4331	4462	4522	3828	3899	4418	3897	4341	4683	4650	4806
Interval 17	2440	2834	2730	2719	2932	2966	3136	2954	3288	3401	3641	3782	3908	4227	4411	4535	4593	3866	4015	4489	3958	4406	4722	4701	4801
Interval 18	2563	2949	2839	2843	3047	3079	3243	3072	3403	3541	3776	3909	4045	4336	4514	4642	4687	3847	4133	4561	4065	4497	4792	4807	4844
Interval 19	2713	3092	2971	2960	3184	3194	3368	3202	3459	3621	3846	3982	4146	4405	4565	4678	4706	3824	4181	4559	4092	4490	4745	4750	4737
Interval 20	2867	3198	3049	3058	3274	3289	3503	3328	3533	3717	3857	3967	4156	4355	4496	4621	4604	3891	4161	4494	4106	4460	4667	4612	4587
Interval 21	3051	3379	3164	3175	3403	3409	3621	3494	3680	3870	3963	4034	4286	4484	4619	4703	4597	3981	4199	4499	4161	4470	4752	4635	4505
Interval 22	3311	3642	3369	3411	3648	3637	3852	3718	3866	3999	4160	4247	4480	4667	4747	4874	4763	4101	4363	4577	4321	4585	4893	4753	4607
Interval 23	3418	3731	3440	3513	3772	3749	3939	3819	4017	4132	4306	4420	4640	4805	4838	5024	4804	4228	4503	4701	4428	4704	5063	4845	4793
Interval 24	3579	3899	3557	3617	3896	3908	4067	3935	4162	4254	4424	4495	4723	4874	4968	5068	4774	4234	4545	4732	4481	4724	5110	4793	4886
Interval 25	3561	3907	3517	3583	3864	3877	4008	3863	3648	3654	3787	3884	4004	4185	4272	4335	4247	3523	3923	4230	3932	4144	4500	4261	4311
Interval 26	3591	3939	3506	3552	3863	3856	3999	3875	3283	3238	3373	3475	3583	3779	3959	3939	3885	3538	3643	3999	3587	3795	4085	4037	4098
Interval 27	3580	3881	3457	3492	3811	3830	3897	3839	3133	3108	3275	3336	3484	3642	3808	3800	3764	3335	3561	3885	3477	3699	3991	4020	4055

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About the data – Supply

S.No.	Source	FY 2015-16	FY 2016-17	FY 2017-18	FY 2018-19	FY 2019-20	FY 2020-21
1	**Hydro (large)**	**1336**	**1507**	**1650**	**1750**	**1750**	**1750**
2	**Thermal**	**4885**	**5237**	**5765**	**6510**	**7289**	**7521**
	Gas	587	587	587	532	532	532
	Coal	4298	4650	5178	5978	6757	6989
3	**Nuclear**	**101**	**101**	**101**	**101**	**101**	**101**
4	**Renewable energy**	**1064**	**1546**	**2360**	**2829**	**3525**	**3878**
	Solar	451	656	1014	1213	1508	1658
	Non-solar RE	612	890	1346	1616	2016	2220
Total installed capacity (MW)		**7386**	**8390**	**9875**	**11190**	**12664**	**13250**

Renewable energy: component wise break-up	
Solar	42%
Wind	42%
Small hydro	5%
Bio-power	11%

Data – Supply

Power availability (MW) for FY 2015-16														
Source	**Installed capacity (MW)**	**PLF**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**January**	**February**	**March**
Hydro	**1335.66**		61%	61%	87%	87%	87%	61%	26%	26%	26%	26%	26%	26%
			815	**815**	**1162**	**1162**	**1162**	**815**	**347**	**347**	**347**	**347**	**347**	**347**
Nuclear	**100.73**	85%	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**
RE Non-solar	**612.14**		**270**	**270**	**270**	**270**	**270**	**270**	**270**	**270**	**270**	**270**	**270**	**270**
Wind	442.05	34%	150	150	150	150	150	150	150	150	150	150	150	150
Small hydro	53.92	50%	27	27	27	27	27	27	27	27	27	27	27	27
Bio-power	116.18	80%	93	93	93	93	93	93	93	93	93	93	93	93
RE Solar	**451.50**	19%	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**
Thermal	**4885.47**	85%	**4153**	**4153**	**4153**	**4153**	**4153**	**4153**	**4153**	**4153**	**4153**	**4153**	**4153**	**4153**
Coal	**4298.47**													
Gas	**587.00**													
Total	**7385.50**		5409	5409	5756	5756	5756	5409	4942	4942	4942	4942	4942	4942

Power availability (MW) for FY 2016-17														
Source	**Installed capacity (MW)**	**PLF**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**January**	**February**	**March**
Hydro	**1506.60**		61%	61%	87%	87%	87%	61%	26%	26%	26%	26%	26%	26%
			919	**919**	**1311**	**1311**	**1311**	**919**	**392**	**392**	**392**	**392**	**392**	**392**
Nuclear	**100.73**	85%	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**
RE Non-solar	**889.68**		**393**	**393**	**393**	**393**	**393**	**393**	**393**	**393**	**393**	**393**	**393**	**393**
Wind	642.47	34%	218	218	218	218	218	218	218	218	218	218	218	218
Small hydro	78.36	50%	39	39	39	39	39	39	39	39	39	39	39	39
Bio-power	168.85	80%	135	135	135	135	135	135	135	135	135	135	135	135
RE Solar	**656.20**	19%	**125**	**125**	**125**	**125**	**125**	**125**	**125**	**125**	**125**	**125**	**125**	**125**
Thermal	**5237.07**	85%	**4452**	**4452**	**4452**	**4452**	**4452**	**4452**	**4452**	**4452**	**4452**	**4452**	**4452**	**4452**
Coal	**4650.07**													
Gas	**587.00**													
Total	**8390.28**		5974	5974	6365	6365	6365	5974	5446	5446	5446	5446	5446	5446

Data – Supply

Power availability (MW) for FY 2017-18														
Source	**Installed capacity (MW)**	**PLF**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**January**	**February**	**March**
Hydro	**1649.93**		61%	61%	87%	87%	87%	61%	26%	26%	26%	26%	26%	26%
			1006	**1006**	**1435**	**1435**	**1435**	**1006**	**429**	**429**	**429**	**429**	**429**	**429**
Nuclear	**100.73**	85%	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**
RE Non-solar	**1357.95**		**599**	**599**	**599**	**599**	**599**	**599**	**599**	**599**	**599**	**599**	**599**	**599**
Wind	980.63	34%	333	333	333	333	333	333	333	333	333	333	333	333
Small hydro	119.60	50%	60	60	60	60	60	60	60	60	60	60	60	60
Bio-power	257.72	80%	206	206	206	206	206	206	206	206	206	206	206	206
RE Solar	**1013.81**	19%	**193**	**193**	**193**	**193**	**193**	**193**	**193**	**193**	**193**	**193**	**193**	**193**
Thermal	**5765.07**	85%	**4900**	**4900**	**4900**	**4900**	**4900**	**4900**	**4900**	**4900**	**4900**	**4900**	**4900**	**4900**
Coal	**5178.07**													
Gas	**587.00**													
Total	**9887.49**		6784	6784	7213	7213	7213	6784	6207	6207	6207	6207	6207	6207

Power availability (MW) for FY 2018-19														
Source	**Installed capacity (MW)**	**PLF**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**January**	**February**	**March**
Hydro	**1750.00**		61%	61%	87%	87%	87%	61%	26%	26%	26%	26%	26%	26%
			1068	**1068**	**1523**	**1523**	**1523**	**1068**	**455**	**455**	**455**	**455**	**455**	**455**
Nuclear	**100.73**	85%	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**
RE Non-solar	**1628.14**		**719**	**719**	**719**	**719**	**719**	**719**	**719**	**719**	**719**	**719**	**719**	**719**
Wind	1175.74	34%	400	400	400	400	400	400	400	400	400	400	400	400
Small hydro	143.40	50%	72	72	72	72	72	72	72	72	72	72	72	72
Bio-power	309.00	80%	247	247	247	247	247	247	247	247	247	247	247	247
RE Solar	**1213.10**	19%	**230**	**230**	**230**	**230**	**230**	**230**	**230**	**230**	**230**	**230**	**230**	**230**
Thermal	**6509.89**	85%	**5533**	**5533**	**5533**	**5533**	**5533**	**5533**	**5533**	**5533**	**5533**	**5533**	**5533**	**5533**
Coal	**5978.07**													
Gas	**531.82**													
Total	**11201.86**		7636	7636	8091	8091	8091	7636	7023	7023	7023	7023	7023	7023

Data – Supply

Power availability (MW) for FY 2019-20														
Source	**Installed capacity (MW)**	**PLF**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**January**	**February**	**March**
Hydro	**1750.00**		61%	61%	87%	87%	87%	61%	26%	26%	26%	26%	26%	26%
			1068	**1068**	**1523**	**1523**	**1523**	**1068**	**455**	**455**	**455**	**455**	**455**	**455**
Nuclear	**100.73**	85%	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**
RE Non-solar	**2028.60**		**895**	**895**	**895**	**895**	**895**	**895**	**895**	**895**	**895**	**895**	**895**	**895**
Wind	1464.93	34%	498	498	498	498	498	498	498	498	498	498	498	498
Small hydro	178.67	50%	89	89	89	89	89	89	89	89	89	89	89	89
Bio-power	385.00	80%	308	308	308	308	308	308	308	308	308	308	308	308
RE Solar	**1508.46**	19%	**287**	**287**	**287**	**287**	**287**	**287**	**287**	**287**	**287**	**287**	**287**	**287**
Thermal	**7288.54**	85%	**6195**	**6195**	**6195**	**6195**	**6195**	**6195**	**6195**	**6195**	**6195**	**6195**	**6195**	**6195**
Coal	**6756.72**													
Gas	**531.82**													
Total	**12676.33**		8530	8530	8985	8985	8985	8530	7918	7918	7918	7918	7918	7918

Power availability (MW) for FY 2020-21														
Source	**Installed capacity (MW)**	**PLF**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**January**	**February**	**March**
Hydro	**1750.00**		61%	61%	87%	87%	87%	61%	26%	26%	26%	26%	26%	26%
			1068	**1068**	**1523**	**1523**	**1523**	**1068**	**455**	**455**	**455**	**455**	**455**	**455**
Nuclear	**100.73**	85%	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**
RE Non-solar	**2231.86**		**985**	**985**	**985**	**985**	**985**	**985**	**985**	**985**	**985**	**985**	**985**	**985**
Wind	1611.71	34%	548	548	548	548	548	548	548	548	548	548	548	548
Small hydro	196.57	50%	98	98	98	98	98	98	98	98	98	98	98	98
Bio-power	423.57	80%	339	339	339	339	339	339	339	339	339	339	339	339
RE Solar	**1658.37**	19%	**315**	**315**	**315**	**315**	**315**	**315**	**315**	**315**	**315**	**315**	**315**	**315**
Thermal	**7521.19**	85%	**6393**	**6393**	**6393**	**6393**	**6393**	**6393**	**6393**	**6393**	**6393**	**6393**	**6393**	**6393**
Coal	**6989.37**													
Gas	**531.82**													
Total	**13262.15**		8846	8846	9301	9301	9301	8846	8234	8234	8234	8234	8234	8234

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