GIS-Based Crisis Response System for Electric Distribution Utility: A Case Study Of Covid-19 Pandemic In Malaysia

N M F N M Kamil¹,² *, K A Razak²,³, F Mat Yatim¹, A H Hidzir⁴

¹GIS Distribution Network, Tenaga Nasional Berhad, 43000 Kajang, Selangor, Malaysia
²Razak Technology and Informatics, Universiti Teknologi Malaysia, 54100 Kuala Lumpur, Malaysia
³Disaster Preparedness and Prevention Centre, Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia, 54100 Kuala Lumpur, Malaysia
⁴Asset Planning and Performance, Tenaga Nasional Berhad, 52000 Kuala Lumpur, Malaysia

*Corresponding author: fadhil.kamil@tnb.com.my

Abstract. COVID-19 pandemic has impacted 188 countries, with more than 6 million infected people, and Malaysia is not exceptional. With stringent control measures and rapid action by multi-sectoral agencies, Malaysia is only a few countries that collectively managed to reduce the number of human and economic losses, far better than the projection. Critical infrastructure remained intact and full of functionality during the unprecedented crisis. The supply and demand by the electric utility companies are of utmost critical to support the Government of Malaysia’s decision in infective prevention and control, rapid response, epidemiological forecasting, pandemic supply chain coordination, continuity of essential service, surveillance, and risk communication. To survive on this new normal, the business and operations of the utilities must rely on good data, advanced technology, and science-based decision support. This article presents local practices and experiences by GIS Distribution Network (GISDN), a project unit in the Distribution Network (DN) division of Tenaga Nasional Berhad (TNB) to co-support the decisions mentioned above. GISDN has supported the TNB Crisis Management Team (CMT) of the Kuala Lumpur and Selangor state, starting from the Movement Control Order (MCO) for COVID-19 pandemic response in Klang Valley. Maps and statistics of TNB assets in the areas of Enhanced Movement Control Order (EMCO) intelligently delivered by GISDN for use by the CMT groups. In the case of EMCO at Selangor Mansion and Malayan Mansion, geographical information provided to ensure the reliable electricity supply from 40 substations in the total lockdown area that involving around 6,000 residents in 365 residential and commercial units. The web-GIS application dashboard for CMT also developed by GISDN to monitor the status of more than 214 gazetted quarantine stations in Kuala Lumpur. Besides, the web-GIS dashboard application for the situational awareness of COVID-19 based on administrative boundaries in Klang Valley delivered to support the Standard of Operating Procedure (SOP) for Return to Work (RTW) program in GISDN, especially for the use of for site-work approval. These geospatial deliverables and web-GIS dashboard applications aid better visualization, risk-informed forecasting, and response planning for TNB to cope with COVID-19 clusters and zones updated by MOH on the daily basis. In conclusion, this study provides a new insight into the future advancement of spatiotemporal GIS capability, its intelligent architecture design, and an evidence-based decision support system to reduce pandemic risk in the future.
1. Background

COVID-19, also known as the coronavirus disease, is an on-going global pandemic, and the impacts have prevailed. The sudden outbreak first occurred in late December 2019 in Wuhan, China, and has rapidly spread to the rest of the world. To date (14th July 2020) World Health Organization (WHO) has reported 12,964,809 cases of COVID-19 with 570,288 cases of deaths from 188 countries around the globe [1].

So far, Malaysia had recorded 8,729 confirmed cases, 122 deaths cases, and 8,524 recovery cases of the COVID-19, as reported by the Malaysia Ministry of Health (MOH) on 14th July 2020 [2]. Federal Territory of Kuala Lumpur had recorded the highest number of cumulative cases (2,446) followed by the Selangor state with the 2,093 cases, and 1,027 cases in Negeri Sembilan state. The number of cases decreasing for a couple of weeks, and currently many new clusters found, and the number of new cases is increasing.

The COVID-19 pandemic has changed our daily lives and livelihood; however, one thing has not changed: critical infrastructure must remain intact and fully functioned during the unprecedented crisis. The supply and demand by utility companies are of utmost essential to support the government in making the decision related to infection prevention and control, rapid response, epidemiological forecasting, pandemic supply chain coordination, continuity of essential service, surveillance, and risk communication. To survive on this new normal, the business and operations of the utility company must rely on reliable data, timely produce, as commonly supported by advanced mapping technology and science-based decision making.

Tenaga Nasional Berhad is known as TNB, the largest electricity utility company in Malaysia. TNB also the largest power company in South East Asia, which is moving towards digital transformation to become a smart utility by the year 2025. Geographic Information System (GIS) project from Distribution Network Division (GISDN) is one of the project initiatives for the Grid of the Future (GoTF) program developed by TNB to become a smart utility company. The main objective of the GIS project is to map the electrical distribution assets that consist of 83,467 distribution substations connected to 683,008 km of power lines that serve up to 9.25 million of the customers in Peninsular Malaysia in GIS platform [3].

Currently, the mapping of existing medium voltage electrical assets has completed for Peninsular Malaysia. The mapping of existing low voltage electrical asset activities is on-going and targeted to be completed by the year of 2022. The outcome of the GIS project shall benefit TNB and the country at large in better managing assets, revitalizing uniform geo-information, increasing productivity, as well as supporting evidence-based decision-making processes.

The rising number of cases of COVID-19 and the increasing number of locked-down areas in Malaysia, triggered TNB Crisis Management Team (CMT) group in Kuala Lumpur and Selangor to seek GISDN capability in mapping out electrical network asset and COVID-19 related data that affected by the Movement Control Order (MCO) imposed by the government. Both Kuala Lumpur and Selangor state, also known as Klang Valley, is the highest densely populated areas in Malaysia, which represent 25.5% of the country's population [4]. Overall, 6 out of 7 of the total lockdown areas of COVID-19 in the country were taken place in these two states, leading to an urgent need and demand for rapid GIS solutions and intelligent services for TNB to secure power to these areas.

2. Impacts Experienced by TNB

The on-going impact of COVID-19 is now, without doubt, a global crisis. Malaysia is no exception. We have reported that the number of COVID-19 cases was increased up to 3,059 percent in just one month, from 22 cases on 17th February 2020 to 673 cases on 17th March 2020. As a consequence, Malaysia began the implementation of MCO throughout the country, starting on 18th March 2020 (see Table 1).

The order of MCO is a cordon sanitaire implemented to restrict the movement of people into or out of a defined geographical area. It is a preventive measure to respond to the COVID-19 pandemic by the Government of Malaysia. In some countries, MCO is also commonly known as a "lockout" or "partial lockout" [5].
Table 1. MCO in Malaysia, as of 14th July 2020

| Order                                           | Timeline and duration          |
|-------------------------------------------------|-------------------------------|
| Movement control order (MCO) – Phase 1          | 18th March – 31st March 2020 (13 days) |
| Movement control order (MCO) – Phase 2          | 1st April – 14th April 2020 (13 days)  |
| Movement control order (MCO) – Phase 3          | 15th April – 28th April 2020 (13 days)  |
| Movement control order (MCO) – Phase 4          | 29th April – 12th May 2020 (13 days)  |
| Conditional movement control order (CMCO) – Phase 1 | 4th May – 12th May 2020 (8 days)  |
| Conditional movement control order (CMCO) – Phase 2 | 13th May – 9th June 2020 (27 days)  |
| Recovery movement control order (RMCO)          | 10th June – 31st August 2020 (82 days) |

During the earlier phase MCO, most businesses and daily activities forced to close, except those categorized as essential services, as listed by the National Security Council [6]. TNB is one of the essential services that are required to ensure the services, i.e., power distribution operation, restoration, and repair, continue to operate fully, making sure customers receive uninterruptible and reliable electricity supply during the lockdowns in Malaysia.

2.1 Strategies and Development Implemented
Currently, CMT is under alert mode for the crisis response. CMT of the state led by the Chief Engineer of Asset Performance and Planning (APP) assisted by the Chief Engineer of Operation & Maintenance (O&M) and supported by a representative of O&M, APP, Business Support Office (BSO), Finance, Security, Procurement, and Fleet, as illustrated in Figure 1. CMT is the body in TNB with roles and responsibilities to make strategic decisions, ensure an emergency response plan (ERP) implemented across the organization, allocate necessary support and resources, and communicate with external parties, regulatory bodies, and media during the crisis.

The GIS-based crisis response system was not initially a significant part of the components used by the respective CMT at that particular time; thus, the engagement by GISDN with CMT not established earlier. As APP is already using GIS Functions developed by GISDN in their work process, APP which is a part of the CMT group, perceived the importance of using geographic information to aid better visualization, analytical data, risk-informed forecasting, and response planning for a crisis.

On 16th March 2020, the Federal Government started to declare and gazette the hospital and non-hospital facilities, including hotels or any other premises throughout the country under the Section 14 of Prevention and Control of Infectious Disease Act 1988 (Act 342) [7]. The gazette place known as the quarantine station is the isolation place with health observance for a person under investigation (PUI) and persons under surveillance (PUS) of the COVID-19 symptom. One of the quick actions taken in combating the pandemic crisis.

Initially, the CMT secretariat started to list out the quarantine station based on the DN operation boundary, and Smartview (one of GIS DN product) was heavily used to identify the source of supply for all quarantine stations in Klang Valley. This information was then used by system planners to evaluate the security of supply for all listed locations as their preparation to respond to any special
requirements by the governments or related agencies in coordinating the pandemic response locally. As the quarantine stations started to accommodate more PUI and PUS, the daily statistics on the number of people reported in these place shared by the Government of Malaysia, through to the public media. Thus these numbers later become an essential part of the CMT group's daily reporting. During the first declared Enhanced Movement Control Order (EMCO) by the Government of Malaysia on 27th March 2020 in the two areas at Simpang Renggam, Johor state there are raising concerns by staff for the site-work in the total lockdown area known as the red zone [8]. Daily reporting is required by CMT KL to update to top management for the number and status of electrical assets in EMCO areas, including the number and status of the quarantine stations. Hence a geographical-based solution was requested urgently by CMT to GISDN. Thus, GISDN delivered quickly to CMT with the responded actions as listed below: -

i. GIS maps and statistics for TNB assets in EMCO areas in Klang Valley, known as C19 EMCO. See the example of the map in Figure 2.

ii. GIS dashboard application for situation report (SITREP) of the COVID-19 quarantine station, known as C19-QUS, see Figure 3.

Figure 2. Example of TNB assets in EMCO areas of Menara City One, Malayan Mansion, Selangor Mansion, and Masjid India

Figure 3. C19-QUS shows the SITREP of the quarantine station with emphasized on the risk visualization for better communication

C19-EMCO developed to visualize the situational awareness of TNB assets such as the location of substations, and detailed information (e.g., ID, name, and status) within the total locked-down areas of EMCO. The order of EMCO is implemented by the government to this specific location (see Table 2) if a large cluster of COVID-19 cases detected within the same area.
Table 2. List of EMCO in Malaysia, as of 14th July 2020

| No | Area                                                                 | State                      | Timeline and duration                           |
|----|----------------------------------------------------------------------|----------------------------|-------------------------------------------------|
| 1  | Kampung Datuk Ibrahim Majid and Bandar Baharu Datuk Ibrahim Majid, Simpang Renggam | Johor                      | 27th March 2020 – 26th April 2020 (30 days)     |
| 2  | Sungai Lui, Hulu Langat                                             | Selangor                   | 30th March 2020 – 14th April 2020 (15 days)    |
| 3  | Menara One City Condominium, Jalan Munshi Abdullah                  | Kuala Lumpur               | 31st March 2020 – 3rd May 2020 (33 days)       |
| 4  | Selangor Mansion and Malayan Mansion, Jalan Masjid India            |                            | 7th April 2020 – 3rd May 2020 (26 days)        |
| 5  | Selayang Baru, Gombak                                              |                            | 25th April 2020 – 15th May 2020 (20 days)      |
| 6  | Pasar Borong Kuala Lumpur                                           |                            | 20th April 2020 – 12th May 2020 (22 days)      |
| 7  | Pasar Jalan Othman, Petaling Jaya                                   |                            | 10th May 2020 – 21st May 2020 (11 days)        |

In the case of the Menara One City Condominium, the area was declared under an Enhanced Movement Control Order (EMCO) by the government on 3rd March 2020. TNB switching team that consists of a foreman and technician deployed on-site to ensure that the condominium’s backup power supply system is ready if needed. The system will allow for the remote switching of the power supply in the event of a breakdown.

For C19-QUS, the web-GIS dashboard application developed for the use of CMT to monitor the status of more than 214 quarantine stations in Kuala Lumpur. Similar to C19-EMCO, the information from the GIS-based decision-making system assists CMT to ensure the reliability and security of electricity supply for the quarantine stations. Before using C19-EMCO, CMT is relying on the excel spreadsheet with the required information, as listed in Table 3. Then, this tabular data of quarantine stations are converted into geographic information for intuitive and interactive visualizations on a single screen of the C19-QUS dashboard application for the better use by CMT, leading to rapid and accurate decision.

Table 3. Example of the list of a declaration quarantine station and related information

| Gazette No | Name of Quarantine Station | No of People | Date Open | Phone No | Name of PIC | Phone No of PIC | Name of PIC | LAT/LONG | Zone | Subzone |
|------------|-----------------------------|--------------|-----------|----------|-------------|----------------|-------------|----------|------|---------|
| 1          | Hospital Sungai Buloh, Sungai Buloh, Selangor | 13       | 14        |          |             |                |             |          |      |         |
| 1          | Pusat Kawalan Kusta Negara, Sungai Buloh, Selangor | 14        | 15        |          |             |                |             |          |      |         |
|             |                             |             |           |          |             |                |             |          |      |         |

The web-GIS dashboard application for demographic cases of COVID-19, known as C19-STAT, was developed for the use of GISDN staff. The data, such as the active cases and cumulative cases of COVID-19 by administrative boundary, is updated daily based on reported data by the MOH. The use of the C19-STAT dashboard application (see Figure 4) is to ensure the safety and compliance of the GISDN staff, as part of the Standard Operating Procedure (SOP) for the Return to Work (RTW)
program. GISDN staff can check the status cases of COVID-19 using C19-STAT for approving or rejecting the site-work application by the staff subordinates and vendors. An area in the green zone (0 active cases of COVID-19 at the time of publication) allowed for the site work to minimize the risk of infection of COVID-19 to the staff, vendors, and the public.

Figure 4. C19-STAT shows the COVID-19 status cases by administrative boundaries

3. Methodology

3.1 Current GIS architecture

Remarkably, GISDN successfully developed six GIS functions for the use of building asset data in GIS, updating existing data, enhancing staff work experience in their daily work, and improving customer service [9]. The six GIS functions developed for the use of Planners, Estimators, Constructors, and Customer Service staff in the business operations of the Distribution Network. Six GIS functions are namely as Asset Register, Supply New Connection, Reconnection, Project Planning and Wayleave Planning, Construction Project, and Customer Service Support, known as TNB CareLine (via SmartView initiative).

Six GIS functions in GISDN were grouped into four main GIS functions by the category of data, i.e., existing asset, new asset/asset changes, and asset visualization and application, as demonstrated in Figure 5. These four main GIS functions run by five GIS solutions, known as Desktop GIS, Mobile GIS, Lite Editor, SmartView, and mySIGHT.

Figure 5. General of current GIS architecture in GISDN

The five GIS solution is a complementary system by different GIS solution providers that fit well with each other for various purposes, depending on GIS functions. The first GIS solution, Desktop GIS, is running on GE Smallworld, followed by Mobile GIS on Geomedia Smart Client, and then Lite Editor that runs on Geomedia Web Map. Smartview as fourth GIS solution is powered by Google API and TuxGeo+; while the last GIS solution, mySIGHT is a mobile application that can work both on either an android or IOS platform.

3.2 GIS architecture for GIS-based crisis response system

GISDN already acquired ArcGIS Enterprise for the use to develop project management and tracking system, known as Low Voltage Project Tracking (LVPT). Compared to the previous GIS solution, i.e., Smallworld, Geomedia, and others; GISDN staff has privileged as the system administrator for the ArcGIS Enterprise that consists of the dedicated and separated database from the existing GIS solutions.
With this capability, GISDN now has the flexibility to entertain the new request from other TNB users, e.g., CMT, either for the new datasets or application, which are not impacting directly to the existing GIS Functions. The new request can be a simple task to add the new layer of non-electrical datasets, e.g., demographic population, or a request to develop new GIS functions. Figure 6 illustrated the proposed GIS function, crisis response, i.e., COVID-19 pandemic response added to the existing GIS function with the use of ArcGIS Enterprise as a data-driven GIS solution.

4. Discussion
The current COVID-19 pandemic presents an opportunity to build on the experience and use of GIS-based solutions to respond better and recover faster to the epidemic. The Johns Hopkins COVID-19 Dashboard is probably the well-known example developed by the Center for Systems Science and Engineering, Johns Hopkins University. The application becomes a global reference for the COVID-19 pandemic for hosting worldwide confirmed cases of COVID-19 with maintained data in near real-time throughout the day from the reliable data source, i.e., WHO, the US Centers for Disease Control, and Prevention and the European Center for Disease Prevention and Control, the National Health Commission of the People’s Republic of China, and media and health departments around the world. The John Hopkins site is getting more than 3 million hits per hour, according to Ryan Lanclos, who leads the disaster response program at Esri [10]. This study complements current government efforts to understand the risk profiles and strategize the ways to reduce the transmission and its significant impacts on other sectors.

In the case of the COVID-19 pandemic response by TNB in Malaysia, GISDN developed the web-GIS dashboard application of C19-QUS and C19-EMCO using ArcGIS Dashboard. ArcGIS Dashboard, through ArcGIS Enterprise, is a configurable web-app that allows users to use maps, charts, gauges, and other visual elements to show the status and output of staff, equipment, resources, and events in real-time. It is worth mentioning that during the crisis, mainly due to biological hazards (e.g., COVID-19) that the risk visualization and communication are critical elements to analyse the local risk and reduce the cascading impacts. The web-GIS dashboard application enables users to monitor the activities and performance indicators that are important to the organization’s business objectives and workflows within a single display. It is a great way to provide information to the CMT decision-maker with an interactive dynamic display of data such as the status of quarantine station or the demographic of COVID-19 cases. Besides, GISDN staff having the experience to use and develop an in-house of GIS application, GISDN is less dependent on the external vendor or the third party to quickly develop the web-GIS dashboard application in the next few hours from the requested by CMT. ArcGIS Dashboard through ArcGIS Enterprise is the best option so far to meet on-time of the new request of GIS Functions with no additional cost, as the system development built using in-house capacity, contributed mainly by GISDN to the CMT for the response of COVID-19 pandemic.

5. Conclusion
The current COVID-19 outbreak presents an opportunity to build on the experience and use of GIS-based solutions by the electric utility company to respond faster to the pandemic in Malaysia. In this study, we shared the local practices and experiences by GISDN to the CMT of the Kuala Lumpur and Selangor state, starting from the Movement Control Order (MCO) for COVID-19 pandemic response in
Klang Valley. Remarkably, this study is the first attempt in the country to explore the new insight into modern GIS and its large potential to combat the pandemic risk via an intelligent based spatial solution and associated services.

The location intelligence, such as maps, asset status, and statistics, including the web-GIS dashboard application, provide valuable insights to help CMT respond well to the crisis and maintain continuity of operations and support the SOP of RTW in the GISDN project. The requested maps, data, and web-GIS dashboard application delivered by GISDN to CMT on time and assisted TNB for the better of crisis response in the rapidly changing environment of the COVID-19 pandemic. With the advancement of GIS, the pandemic risk can be visualized spatially and analyzed temporally by multi-sectoral decision-makers. A single platform serves a multi-purpose action for reducing future pandemic risk. In conclusion, this study provides new insight into the future advancement of spatiotemporal GIS capability, its intelligent architecture design, and an evidence-based decision support system to prevent pandemic risk in the near future.

References

[1] WHO. July 2020. Coronavirus disease (COVID-2019) situation reports. Retrieved from https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200714-covid-19-sitrep-176.pdf?sfvrsn=d01ce263_2

[2] MOH. July 2010. Coronavirus disease (COVID-2019) situation reports. Retrieved from http://covid-19.moh.gov.my/terkini/072020/situasi-terkini-14-julai-2020

[3] TNB. (2019). TNB Annual Report, 2019. Retrieved from https://www.tnb.com.my/assets/annual_report/TNB_IAR_2019v2.pdf

[4] DOSM. (2020). Statistics COVID-19 by state in Malaysia. Retrieved from https://www.tnb.com.my/assets/annual_report/TNB_IAR_2019v2.pdf

[5] Sukumaran, Tashny (2020). Coronavirus: Malaysia in partial lockdown from March 18 to limit the outbreak. South China Morning Post.

[6] MKN. (2020). Statistics COVID-19 by state in Malaysia. Retrieved from https://www.mkn.gov.my/web/ms/covid-19/

[7] Federal Government Gazette. (2020). Declaration of quarantine station. Retrieved from http://www.federalgazette.agc.gov.my/outputp/pub_20200316_PUB171.pdf

[8] NST. March 2020. Enhanced MCO issued for two areas in Simpang Renggam. Retrieved from https://www.nst.com.my/news/nation/2020/03/578443/enhanced-mco-issued-two-areas-simpang-renggam

[9] Yatim, F.M. (2019). Assessment of Key Success Factors in Geographic Information System at Tenaga Nasional Berhad Distribution Electrical Network. Universiti Teknologi Malaysia

[10] Bloomberg. May 2020. The Software That’s Powering All the Coronavirus Dashboards. Retrieved from https://www.bloomberg.com/news/articles/2020-05-12/coronavirus-dashboards-are-being-powered-by-this-software