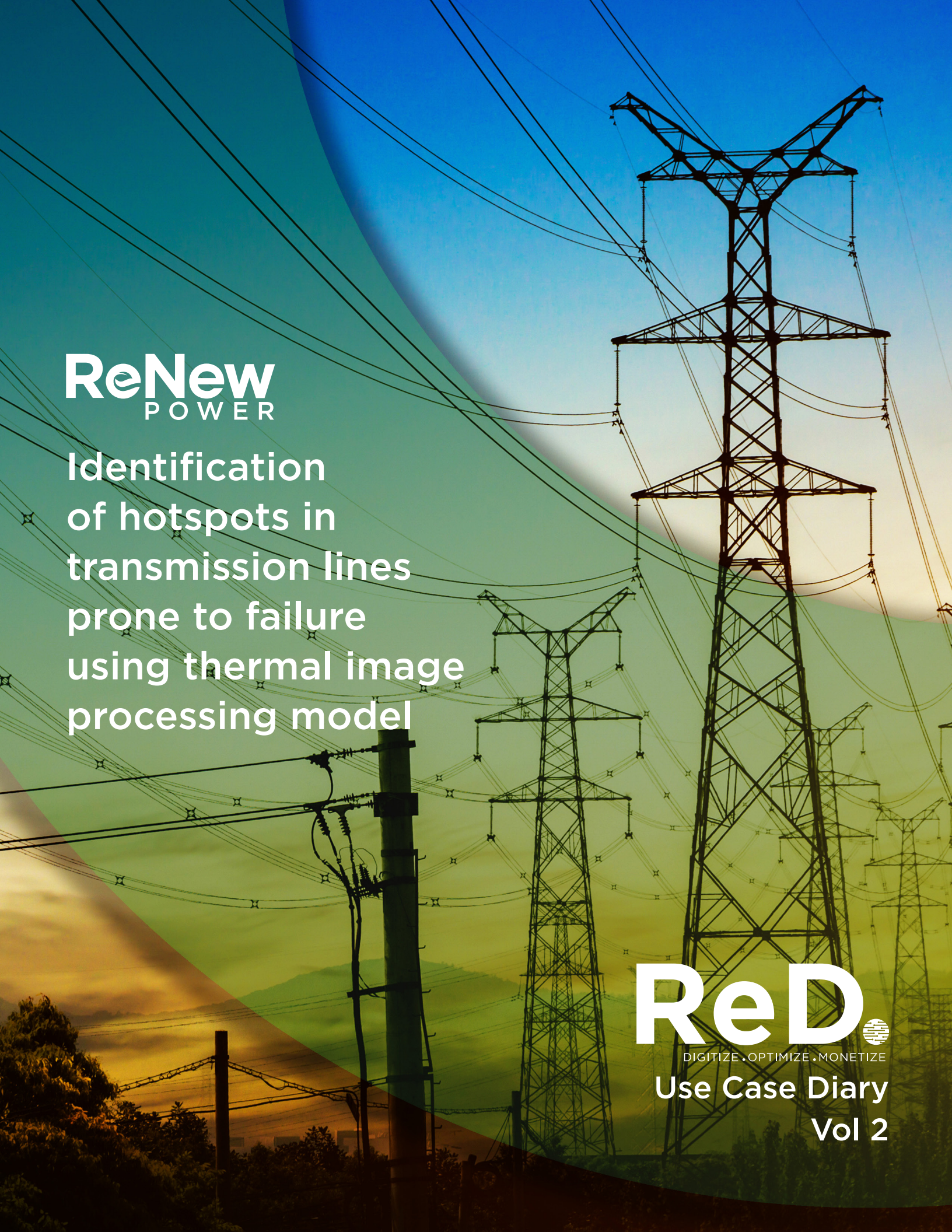


ReNew POWER

Identification of hotspots in transmission lines prone to failure using thermal image processing model

ReD

DIGITIZE . OPTIMIZE . MONETIZE

Use Case Diary
Vol 2

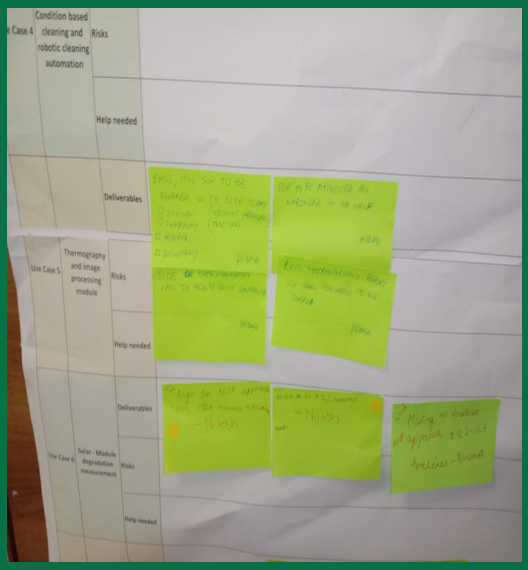
About The Initiative

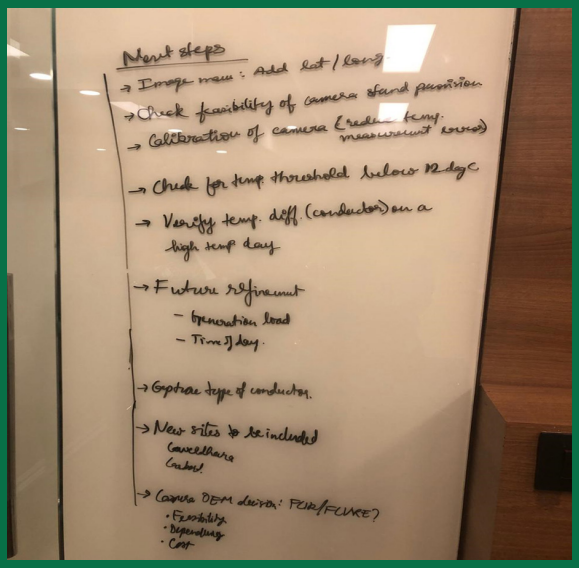
Balance of Plant (BoP) is a term given to all the infrastructural components of a wind & solar farm with exception of Turbines and Solar panels & inverters. It consists of unit substation (applicable for wind), pooling substation/switchyard & HV/EHV transmission line. Energy generated from Wind Turbine/Solar panels, transmitted through High voltage line spread across Wind & Solar farms to the Wind farm /Solar farm Pooling substation. Post this, it is fed to grid via extra high voltage line. So along this journey from Turbine/ Solar Inverters to grid, if any asset fails, then we stand to incur huge revenue losses. If there is some failure in transmission line, it can take very long to detect and rectify. This initiative is to proactively identify and rectify such failures in HV/EHV transmission lines due to hotspots using thermal image processing model. This initiative has been scaled up for all the solar & wind transmission lines.

Key Persons involved:

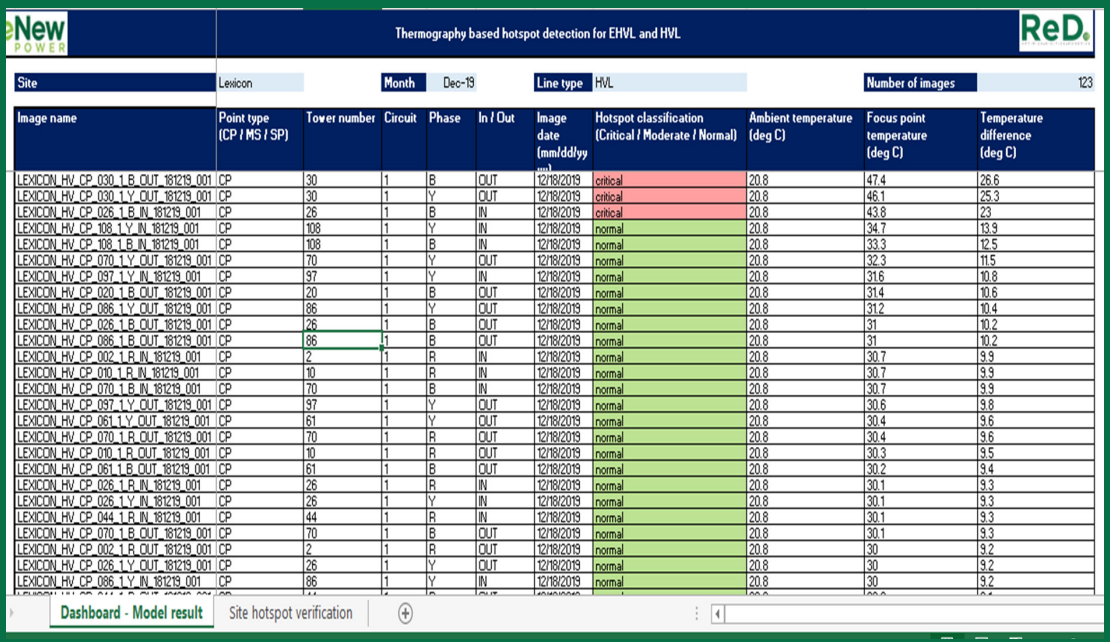
A team consisting of experts drawn from various disciplines was involved in working on this use case.

- **Shubhanki Garg** (Electrical Engineer with 4+ years of experience in BoP field) was the use case owner. She was also responsible for data analysis. For example: image raw data, model data etc.
- **Padmanava Swain** (Electrical Engineer with 13+ years of experience in Renewables) was overall Project Manager
- **Ganesh Kamble** helped us resolve the IT related issues if any.
- **Harman Chopra** helped us with Solar model run for most of the sites. He also supported us in wind thermography and in incorporating the correct ambient temperature (for FLIR E6 model results) from respective site DGRs.
- **Madhur Modi** from ReD. core team was involved in running the image processing model and all the model related modifications
- **Prakash Vora** (Electrical Engineer with ~18 years of experience in Renewables) was leading implementation of the overall use case across the portfolio.
- **Knayha Mongha**, **Snehal** and **Adarsh** assisted us in gathering and maintaining the Implementation status data and further reporting to leadership team.
- **Wind State SPoCs (Ravi Shekhawat, Vivek Pathak, Hiren Pathak, Romeo P, S Raja & Ramchandra Mali)** were responsible for implementing this activity in each state.





Daily check-in activity



Thermography based hotspot detection for EHVL and HVL

Site: Lexicon | Month: Dec-19 | Line type: HVL | Number of images: 123

Image name	Point type (CP / MS / SP)	Tower number	Circuit	Phase	In / Out	Image date (mm/dd/yy ...)	Hotspot classification (Critical / Moderate / Normal)	Ambient temperature (deg C)	Focus point temperature (deg C)	Temperature difference (deg C)
LEXICON_HV_CP_030_1_B_OUT_181219_001	CP	30	1	B	OUT	12/18/2019	critical	20.8	47.4	26.6
LEXICON_HV_CP_030_1_Y_OUT_181219_001	CP	30	1	Y	OUT	12/18/2019	critical	20.8	46.1	25.3
LEXICON_HV_CP_026_1_B_IN_181219_001	CP	26	1	B	IN	12/18/2019	critical	20.8	43.8	23
LEXICON_HV_CP_108_1_Y_IN_181219_001	CP	108	1	Y	IN	12/18/2019	normal	20.8	34.7	13.9
LEXICON_HV_CP_108_1_B_IN_181219_001	CP	108	1	B	IN	12/18/2019	normal	20.8	33.3	12.5
LEXICON_HV_CP_070_1_Y_OUT_181219_001	CP	70	1	Y	OUT	12/18/2019	normal	20.8	32.3	11.5
LEXICON_HV_CP_097_1_Y_IN_181219_001	CP	97	1	Y	IN	12/18/2019	normal	20.8	31.6	10.8
LEXICON_HV_CP_020_1_B_OUT_181219_001	CP	20	1	B	OUT	12/18/2019	normal	20.8	31.4	10.6
LEXICON_HV_CP_086_1_Y_OUT_181219_001	CP	86	1	Y	OUT	12/18/2019	normal	20.8	31.2	10.4
LEXICON_HV_CP_026_1_B_OUT_181219_001	CP	26	1	B	OUT	12/18/2019	normal	20.8	31	10.2
LEXICON_HV_CP_086_1_B_OUT_181219_001	CP	86	1	B	OUT	12/18/2019	normal	20.8	31	10.2
LEXICON_HV_CP_002_1_R_IN_181219_001	CP	2	1	R	IN	12/18/2019	normal	20.8	30.7	9.9
LEXICON_HV_CP_010_1_R_IN_181219_001	CP	10	1	R	IN	12/18/2019	normal	20.8	30.7	9.9
LEXICON_HV_CP_070_1_B_IN_181219_001	CP	70	1	B	IN	12/18/2019	normal	20.8	30.7	9.9
LEXICON_HV_CP_097_1_Y_OUT_181219_001	CP	97	1	Y	OUT	12/18/2019	normal	20.8	30.6	9.8
LEXICON_HV_CP_061_1_Y_OUT_181219_001	CP	61	1	Y	OUT	12/18/2019	normal	20.8	30.4	9.6
LEXICON_HV_CP_070_1_R_OUT_181219_001	CP	70	1	R	OUT	12/18/2019	normal	20.8	30.4	9.6
LEXICON_HV_CP_010_1_R_OUT_181219_001	CP	10	1	R	OUT	12/18/2019	normal	20.8	30.3	9.5
LEXICON_HV_CP_061_1_B_OUT_181219_001	CP	61	1	B	OUT	12/18/2019	normal	20.8	30.2	9.4
LEXICON_HV_CP_026_1_R_IN_181219_001	CP	26	1	R	IN	12/18/2019	normal	20.8	30.1	9.3
LEXICON_HV_CP_026_1_Y_IN_181219_001	CP	26	1	Y	IN	12/18/2019	normal	20.8	30.1	9.3
LEXICON_HV_CP_044_1_R_IN_181219_001	CP	44	1	R	IN	12/18/2019	normal	20.8	30.1	9.3
LEXICON_HV_CP_070_1_B_OUT_181219_001	CP	70	1	B	OUT	12/18/2019	normal	20.8	30.1	9.3
LEXICON_HV_CP_002_1_R_OUT_181219_001	CP	2	1	R	OUT	12/18/2019	normal	20.8	30	9.2
LEXICON_HV_CP_026_1_Y_OUT_181219_001	CP	26	1	Y	OUT	12/18/2019	normal	20.8	30	9.2
LEXICON_HV_CP_086_1_Y_IN_181219_001	CP	86	1	Y	IN	12/18/2019	normal	20.8	30	9.2

Dashboard - Model result | Site hotspot verification

Thermography model results

The Use Case

Before ReNew started its digital program, thermography was done with the help of third-party vendors, who prepared their report and submitted it to us for rectification. In this process, we were completely dependent on the external vendor's report. They used to take more than a month to submit the reports and this significantly delayed the rectification process. We did not have any tool to identify false positive cases or actual

hotspots which the vendors failed to detect. Additionally, we could cover only 10%-15% of the total line for thermography.

However, now under the digital regime, we are using an advanced analytics model to detect hotspots using thermal images with zero false positives (90-95% Accuracy). The TAT for hotspot identification as compared to external vendors has improved by 30x. We now get model results within a day as compared to more than a month taken by external vendors. A new SOP has been implemented and enforced at the site level. There is an automated data pipeline running from FTP server to the MS Azure cloud platform which feeds images into the model without any interventions. We have also set up a real-time dashboard to monitor and track progress of images clicked, model run and hotspots identified.

The methodology adopted for this use case is to upload all the raw images on FTP portal in required format after renaming them. Then the model is allowed to run on all these images. Images with temperature difference between ambient and focus point above 18 degree Celsius are classified as critical, images with temperature difference between 15-18 degree Celsius are classified as moderate and those with less than15 degree Celsius temperature difference are considered as zero deviation or normal.

Impact on organization

Once hotspot rectification is completed at site, it allows us to measure impact. We are able to detect the root cause of the hotspots and establish a feedback loop to strengthen infrastructure and minimize hotspot occurrence. Earlier, as the vendor reports were delayed, very often the super critical points used to trip. By applying digital and analytics, we can now overcome this issue and can take timely actions to protect our revenue.

We have set up a central repository of all the data/images. Till now we have completed a scale up of this use case at 84% of operational assets and balance WIP. It is still in progress for wind sites-lines.

This use case will enable us to deliver tangible value to business.

Key Success Factors

- Enhanced cross functional collaboration between Asset Management, Implementation, IT & Power Evacuation.
- An agile and strategic approach adopted for ensuring steady day to day progress.
- Daily check-ins to review the previous day's progress along with action plan for next 2 days or so and also address the concerns being faced. This helped us to achieve quick results.
- Rhythm of weekly/fortnightly reviews by leadership team helped us in refining our methodologies adopted for model building, impact measurement & process improvements
- Team was able to expand their digital know how.

Engagement & Contribution of Site Employees

The process of involving our site personnel began right from the idea generation stage. They were communicated about this mission and why we were doing it and were invited to contribute their valuable ideas for improvement through face to face or online

workshops. From idea generation to refinement to implementation phase, designated site employees were nominated as Single Points of contact (SPOC) for their respective areas and worked closely with the implementation team. The site SPOCs provided feedback on execution and challenges faced, if any. Thus, they acted as a critical link between the site team and the development team via the implementation team resulting in a robust closed loop process.

Impact on site operations

The most visible impact on site has been an increased motivation level of employees. Employees could see their ideas and insights being accepted, refined and implemented across the fleet, giving them a sense of "belonging" and the satisfaction of making a visible contribution.

Second most striking impact has been the change in mindset and approach of site team members. They have gradually shifted to understanding and adopting model-based results, rather than relying on external vendor reports. This has also enabled quicker rectification.

Third big change has been the increase in interactions between experts and site service team, enhancing the latter's learning and knowledge.

Last, but not the least, the team now knows about this activity better and they can overcome all the technical issues faced at site level.

Overcoming Key Challenges

There were many challenges we faced while working on this initiative. Some of these are listed below:

1. Conversion into Excel format: We have two different makes of camera available at ReNew sites. One is FLIR-E6 &E75 model, and another is FLUKE Ti-450 model. The model used can read the jpeg images generated by FLIR camera but not the IS2 files generated by FLUKE Ti-450 model. So, we had to convert the IS2 images into two excel files through FLUKE connect software for the analytics model to be able to read the temperature data. This process of conversion used to take 2-3 minutes per image (very time consuming). After exploring details about the Fluke connect software and talking to OEM experts, we came to know that we can select and convert multiple files into excel in one go. After verifying this for 50-100 group conversions, we incorporated this into our SOP.
2. Unpredictable wind this year (during High Wind Season) at most of the sites was a major concern for us specially for wind lines thermography as for this activity there should be >40% loading of lines. We took the help of data provided by forecasting agencies for planning the activity in an effective way. In spite of this, we continued to experience deviations in wind speed from what was forecast. Due to this, team had to remain idle for a few days.
3. There were execution difficulties at site, arising out of restrictions in movement due to outbreak of Covid19 pandemic and precautionary lockdowns imposed by state Governments. Both ReNew and OEM team worked hard to keep their teams safe, healthy and well looked after, obtain all necessary travel permissions and ensure all safety guidelines were complied with.

4. To define Impact measurement methodology. Initially we had considered 100% value for all the critical hotspots and 100% value for all the moderate hotspots. However, after deep analysis of the site hotspot rectification report/site feedback, discussion with contractor & image analysis through software, we came to know that all the hotspots will not lead to line breakdown within this year. Some may fail in the coming years as well. After analyzing solar data (each & every hotspot) of 1st batch, we froze 20% value for moderate cases in present year, 30% in 2nd and 50% value in 3rd year. This continued for solar 2nd & 3rd batch & wind after analyzing each & every hotspot again.

After analyzing solar 1st batch, we categorized the critical hotspots into 3 sub-categories which are critical worst case (100% in 1st year), critical worse cases (50% in 1st year, 50% in 2nd year) & critical moderate cases (same as moderate cases). Weighted average of the value with respect to number of hotspots was applied on each hotspot. Same approach continued for solar 2nd, 3rd batch & wind after analyzing each & every hotspot.

Next Steps

The next steps for this use case are:

1. Continued refinement of model using feedback from various stake holders.
2. Digitalization of rectification reports and analysis of false positive cases.
3. Scale up at balance 32% wind sites and 100% completion of identified hot spot rectification.
4. Development of other use cases is in progress like digitization of eBoP Asset health audit

Solar Team doing hotspot rectification at site during night time

ReNew POWER