S.M.A.R.T. I-C-C Program

1. Background

The International Commerce Centre (ICC) is a 118-storey building developed by Sun Hung Kai Properties Limited (SHKP) and managed by its wholly owned subsidiary Kai Shing Management Services Limited (KS). For information relating to SHKP and KS' environmental goals, please refer to the sustainability report https://www.shkp.com/html/CSR/SHKPSReport/SR2018/index_eng.html). ICC is a composite building comprising office premises, restaurants, an observation and a hotel. The building has a floor plate of 3 million square feet (278,700 square metre) and over 86% of floor area is dedicated for office use. Everyday, 10,000 occupants of the building come and go to conduct various different kinds of economic activities reflecting the busy life of the vibrant financial center of Hong Kong.

With a large footprint, ICC has been designed and operated with a mission and goal of minimizing its environmental impacts. The building has many green features that can help to reduce resource consumption and carbon emission. In its daily operation, Kai Shing's ICC team is doing its best to implement a sustainable development policy to:

1. adopt the best property and facility management practices;
2. reduce the use of resources
3. organize activities and events to promote environmental protection.

Commercial buildings in Hong Kong and around the world have the highest consumption of energy and carbon emission. In the case of Hong Kong, over 90% of carbon emitted is attributable to buildings. As ICC is a landmark and the tallest building in Hong Kong, it shall set a standard in energy management and acting as an icon to lead the industry to combat the climate change.

'Environmental protection and energy management shall not be an act, but a habit', said K F Chan, the Managing Director of Kai Shing Management Services Limited, drawing on the wisdom of the Greek philosopher Aristotle. This aphorism from our company leader defines what the ICC team does in our pursuit for an environmentally friendly and sustainable property management policy. With ten years in existence, ICC is now stepping into the next ten years of operation. A S.M.A.R.T I-C-C program has been initiated to sustain the building performance. This program comprises two parts. The first part is an operational model based on the concept of Intelligence (I), Collaboration (C) and

Continuity (C). The second part of the program further elaborates the elements required to sustain the optimization of energy consumption of the building. By S.M.A.R.T., the following graph provides an overview of the meaning of the program.

S – Sustainability – the building's operation is fully sustainable based on the requirements of BEAM Plus and other international green building standards such as BREEAM and LEED.

M – Machine Learning – We shall continue to devote resources on establishing a data lake in order to collect a significant amount of operational data from the building facilities and building occupancy. The continuous generation of big data will necessitate the use of machine learning for the association of relevant factors for resources optimization.

A – Artificial Intelligence – We shall continue to conduct exploratory studies on the application of artificial intelligence. AI will be used for prediction, recommendation and automation of building facilities and process so that timely and automatic adjustment will eventually be deployed to further optimize the building's energy.

R – Research and Development – We shall continue to provide necessary resources to academics and universities to conduct researches that will develop cutting edge practices and technologies to further save energy benefiting the society.

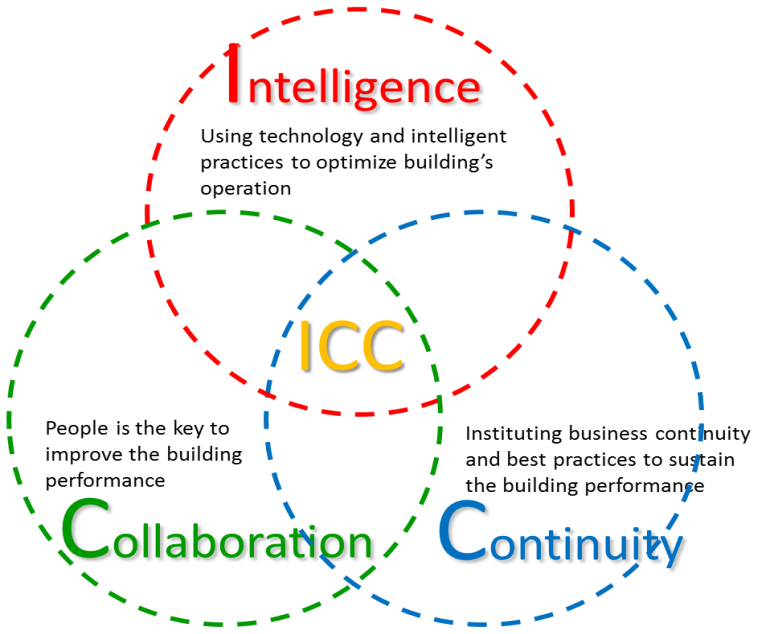
T – Training – People are the key to pursue the objectives of the building. General and specific trainings have to be conducted for staff members.

2. Systematic and Long-term Commitment towards Energy Management

In 2011, ICC was the first building in Hong Kong received the first ISO50001 Energy Management Certification in Hong Kong. Eight years till now, we have been sustaining this international standard as our guiding tool to manage energy use. In 2019, we are undergoing a renewing certification based on the latest ISO 50001: 2018 standard. The new standard has a tighter control over the

measurement of energy consumption and makes energy improvement as a primary target. The building has setup a dedicated team of qualified members to measure, monitor and conduct necessary exercises to manage energy consumption. This includes setting up goals and objectives, the energy management targets and establishing the energy baseline for comparison purpose. Based on this standard, we have set our target of reducing the energy consumption in 2020 by 15% as compared the baseline for the year from 2015. Up to now, we have advanced our saving and achieved this target in 2019.

The implementation of this standard has also motivated us to develop a building's operation model to fit the actual situation of the building. The ICC's operation model is shown below.



ICC is essentially operating at the optimal point where the three circles intersect with each other. The first circle is Intelligence. By Intelligence, the building shall make use of intelligent practices and systems to improve its performance and ultimately hoping to achieve a net carbon emission state. The energy management committee continuously drives the whole team about using new practices to do the same thing. Any major parts and components replaced shall have higher energy efficiency. "Thinking out of the box", using cutting-edge techniques and technology, is a clear objective of the management team.

The second circle is about collaboration. We cannot do everything by our own. Hence, we maintain regular communications with our stakeholders, consultants, partners and contractors about the best way to conserve energy. We have conducted a number of studies to promote the use of operational techniques to improve energy efficiency.

We have conducted energy audit on a yearly basis, which seek to exploit any energy management opportunities. We have engaged with a third party Registered Energy Assessor (REA) of the Hong Kong SAR to conduct the audit to review our energy use. This yearly audit, in addition to the ISO 50001 Energy Management Systems internal and external audits, has provided a lot of insights for the team to enhance the energy performance of the building. In particular, we have conducted several yearly-based programs to phase out obsolete lighting fixtures and fittings. These yearly programs help to conserve resources and replace the failed or less energy efficient equipment at the appropriate time without compromising our commitment to the environment for creating less waste.

After conducting one of the programs for several years, we now have over 90% of lamps in ICC are of the LED type. For an existing building which has over 10 years history, this program is the most appropriate and economical and environmental friendly program.

Besides, we have a strong collaboration with the local universities. We treat the building as a large scale laboratory, so that academics can put their theories into actual use. For instance, we have engaged with Professor Shengwei Wang, the Chair Professor of the Building Services Department of the Hong Kong Polytechnic University for conducting an exploratory study about energy optimization for chiller plants. Professor Wang has pioneered the life-cycle testing and commissioning approach, using actual operation data, helping the team to make informed choices about fine tuning and adjusting the operation parameters of equipment. This approach emphasizes the need to conduct commissioning not only at the time of handing over the equipment from the project team to the facility management team, but to continuously adjust the chillers and other equipment with significant energy use based on the actual operation. The use of the 'digital twin' approach to compare and contrast the energy consumption of chiller pumps help us to optimize the required chilled water temperature against the large scale chilled water pump is an example. The study changed the normal thinking that the higher the supply chilled water temperature, the lower the energy consumption. Instead, after taking into account of the overall large scale pump power, the higher temperature setting will cause the system to consume more energy based on the result. Instead, the energy shall be optimized based on the new algorithm, which balances the energy and chilled water supply temperature to achieve the true optimization. Through big data collected through the 133,300 building management system's observable point list, we have been making use of big data and artificial intelligence to analyze the data distribution pattern. Our next step will be deploying the machine-learning algorithm to learn and by phase adjusting the actual operational parameters based on this new technique. This step by step approach of technology deployment is especially useful for existing building projects with limited feasibility to make large scale upgrading of physical systems, which have burdens for the environment.

At present, we are working with our partner of exploring a 'Air Handling Unit (AHU)' reborn project. Usually, any failed parts of the air handling unit shall be replaced and the condition of the AHU could only be assessed by human eyes. In this project, we have linked this equipment wirelessly and implanted the AHU with sensors to monitor its condition. This gives a new life to equipment which previously could not by itself giving useful feedbacks. In some programs, we have also explored the use of permanent magnets motors in the form of electronically commutated (EC) plug-fan to further optimize the energy performance of a chilled air system. These results and programs are made possible through our collaboration with stakeholders of the building and the professional field. At present, we are conducting exploratory study based on the actual condition of the building, using AI and Building Information Modeling (BMI) to analyze the relationship between passive design and mechanical as well as electrical systems to optimize energy consumption. Sensors and detectors are installed wirelessly in different parts of the building to collect useful data and forming the data lake. In this way, we could examine the energy consumption pattern and adjust the operational parameters based on AI and machine learning techniques.

The final circle is about continuity. To achieve energy saving, we have to invest in training, forming partnership with professionals and stakeholders as well as dedicating our resources to support academics for conducting exploratory studies aiming to further cut down the energy use. These diligent and dedicated works require time and resources. As our company has a strong commitment towards energy management and environmental protection, we continue this practice throughout

the past decade. Every year, about 5% of the building operational budget is devoted to energy management and this commitment will continue in the next decades to come. In the past four years, we have also setup fund to sponsor the tall building research in the area of energy management, building design and building operation optimization through the international non-profit organization 'Council on Tall Buildings and Urban Habitat (CTBUH). This initiative together with the current research partnership with local universities shall bring benefits to the environment as a whole.

3. Strategy

Innovativeness

1.) What is the origin of this innovative technology/concept?

There are over 42,000 buildings existed in Hong Kong and account for 90% of energy consumption and carbon emission. While design and operation should go hands in hands, it is very often found that there are disparities between the two sides. As a landmark building in Hong Kong, ICC has the responsibility and goal to demonstrate how to make use of the 'S.M.A.R.T. I-C-C' model and the 'Life-cycle Testing and Commissioning' (LCTC) approaches to optimize energy use with existing equipment of the building. The ICC operational model and the LCTC approach is in contrast with the 'run-to-failure' approach very often seen in the market. Many equipment lacks proper maintenance and adjustment, causing high energy consumption and operational inefficiency and abandonment. The abandoned machines are then discarded and added pressure to the landfills and not environmentally friendly.

Through the S.M.A.R.T. I-C-C and LCTC approaches, we have developed over 20 strategic operational methods, cutting down energy consumption by 14% amounting to 14million kWh of energy over the past 8 years based on similar occupation condition. These strategic operational methods are documented in leading academic journals and articles for engineers making reference to. This benefits future design and construction of buildings by carrying out appropriate adjustments. In recent years, a number of new buildings have been built and existing buildings being fine-tuned based on these strategies.

Besides, the use of Internet-of-things (IoT) has significantly cutting down the needs for laying new cables and wires for connecting to the environmental sensors. Based on the low power, wide area network (LPWAN), technology in the form of narrow-band IoT, temperature, energy and indoor air quality sensors have been installed in different areas within the building. Thus, we have successfully collected and analyzed the data collected for making better choices of balancing indoor air quality data and energy consumption. The application of this new technique and technology has also open up new ways to cut down idle labour resources and material costs. The economic benefits through cutting down energy consumption can enable the building operator making use of the savings to conduct other building improvement projects.

2. Is the policy design innovative which can encourage financial support and public-private partnership?

Based on the Smart City Blue Print of Hong Kong issued in December 2017, the Government of the HKSAR encouraged all businesses in Hong Kong to embrace the benefits brought forward through

the application of new techniques and technologies. The use of building data for conducting adjustment in operational parameters leading to energy saving has broken the equipment's 'run to fail' operational practice which is prevalent among the building industry. ICC has successfully demonstrated that energy saving could be achieved through analyzing the operational data of the building and conducting predicative maintenance strategy. Resources could be optimized as compared with the trade practices in the past.

Inspiration

1. *Can this idea inspire/subsequent cases?*

Very often, people perceive existing buildings as aged facilities with less than optimal efficiency in their operation. Systems are continued to run until their failure. The Life-cycle of facilities is short and the abandonment of those systems and equipment has brought pressure to the environment of Hong Kong. By detailing the history and operational practices of ICC, other stakeholders in the society can read the ideas and see the actual performance of the building. The transparency of ICC has set a good standard of revealing operational data. There are already new and existing buildings adopted the 'demand control' variable (DCV) approach piloted in ICC to adjust the fresh air supply to office premises and achieve significant energy savings. The AHU re-born project with suitable IoT sensors instilled in the existing equipment has cut down unnecessary labour efforts and materials. The strategies developed in ICC are especially applicable to commercial buildings in Hong Kong and around the world.

2. *What domains have been enlightened by this policy?*

Through various different sharings and documented information available to the public through the World-wide-web, public talks and property visits by developers, engineers and owners in the mainland and other western countries, ICC's operation model and energy saving attainments have been communicated with different level of people. There have been over 3,000 visits conducted in the past decade. We have shared our practices with Government officials, energy specialists, engineers, architects, facilities managers and other supporting staff in Hong Kong and overseas states.

Clearness

1. *Are there any open and transparent channels of public communication?*

We have participated in the Hong Kong Government's 4-T program (Target, Timeline, Transparency and Together). One of the requirements of this program is to make known of the building operation to the public through various different means. From time to time, we have published our energy consumption and updated the information after verified by our appointed registered energy assessor. We share with thousands of visitors about our energy information and strategy in achieving energy saving through our various optimization program. We report our energy consumption also to tenants and occupants throughout the building. We have published our achievements through the property's dedicated website.

2. *Are there any differences between this policy and other similar policies?*

We emphasis the importance of making use of intelligent practices, new techniques and technologies, collaborating with professionals and various different parties as well as continuously

keeping track of the best practices in the industry. This S.M.A.R.T. I-C-C model has proven to be a right approach towards sustainability. This is in contrast with the very often seen 'run to fail' equipment approach prevalent in the industry. With a clear approach towards energy management and environmental protection, the S.M.A.R.T. I-C-C approach is an applicable and feasible approach for all types of buildings.

4. Measure

Practicability

1. *Has any effective measures for moving ahead been made?*

The Smart City Blueprint of the Hong Kong SAR Government has a strong commitment towards using smart technologies to improve the life of citizens. The 4-T, namely, target, timeline, transparency and together have transformed the current trade practices of the industry. The energy management initiatives put forward by ICC has a strong emphasis on the applications of intelligent techniques and technologies, promoting the need for collaboration and continuity. Not only does this model coincides with the Government's initiative, the ICC operation model starting from a decade ago has gathered together important data and tested results, thus providing useful and insightful references to the industry. The Life-cycle Testing and Commissioning approach promulgated by the energy optimization team throughout the last decade has become the main stream of maintenance practice through the Government's promoted retro-commissioning maintenance practice. Now, building owners and operators in Hong Kong are focusing more on the operation aspects of the equipment instead of solely focusing on the replacement of equipment.

2. *Are there any numerical goals for reference?*

Since 2015, we have started yet another 5-year energy saving target plan. We plan to save 15% of energy compared with our baseline by 2021. This is equivalent to 6.9 million kWh of energy.

Reliability

1. Can the ideals, methods or techniques be applied internationally?

The SMART ICC model can be applied internationally. The model is developed based on the operational experience of ICC and can be applied in any other buildings in the world. This model is particularly suitable for applying to the operation of commercial buildings. We have communicated this model to the public through our written submission to the World Sustainability Conference in Hong Kong in 2017 and presented the ideas with the participants of the conference.

During our pursuit of energy optimization, we have identified several operational algorithms of the chillers. This includes a new chiller sequencing control method[1], peak demand electricity control

[1] Shan, K., Wang, S., Gao, D., & Xiao, F. (2016). Development and validation of an effective and robust chiller sequence control strategy using data-driven models. Automation in Construction, 78-85.

algorithm[2] and air handling unit temperature reset strategic operation. These operational algorithms have derived significant energy savings according to our experience. At present, we have applied the big data approach with the use of IoT sensors on collecting environmental data. The use of IoT on collecting data enables a flexible data streaming method. Unlike in the past where we have to rely on wires and cables, a IoT device can feed data to the server with little efforts. This also enhances the application of machine learning and artificial intelligence approach towards the operation of lifts, lighting and air conditioning systems. Although these methods are still at the exploratory stage, we have already seen some benefits out of it. For instance, we have used the Artificial Intelligence – IB Manager helping us to analyze the use of water condensers and sequence of its operation. We have also made use of this system to analyze and automate the operation of fresh air control based on a number of environmental factors and occupancy level. These methods and results are highly replicable to other buildings in the world.

2. Are there any specific SOPs or responsible organizations?

We have published over 20 papers based on the collaboration with the Hong Kong Polytechnic University. In addition, we have also advanced our use of IoT through our collaboration with prominent telecommunication company in Hong Kong and research academics. These SOPs could be obtained through the public domain and our sharing sessions with the public. Over the past years, we have conducted over 100 sharing sessions with professionals and developers in the field at no cost. Other parties could apply our published strategies without having additional royalties and fees. We believe this collaborative approach is the best way to promote the use of intelligent and smart approach on energy management and can contribute towards the reduction of carbon emission and climate change.

Cost –effectiveness

1. Will it be cost effective to implement?

In implementing the S.M.A.R.T. ICC project, we have been carefully estimating the cost of each project and work. Overall, we have been able to save a significant amount of energy and carbon emission. Up to Jan 2019, we have saved 14.87 million kWh amount of energy and equivalent to HK$14.87 million. The collaboration with our partners also greatly benefits the environment and this is beyond the monetary value of the work.

2. Is there any measurable reduction of emissions or energy use?

Our goal is to reduce the energy intensity and consumption by 6.89 million kWh from 2015 to 2021. Since our implementation of the ISO50001 Energy Management Systems and our collaborations with our partners, we have saved 4.48 million kWh of energy and this is equal to 3,136 Ton CO_2.

Consistency

1.Are adopted measures consistent with energy policies and strategies?

The S.M.A.R.T. ICC model is to make sure we run the building based on our objective of minimizing the environmental impacts. Through setting up target, utilizing and exploring technology,

[2] Shan, K., Wang, S., & Tang, R. (2018). Direct chiller power limiting for peak demand limiting control in buildings—Methodology and on-site validation Kui Shan-Shengwei Wang-Rui Tang - Automation in Construction - 2018. Automation in Construction, 333-343.

collaborating with our partners and stakeholders based on the operational model, we have been able to meet with our goals.

2. Are there any long-term measures or implementing organizations for this project?

As a landmark building in Hong Kong, the special status of ICC is to showcase how sustainability and profitability can go hands in hands together. The S.M.A.R.T. ICC model is essentially a triple bottom line model emphasizing the importance of striking a balance among People, Place and Profit. With a vision of becoming a centurial project, ICC has setup different programs spanning short, medium to the long term to demonstrate how technological evolvement could be meeting the business objectives.

5. Performances

Completeness

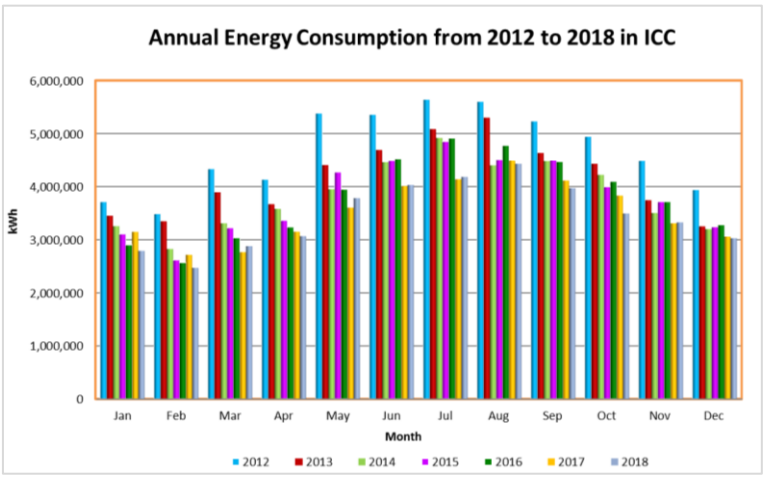
1.Is the achievement scale measurable?

All the energy savings are calculated according to the electricity bills issued by the Power Company of Hong Kong. The energy savings are also verified by the Registered Energy Audit Assessor. In projecting our future energy consumption in setting our target, we make use of past statistics as well as statistical analysis and inferences based on actual historical data.

2. Will it make considerable success in project goals?

The energy saving performance of ICC is exceptionally good. During the past years, we have shared our experiences with a great number of internal and external parties. Not only does the energy saving target be fulfilled, we are honored in receiving recognitions from international organizations such as the Council on Tall Buildings and Urban Habitat (CTBUH), the International Facilities Management Association (IFMA), the International Workplace Management Association (IWMA), the Hong Kong Environment Bureau's Energy Saving Championship 2016 and 2017.

Verifiability



1. Are there any data presented to support the project

All the energy saving data can be verified by the third party. We have a transparent disclosure policy based on the Hong Kong SAR Government 4-T strategy and all operational data is comparable to the previous years based on the same criteria.

2. Are there any supportive measurements or references for the provided data?

We are pleased to provide with you with our verified energy assessment report, energy bills as well as research papers documented by the Hong Kong Polytechnic University for your references. We are pleased to offer site visit to the jury panels to further verify our work and initiatives.

Impacts

1. Will it make a significant change in the field of energy efficiency and energy savings?

By demonstrating the actual benefits of applying data analysis, life cycle testing and commissioning as well as using IoT technology to conduct energy saving, we are driving the industry towards the application of intelligent methods in saving energy. The experience of ICC in applying energy saving strategy to achieve actual saving has shown a strong case to the public that energy saving is not only for new building but can also benefit existing building.

2. Will it impact multiple operational areas or just one specific area?

Energy saving is a territory-wide initiative. The current program of ICC of conserving energy based on the S.M.A.R.T ICC model has yield a significant energy reduction as well as actual monetary gain. This is a true example of how energy saving can be blended into businesses and benefited the public as a whole. With the strategies developed being shared, more and more existing buildings in Hong Kong have started to look into similar ways as ICC to conserve energy. In particular, there are a number of projects have started to operate the chiller sequencing control and using IoT to collect environmental data helping to optimize energy consumption.

Matrix of Criteria for Appendix - ICC-ESCI Award Supplementary Report

STRATEGY			Cross-reference	Remarks
Innovativeness	I	Is the innovative concept come from the project itself or other existing programs?	Report page 4,5,19-23,25-31, 39	The concept is come from company missions and visions as well as support of Government
	II	How the innovative policy design encourages financial support and public-private partnership?	Report page 26,28,36, 41,62-93	- Page 28 & 29 : collaboration with different partners - Page 62-93: highlighted projects for public-private partnership
	III	How does the innovative concept catch the trend of future development?	Report page 24-27,30-39, 68-99	Page 62-93: highlighted projects for IoT, RCx & renewable energy application
Inspiration	I	Whether the idea can inspire later/subsequent cases?	Report page 36, 48-55	
	II	What domain has been enlightened by this policy?	Report page 36,38, 57-58	
Clearness	I	Is there any open and transparent channel of public communication?	Report page 48-55	
	II	Is there any difference between this policy and other similar policies?	Report page 18-31	

MEASURE			Cross-reference	Remarks
Practicability	I	Has any effective measure for moving ahead been made?	Report page 19-23,36, 39-40	
	II	Is there any numerical goal for reference?	Report page 5	
Replicability	I	Could the ideas, methods or techniques be applied internationally?	Report page 36, 48-51,57-58,107-117	
Cost-effectiveness	I	Will it be cost-effective to implement?	Report page 36, 92-99	
	II	Is there any measurable reduction of emission or energy use? Please describe the measurement method.	Report page 92, 101-105	
Consistency	I	Are adopted measures consistent with energy policy and strategy?	Report page 23,34, 36, 38,68-99	
	II	Is there any long-term measure or implementing organization for this project?	Report page 19-23, 30-31,37-41,51	The long-term goal of ICC is smart building development

PERFORMANCE			Cross-reference	Remarks
Completeness	I	Is the achievement scale measurable?	Report page 92, 103-105	
	II	Will it make a considerable success in project goals?	Report page 92-93, 105	
Verifiability	I	Is there any data presented to support the project?	Report page 92-93, 104-106	
	II	Is there any supportive measurement or reference for the provided data?	Report page 92-93, 104-106	
Impact	I	Will it make a significant change in the field of energy efficiency and energy saving?	Report page 36, 104,107-109	Page 104: Display of the EUI performance
	II	Will it impact multiple operational areas or just single specific area?	Report page 36, 48-51,112,119	