E-PROCEEDINGS

INTERNATIONAL TINKER INNOVATION & ENTREPRENEURSHIP CHALLENGE (i-TIEC 2025)

“Fostering a Culture of Innovation and Entrepreneurial Excellence”

23 January 2025
PTDI, UiTM Cawangan Johor Kampus Pasir Gudang

e ISBN 978-967-0033-34-1

ORGANIZED BY:

Electrical Engineering Studies, College of Engineering
Universiti Teknologi MARA (UiTM) Cawangan Johor
Kampus Pasir Gudang
https://tiec-uitmpg.wixsite.com/tiec

E-PROCEEDINGS
of International Tinker Innovation & Entrepreneurship Challenge (i-TIEC 2025)

"Fostering a Culture of Innovation and Entrepreneurial Excellence"

23rd JANUARY 2025
PTDI, UiTM Cawangan Johor, Kampus Pasir Gudang

Organized by

Electrical Engineering Studies, College of Engineering,

Universiti Teknologi MARA (UiTM) Cawangan Johor, Kampus Pasir Gudang.

https://tiec-uitmpg.wixsite.com/tiec

Editors

Aznilinda Zainuddin

Maisarah Noorezam

e ISBN: 978-967-0033-34-1

The extended abstracts featured in this e-proceeding book have not undergone peer review or verification by i-TIEC 2025. The authors bear full responsibility for the content of their abstracts, guaranteeing that they are original, unpublished, and not concurrently submitted elsewhere. The opinions presented in the abstracts reflect those of the authors and do not necessarily align with the views of the editor.

Published in Malaysia by
Universiti Teknologi MARA (UiTM) Cawangan Johor
Kampus Pasir Gudang, 81750 Masai

A-ST007 - A-ST159

A-ST018: INTEGRATED IMMUNE CHAOTIC EVOLUTIONARY PROGRAMMING (IICEP) OPTIMIZER TOOL FOR INTEGRATING BATTERY ENERGY STORAGE SYSTEMS IN TRANSMISSION NETWORK FOR LOSS MINIMIZATION

Nur Farahiah Ibrahim[1], Ismail Musirin[1], Nor Azwan Mohamed Kamari[2], and Nor Zulaily Mohamad[1]

[1]School of Electrical Engineering, College of Engineering, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia

[2]Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, Bangi, Malaysia

Corresponding author: Nur Farahiah Ibrahim, nurfarahiahibrahim@uitm.edu.my

ABSTRACT

Demand for renewable energy resources has increased in today’s energy landscape, seeking technological solutions to improve power systems' flexibility and stability. Transmission networks are critical components for delivering electricity in an efficient and reliable manner. However, the networks are susceptible to power losses, which lower overall system efficiency and increase operational costs. The development of a new novel optimization technique called Integrated Immune Chaotic Evolutionary Programming (IICEP) has successfully meet its objective to minimize loss by finding the optimal position and sizing of BESS within the transmission network. IICEP combined the benefits of Evolutionary Programming (EP) and clonal qualities of Artificial Immune System (AIS) with the addition of a chaotic process to provide a superior solution in optimization techniques. Three battery energy storages are inserted into the networks, each with the proper placement and sizes to achieve the purpose. The IICEP algorithm is tested on an IEEE 30-Bus RTS to determine its efficacy. The findings are compared to standard EP and AIS. It demonstrates that the IICEP technique offers a better performance in lowering power losses. This optimization technique can aid networks system strategy. When power losses are eliminated, proper network planning can lower operational cost and improve energy efficiency.

Keywords: Battery Energy Storage System (BESS), optimization process, loss minimization, Immune Chaotic Evolutionary Programming (IICEP)

1. Product Description

The Integrated Immune Chaotic Evolutionary Programming (IICEP) is an advance optimization technique that aims to improve the efficiency of electrical transmission networks by reducing power losses. By adding Battery Energy Storage Systems (BESS), the technique discovers the optimal locations and sizing for energy storage, lowering networks inefficiencies. IICEP integrate the clonal properties of the Artificial Immune System (AIS) with chaotic dynamics incorporated in Evolutionary Programming (EP), resulting in greater performance over standard algorithms. When tested on the IEEE 30-Bus Reliability Test System (RTS), IICEP showed considerable improvements in loss minimisation while exceeding EP and AIS in accuracy and convergence. The methodology considers critical elements including network topology, resistance, and distance to achieve perfect optimization. This novel strategy offers the door for sustainable energy management, improving grid stability while lowering operational expenses.

2. Flow Chart

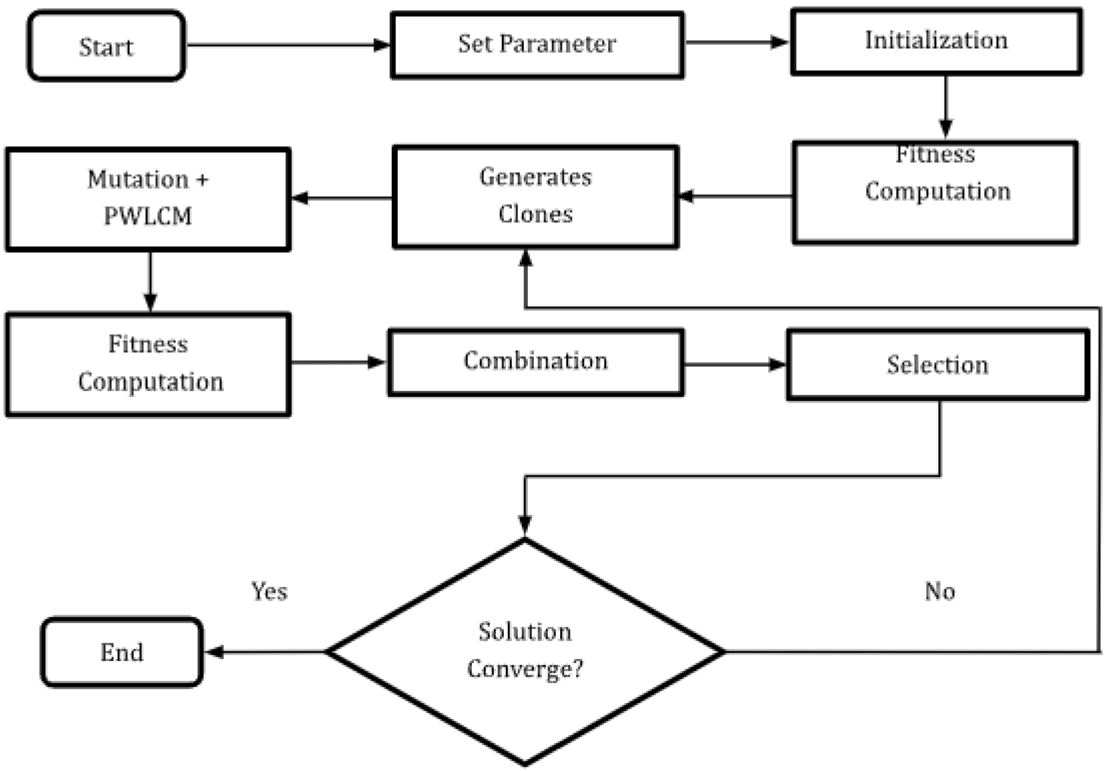

Figure 1. Flowchart of IICEP Optimization Technique

Figure 1 illustrates the process of IICEP in general. The design of IICEP involves a step-by-step technique that begins with the initialization phase and ends with determining the ideal combination of location and sizing to get a better loss profile. The code is written with an emphasis on advances computational and strategies to overcome the complexity of power system optimization. **Figure 2** shows the IICEP Optimizer Tool Interface. It features a simple and user-friendly interface designed for seamless operation. It includes two input fields: the Bus Value, where users specify the bus number for optimization, and the Load Value (MVA), where the corresponding load value is entered. After entering the required data, users click the Run Optimization button to initiate the process. The tool then applies the IICEP algorithm to calculate the optimal BESS placement and sizing, displaying the results in the output section below. This interface streamlines the optimization process, making it efficient and easy to use for improving transmission network performance.

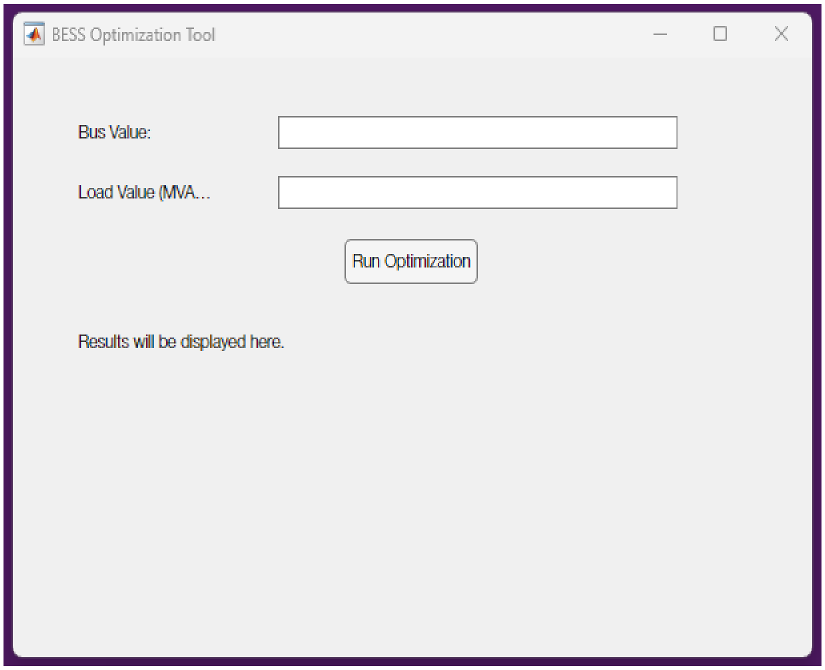

Figure 2. IICEP Optimizer Interface

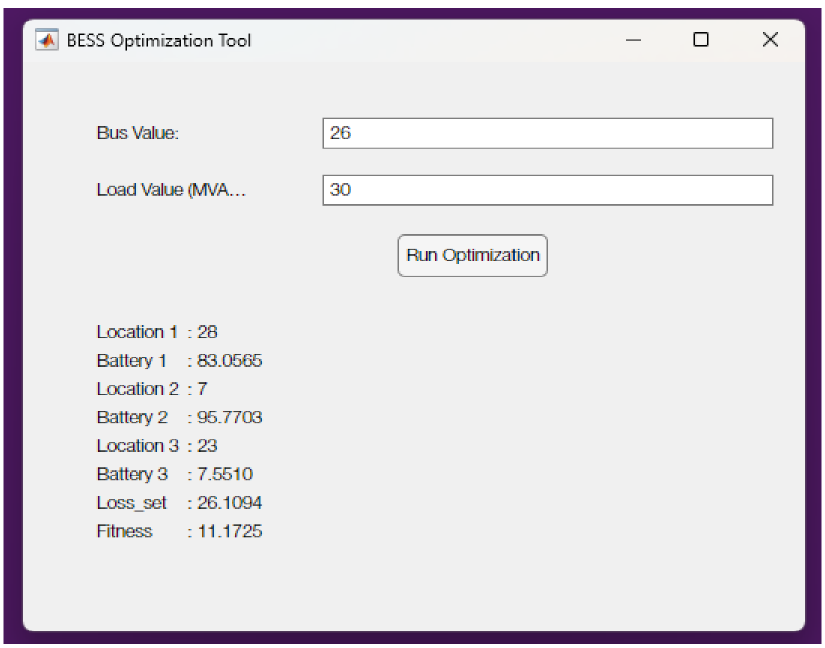

Figure 3. IICEP Optimizer Interface

Figure 3 shows the results after completing the optimization process, the IICEP Optimizer Interface displays the results, providing the optimal placement and sizing of the Battery Energy Storage Systems (BESS). IICEP enhances existing optimisation techniques by including chaotic sequences to increase solution diversity and exploration. It specifically uses the Piecewise Linear Chaotic Map (PWLCM) because of its simplicity, efficiency, and advantageous dynamic features. The PLCM directs the chaotic behaviour in the optimisation process, with the initial chaotic variable and control parameter shaping the iterative updates. **Figure 4** depicts a scatter plot of all battery locations and sizes during the initialization process for 20 sets. The batteries are scattered randomly within the limit of 200 MW. **Figure 5** illustrates the plot of location and sizing of all batteries after optimization process when tested at Bus 26. Battery 1 is located at Bus 18 and has a capacity of 16 MW, battery 2 at Bus 28 and has a capacity of 97 MW and battery 3 is at Bus 17 with a capacity of 26 MW. **Figure 6** depicts the plot of the location and sizing of all batteries after the optimization process when tested on Bus 29. Battery 1 is located at bus 28 and has a capacity of 29 MW, battery 2 is located at bus 23 and has a capacity of 30 MW, and battery 3 is located at bus 29 and has a capacity of 11 MW. To access loss performance, the algorithms are run with reactive power inputs ranging from 0 to 30 MVAR on both buses. In general, as the load increases, the loss value will also increase. **Table 1** and **Table 2** displayed the loss value before and after optimization using IICEP and the other two optimization techniques, EP and AIS when tested on Bus 26 and Bus 29 respectively. **Figure 5** and **Figure 6** show the results of the loss profile with respect to load variation on the IEEE 30 - Bus RTS. It demonstrates that it is worth implementing any optimization technique to integrate BESS for loss minimization. While EP and AIS perform similarly due to early convergence, the IICEP technique outperforms both. This is a promising indication of the success of the IICEP technique.

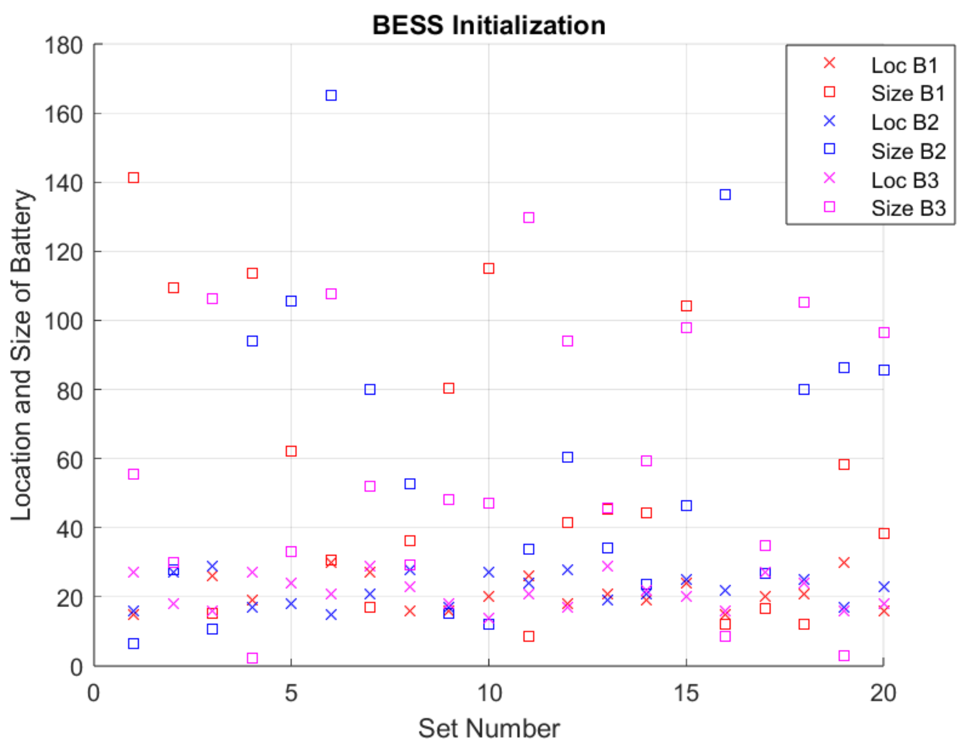

Figure 4. Scatter plot of battery placement and sizing during initialization process when reactive power loading is subjected to Bus 26

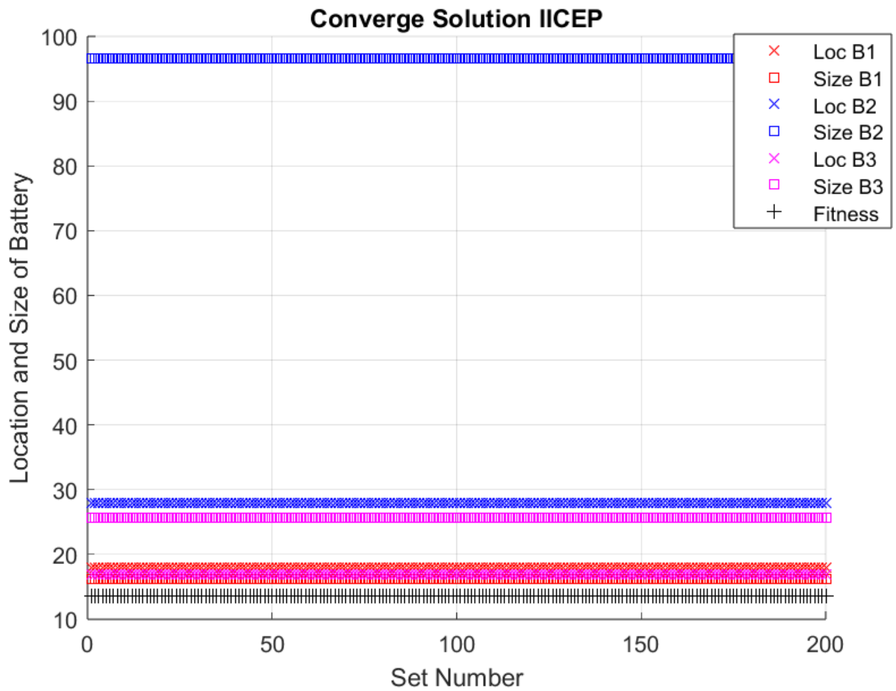

Figure 5. Converge solution for BESS placement and sizing, optimized using IICEP when reactive power loading is subjected to Bus 26 at load value 30 MVAR

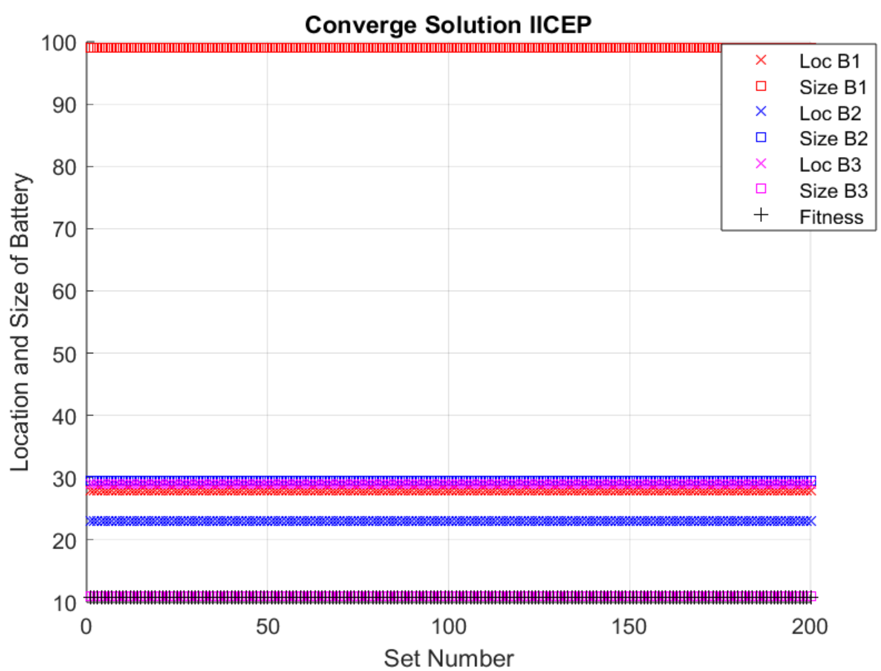

Figure 6. Converge solution for BESS placement and sizing, optimized using IICEP when reactive power loading is subjected to Bus 29 at load value 30 MVAR

Table 1. Loss Value Before and After Optimization at Bus 26

Load (MVAR)	Loss Set (MW)	EP		AIS		IICEP	
		MW	%	MW	%	MW	%
0	17.55	7.56	56.94	7.56	56.94	5.98	65.88
5	17.72	7.74	56.29	7.74	56.29	6.32	64.34
10	18.23	8.15	55.28	8.15	55.28	7.32	59.82
15	19.00	8.84	53.46	8.84	53.46	7.59	60.07
20	20.25	9.92	51.00	9.92	51.00	8.96	55.74
25	22.27	11.59	47.96	11.59	47.96	10.63	52.23
30	26.11	14.30	45.25	14.77	43.43	13.06	49.98

Table 2. Loss Value Before and After Optimization at Bus 29

Load (MVAR)	Loss Set (MW)	EP		AIS		IICEP	
		MW	%	MW	%	MW	%
0	17.58	7.60	56.80	7.60	56.80	6.25	64.44
5	17.73	7.77	56.19	7.77	56.19	6.89	61.12
10	18.12	8.07	55.45	8.07	55.45	7.06	61.02
15	18.62	8.54	54.13	8.54	54.13	7.49	59.79
20	19.39	9.22	52.42	9.22	52.42	8.14	58.02
25	20.53	10.20	50.34	10.20	50.34	9.09	55.71
30	22.44	11.59	48.33	11.59	48.33	10.40	53.68

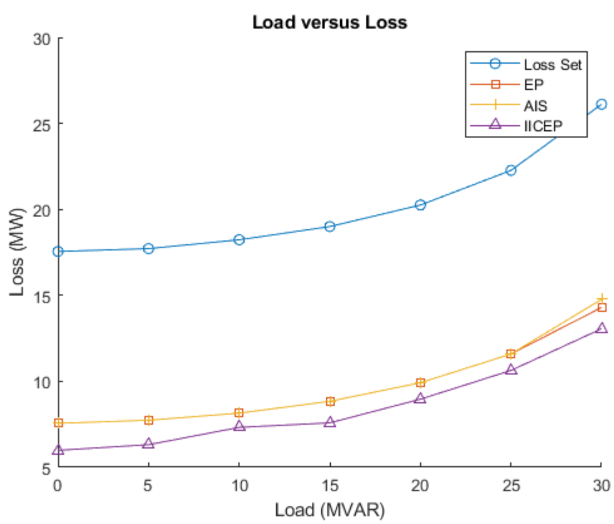

Figure 7. Comparison of loss profile among three different optimization techniques with its original loss set when reactive power loading varies from 0 to 30 MVAR at Bus 26.

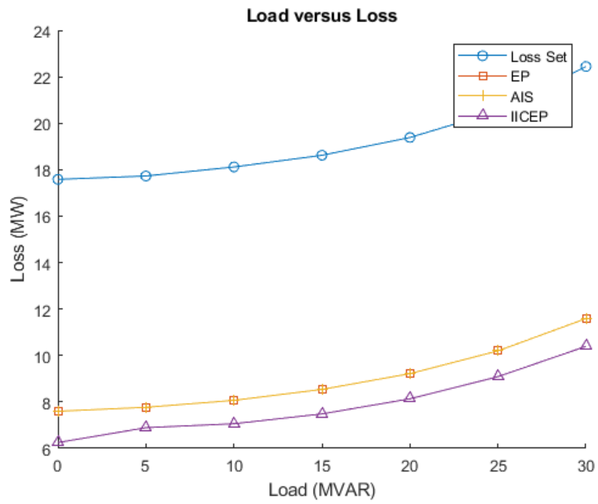

Figure 7. Comparison of loss profile among three different optimization techniques with its original loss set when reactive power loading varies from 0 to 30 MVAR at Bus 29.

3. Novelty and uniqueness

IICEP presents an innovative combination of optimization concepts that distinguish it from other optimization strategies. By integrating chaotic sequences with immune-based clonal selection, the technique creates a balance between global exploration and local exploitation, addressing the limitations of standard EP and AIS approaches. The chaotic aspect ensures diverse solution spaces, preventing premature convergence, while clonal process refines candidate's solutions with outstanding precision. IICEP easily adapt to complex and dynamic power systems. Its capacity to allocate BESS in optimal position with a proper sizing ensures maximum loss reduction. In addition, the technique scalability and adaptability make it a major advance in the field of smart grid technology. The performance validation against established technique proves its effectiveness, with loss reduction rates of up to more than 60% under various load conditions.

4. Benefit to mankind

The implementation of IICEP makes significant improvements to sustainable energy practices, addressing the growing global demand for efficient power systems. The technology promotes sustainability by minimising transmission losses, which can help improve energy efficiency. This improvement ensures reliable electricity delivery, which benefits both industries and homes. Besides, cost reductions obtained through operational efficiency are directly reflected in economic benefits for energy providers and consumers. Furthermore, the incorporation of BESS encourages the use of renewable energy sources, which aligns with worldwide initiatives to reduce carbon emissions and SDG-7 to ensure access to affordable, reliable, sustainable and modern energy for all. This innovation not only addresses technical issues, but it also promotes societal growth by providing access to reliable, inexpensive, and sustainable energy.

5. Innovation and Entrepreneurial Impact

The IICEP demonstrates innovation by employing advanced computational techniques to address critical challenges in electricity transmission. Its implementation encourages collaboration between researchers, industry and energy stakeholders, The technique's adaptability promotes innovation in related fields such as renewable energy integration and smart grid optimization. By addressing real-world energy concerns, IICEP promotes the development of market-driven solutions, allowing energy providers to profit from enhanced grid management technologies.

6. Potential commercialization

IICEP is ready for commercialization, with immediate applications in power system planning and operations. Its adaptable design allows smooth integration into current grid infrastructures, making it an appealing option for energy companies looking to boost efficiency through the use of BESS technology. The algorithm's scalability enables application in networks ranging from small grids to national transmission systems. Furthermore, the increased demand for energy optimization tools opens up a significant market opportunity for IICEP-based solutions. Potential commercialisation paths include licensing the technology to grid operators, incorporating it into energy management software, and providing grid optimization consulting services. With its demonstrated success and adaptability, IICEP has the potential to transform the energy sector.

7. Acknowledgment

We would like to convey our heartfelt gratitude to Universiti Teknologi MARA for providing the necessary resources and fostering an ideal research environment. Finally, we'd want to thank everyone who shared valuable information through their articles.

8. Authors' Biography

Nur Farahiah Ibrahim received her B.Eng. (Hons) in Electronics Engineering from Universiti Sains Malaysia in 2006 and Master of Science in Telecommunication and Information Engineering from Universiti Teknologi MARA in 2014. She is currently pursuing a PhD in Electrical Engineering, specializing in power system at Universiti Teknologi MARA. She has been a lecturer at Universiti Teknologi MARA Cawangan Sarawak since 2007. Her research interests include renewable energy, artificial intelligence and power system optimization.

Ismail Musirin received the bachelor's degree (Hons.) in electrical engineering from Universiti Teknologi Malaysia, in 1990, the M.Sc. degree in pulsed power technology from the University of Strathclyde, U.K., in 1992, the Ph.D. degree in electrical engineering from Universiti Teknologi MARA (UiTM), Malaysia, in 2005. He is currently a Professor of power system with the Faculty of Electrical Engineering. He has authored and co-authored two books, more than 300 articles in international journal and indexed conferences. His research interests include artificial intelligence, optimization techniques, power system analysis, renewable energy, distributed generation, and power system stability.

Nor Azwan Mohamed Kamari received his Bachelor of Engineering from Meiji University, Japan; Master in Science and Engineering from Ehime University, Japan and Doctor of Philosophy from Universiti Teknologi MARA. He is currently working as a senior lecturer at Universiti Kebangsaan Malaysia. He is a Technical Editor for Journal of Engineering and a reviewer of local and international journals. He is also a Professional Technologist under Malaysia Board of Technologists (MBOT). He has published more than 80 technical papers in international indexed journals and conferences. His areas of research are artificial intelligence, energy efficiency, power system stability and power quality.

Nor Zulaily Mohamad was born in Malaysia, on October 7, 1985. She obtained Bachelor of Engineering in Electrical Engineering from Universiti Teknologi Malaysia in 2007 and Ph.D in Electrical Engineering from Universiti Teknologi MARA (UiTM), Malaysia in 2017.Her research interest includes power system protection and power quality.

She is currently a senior lecturer at School of Electrical Engineering, College of Engineering in Universiti Teknologi MARA (UiTM) Shah Alam, Malaysia.