The Pre-Process of Smart Grid Algorithm Design For Network Centric Air Operation during Crisis Management

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***Abstract*—From the COP21 Paris Agreement 2015, the committees have agreed to reduce the energy consumptions that are produced from coal and fossil. As in effect to the developing countries as similar as the Association of Southeast Asian Nations (ASEAN) because these energy resources are still used widely and high demand for supporting micro-economic level. Furthermore, the coming ASEAN challenge is how to cooperate and sustain the energy assurance against with a disastrous crisis that has created the non-stabilize electrical power has fed into the essential infrastructure of network centric operation (NCO) as well as degrading military operation other than wars (MOOTW) and Humanitarian Assistance and Disaster Relief (HADR) capability. The smart grid is one of the ways out for trouble shooting by effective renewable energy management in Thailand. By the way, the key energy management system (EMS) is a reasonable algorithm which shall be designed to properly recognize the core of the essential demand response and understanding the renewable energy characters are inflexible and unpredictable. The proposed study approach is how to maintain air operational capability, energy assurance, and human assistance during humanitarian catastrophe. The HADR mission requirement, the NCO concept, and the five rings model is mainly integrated into the specific design of smart grid development tool. The results of study indicate energy assurance design model that is able to secure the essential of air operational process failures on the significant NCO concept which is improved by Smart Grid.**

***Index Terms*—Association of Southeast Asian Nations (ASEAN), Energy assurance, Energy Management System (EMS), Five Ring Model, Humanitarian Assistance and Disaster Relief (HADR), Military Operation Other Than War (MOOTW), NCO (Network Centric Operation), Renewable energy, Smart Grid (SG)Introduction**

I. INTRODUCTION

When the world is Flat [1]. The data feeding is shorter time and faster reachable that compares with the past. Network Centric Operation (NCO) is the one technology of operational information advantage management in the 21st century. Mostly, the backbone system be run through Information and communications technology (ICT) [2] which is needed more robust electrical power supply on demand side. Usually, the positive load is supplied and connected to feeder grid. However, during the disastrous attack (for example, floodor tsunami.), It's possible to loss of power, blackout, brownout, surges and transient. It means the NCO can't operate perfectly. It may cause lack of advantage during the war as well as loss of MOOTW and HADR operational effort during peace time operation.

Generally, the backup power system installations are supported by traditional trend such as gas turbine generators. In the current day, our world has climate change crisis challenge. The important agreement was delivered strongly from "Paris commitment" COP21 conference 2015 [3]. The main issues were climate change, how to reduce carbon credit footprint and replace fossil energy by using renewable energy as much as possible. Nevertheless, anything has pros and cons. Cons: renewable energy has specific characters that are inflexible and unpredictable, but Pros [4-Logica]: we can control them by smart grid for now.

On research, we found some smart grid potential that is able to apply to sustain Network Centric Operation Energy Assurance. For example the study case in Thailand, Methodology is integrated standard IEEE design model with Government Policy [5], Thailand Smart Grid Plan 2015 [6], Regulation [7], Traditional and Altered Five Ring Model [8], UN HADR Guideline [9], USAF Energy Strategic Plan 2013 [10], and Local Private IPP Sector policy [11] to ensure the core of NCO capabilities are able to operate safely with island and hybrid mode under any energy crisis situation as well as cyber security.

II. DEFINITIONS

Network Centric Operation (NCO) [12] is a near/real time operational command and control (C2) through the information and communication technology (ICT) to dominate the battlefield as well as the Chain of command is able to maneuver the OODA loop concept to take the information advantage over the threat.

Military operations other than war (MOOTW)[13] is the military operational maneuvering commences the forces that is focused on peacekeeping, peace building, humanitarian assistance and disaster relief. Alternately, in the UK Military definition is peace support operations (PSO) [14]. In case of no bilateral agreements and action may be required, the action enables us to establish agreement based on the situation [15]. Disaster Relief (DR) [16] means the immediate need assistance to effected disaster-communities

Humanitarian Assistance (HA) [16] means conducting the relief or reducing activities on conditions of disease, hunger, human pain, or privation that might be a threat to life or result of super severe damage or property lost.

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Acronyms
BEMS – Building Energy Management System
CEMS – Community Energy Management System
DER – Small-Scale distributed generation (DG)
DR – Demand Response
DSM – Demand Side Management
EGAT - Electricity Generating Authority of Thailand
EV – Electric Vehicle
FEMS - Factory Energy Management System
GHG - Greenhouse Gas
HEMS – Home Energy Management System
IEEE – Institute of Electrical and Electronics Engineers
MEA – Metropolitan Electricity Authority
PEA - Provincial Electricity Authority
RE – Renewable Energy
RTP- Real Time Pricing
SG – Smart Grid
SMEs - Small and Medium Enterprises
TSO – Transmission System Operator
VPPs – Visual Power Plants

III. BACKGROUND AND CHALLENGE

A. Background

In the current day, our world needs more energy consumption. From the COP21 Paris Agreement in 2015 [3], the key leaders motivate the committees how to generate green energy in the next decades. The climate change and CO2 footprint problems are the main discussions. The conference committee has agreed to reduce the energy consumptions from coal and fossil productions. In terms of national security, the coal and fossil energy resources are still very important for developing country economies such as the Association of Southeast Asian Nations (ASEAN) [17]. The four coming threats are the first is the most of electric powers are supplied from coal power plants that are contrasted with the green energy concept, the second is the unbalancing between supply sides and demand response sides, the third is the most of national grids are not smart two-way communication enough, and the last is the instabilities of power grid feeding. Energy Assurance is an enormous challenge mission for the next generation of military operation during wars and other than wars [18].

In present day, we believe in ASEAN concept and progress forward together. It means no real war and fighting between countries. The ASEAN military operations are peacekeeping forces and humanitarian assistance [19]. The possible threat is climate change effect. Most likely during the population displacements in this region is caused by severe weather and natural disasters (example, flood, tsunami.), it is possible to create electrical power loss consequences due to supply system damage that be degraded the chain efficiency of command and control, communication system and "Big data and the OODA Loop decision making model [20, 21]" as shown on figure 1. Those are used to conduct military operations via network centric operation (NCO) [22] concept. Smart grid is the innovative way out which is able to manage renewable energy for solving out and increasing redundancy of energy sustainability assurance [10]. However, the energy management system algorithm is the key which has to be a proper design to analyze the core of essential demand response areas because the renewable energy characters are inflexible and unpredictable [4]. In addition, algorithm design criteria shall ensure its safety, security, and protection from blackout, brownout, surge and transient scenarios. Likewise, the real time energy management capability is enabled to assure the automatic selection of power source fed into the infrastructure by the five ring model theory [8]. According to researcher's background experiences in aviation business. Hence, the focused study approach is how to develop the smart grid design concept for maintaining air operational capability, energy assurance, and human assistance enables during humanitarian catastrophe. Meanwhile, the Humanitarian Assistance and Disaster Relief (HADR) guideline, the NCO concept and the five ring model theory are implemented into design criteria. The results of this study clearly indicates the essential energy assurance and system protection based on the significant NCO concept and the new developed algorithm.

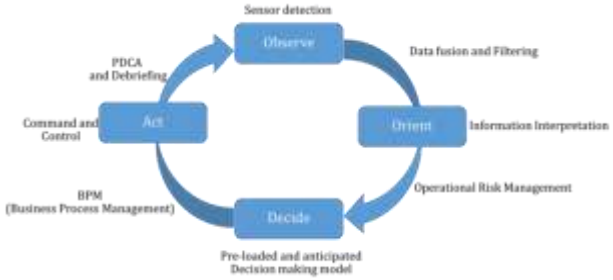

Fig. 1. Adaptive OODA loop concept of decision making of fighter pilot to business process management (source: Chris Taylor (2013))

B. Challenge

From the literature reviews from ScienceDirect about the policy options and international experience [23] as Figure 2 International experience of distributed energy development. The challenges of smart grid development are needed to move forward with situation awareness into three areas as follows: 1. Development goal, 2. Macro-level, and 3.Micro-level. Most likely issues, the challenge barriers are similar to Thailand condition.

Fig. 2. International experience of distributed energy

development (source: ScienceDirect; Clean distributed generation in China: Policy options and international experience).

First, the development goal has two challenges in the official released legal system and policy planning those had just supervised about the smart grid vision, aims, and objectives. Even though, the legal was deregulated to allow consumers can install own rooftop PV system individually with no additional installation permit document that is referred to Royal Thai Government Gazette 2013 [24], Energy Regulatory commission (ERC)[25], and Provincial Electricity Authority (PEA)[26], but still having no more new trade options contract in electricity purchased law and power supply law. That is a risk for power users who are supposed to commit the renewable energy lifestyle without demand response-knowledge based. They might produce the electricity beyond the exactly demand and creating the overflow back unintentionally into on-grid feeder what it means they did illegal. In the same way, the current policy plans are provided from Government and Ministry of Energy on 12 September 2014 [5], Energy Policy & Planning Office(EPP); Thailand Power Development Plan- PDP2015 [27], Draft Energy Efficiency Plan-EEP 2015 [28], and (Alternative Energy Development Plan-AEDP2015 [29] and Energy private sector such as EGAT [30] and PEA [31] still under the pilot projects that are focused on HEMS, BEMS, CEMS, DR, Micro-grid, and Storage from now to 2021 and Phase 2 will start Real Time Pricing (RTP) solution after 2022.

After that, the second challenge is the Macro-level that are composed with 4 aspects. The total of big picture after midyear 2015, that had many local brand news started up the renewable energy SMEs, for example SENA group started up a solar rooftop business to be associated with ex-business in real property [32], or the fact sheet of solar power from Kingdom of the Netherlands explained the growth of Solar business in Thailand that was shown the forecast of solar and electric power generating capacity will increase from 1,579 MW from 2014 to 6,000 MW in 2036 [33]. The financial loan is the only one clearly benefit. Some of financial institution promoted the separated low interest rate for interested customers with a long term commercial loan that is named The K –Energy Saving Guarantee Program (Solar Rooftop). Such as a Kasikorn bank provides a 12 years and 100% financial amount investment to pay by contract instalments [34]. In contrast, the other are consisted of tax subsidies, grid connection techniques, and market regulation there are still in the process to set up the certain proportion. Especially from Ministry of Energy's smart grid roadmap [6], the grid connection techniques are studying the standard interoperability development and pilot project during 2017 to 2023 [35]. The line of business productions is expected to launch after that.

Lastly, in terms of the Micro-Level were in process and tracking the progress of research and development which found the most of in-handed productions were emphasized to supplier sides more than the demand side. These mostly were from power generation enterprise and power grid enterprise. The interesting case of energy enterprises as follows:

First, PEA's micro-generation pilot project at Mae Hong Son green smart city [36], the proposed concept is aimed to 1. Supply Side; Accommodate high penetration of RE (mainly micro-hydro and solar photovoltaic) and GHG emission reduction, 2. Operation Side; Improved reliability and power quality (voltage regulated) with fast fault isolation and system restoration, and self-sustainable Micro-grid enables during a disaster (only for a mudslide, and wildfire scenarios), and 3. Demand Side; Pilot DSM/DR monitoring with smart metering in government buildings and hotels for enhanced reliability. The final solution will be toward Net zero energy, and Net zero emission capability, except at least limitation during high water season with some additional DER, and the another energy enterprise case is Electricity Generating Authority of Thailand (EGAT) pilot project at the Thap Sakae community at Prachuap Khiri Khan Province [37]. That proposed to the Ministry of Energy intends to develop the renewable energy instead of coal power plants or big power plants. By the way, the most of the alternative energy development in the present was non-firm power plants. The base load power plants come from 1,500-2,000 MW renewable energy power plants, especially firm biomass power plants in the same proportion of renewable energy development, whose cost would become the burden on the electricity users, not on the renewable energy producers. Conversely, the micro-level development from power users that has just concentrated only the installed smart meter monitoring.

IV. HYPOTHESIS

In this study, the directional hypothesis are assumed if engineering the smart grid design with this new implemented concept, then the NCO's energy assurance will be better sustainable than the current system and able to maintain the prioritized operation enable and security automatically. The final stage test uses the HOMER®Microgrid Software [38] to evaluate the simulation harmoniously, optimization and sensitivity analysis. This paper will be explained only the steps of smart grid design without the result of software testing and the classified information.

Remark: The know how to integrate the added-on concepts, theories and tools deeply into algorithm design is patent of researchers who own this paper.

V. METHODOLOGY

The main methodological objective is to study how to increase energy assurance for CEMS and military NCO's operation ability in the national strategic level (Macro-level).

Because one of the researcher has the ex-fighter pilot background. For this reason, the originality of design steps was inspired from the automatic redundant of fly-by-wire [39] system in the modern fighter aircraft. As its smart flight control computer shall respond to monitor, manage, reconfigure the aircraft stability automatically whatever any worst condition. In the same way, before the fighter pilots had gone into the battle, they always study their planning thoroughly with deeply risk management [40], threat analysis

[18, 41], effect based of operation [8], policy and restriction [24]-[31], security [42], and safety above all [43].

Beforehand, the smart grid standardization roadmap has focused on term of the safety, security, and self-healing with robust connectivity and interoperability enabled. But it's not enough for the worst case scenario "disaster attack", its effect may create the collateral worst consequence to the electric national-grid, for instance; totally blackout, brownout, etc. From IEEE power and energy magazine, journal "Challenges and Opportunities in Power System Security, Resiliency, and Privacy" [44], its meaning we need the power delivery system is existed unstable to both natural disasters and intentional attack. The future coming threat is a terrorist who attempts to strike into the cyber-grid system that could have adverse effects on national security, the economy, and the people living. The next fundamental of the national and international economic systems, security, and quality of life are how to secure and reliable operation of the electric system. It means we need to think more than the past, willing to hope energy sustainable keeping, and developing innovation to control the potential uncontrollable factors. Especially the military responsibility, the duty is national security and people life protection whenever is not a matter wartime or peacetime. That's why the whole of additional items is integrated into this research methodology.

In terms of military management level [45] is classified by level of war, it defines to 3 levels that consists of tactical level (local/area management level), operational level (micro-management level), and strategic level (macro-management level). Each level is involved with planning (strategy making), which concerns analyzing the situation, estimating friendly assets and hostile capabilities and limitations, and decides possible courses of action (COA). Analogous to the all war levels and conflict are impact of desired grand strategy. Therefore, a key to success in all situations is the rapid adaptability with situation change and to exploit transient opportunities rather than adhering strictly with a predetermined COA. The ability to adapt and exploit requires extraordinary judgment, feeling the situation, and knowing what and how to do it next. Judgment training is the art of war at any level.

The new implemented methodology, the researcher named it as the "RRSSQ" 5 step design model as figure 3. From application above, If comparing with The RRSSQ design concept, the researchers bring the military planning concept into the smart grid design method as well as wish the end-state of employment will be impacted to a big picture of energy management in national strategic level during critical situations, That RRSSQ stands for R-Risk Assessment, R-Regulation and Policy Restriction, S-Safety, S-Security, and Q-Quality Assurance to let us user can remember the steps flow easier. How to start up as steps:

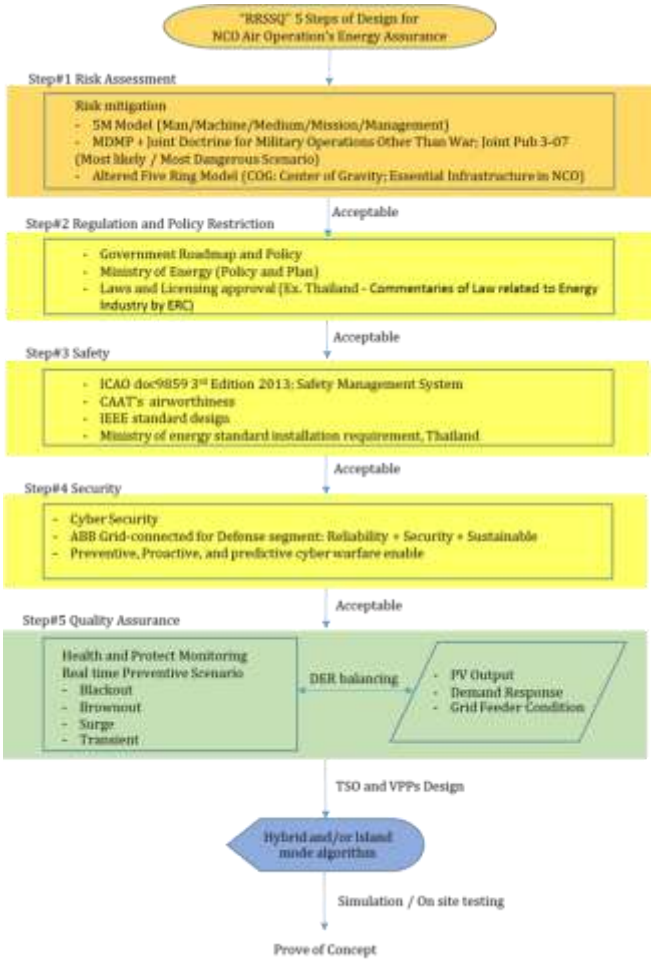

Fig. 3. The "RRSSQ" 5 step design model for NCO air operation's energy assurance

STEP 1 Risk Assessment

The First step is always the most important. In this Step, starting up the pre-process of design for NCO's energy assurance by identifying the severity and frequency of risk. The conceptual design idea of researcher was applied from the literature review of U.S. Air Force Energy Strategic plan 2013 [10] to fit the national norms. Attempting to take time to study risk deeply and making the robust mitigated design. The tips are as follows:

1.1 5 M Model

This step is used to encountering a threat that is analytic risk/hazard with a 5 M model assessment. The most common 5M model in the aviation industry that comprises of Man, Machine, Medium, Mission, and Management [40] as figure 4. The five core areas that is a failing factor of accident/incident may appear in. It provides managers with a systematic way of focusing and analyzing areas where errors mostly occur within the structure of Distributed Generation (DG) allocation. To sustain smart grid performance, the Machine and Management are mainly area for solving solution and achieving missions as reference as the smart grid concept is "Connect and Manage" (Smart grid for dummies, 2010-Logica)

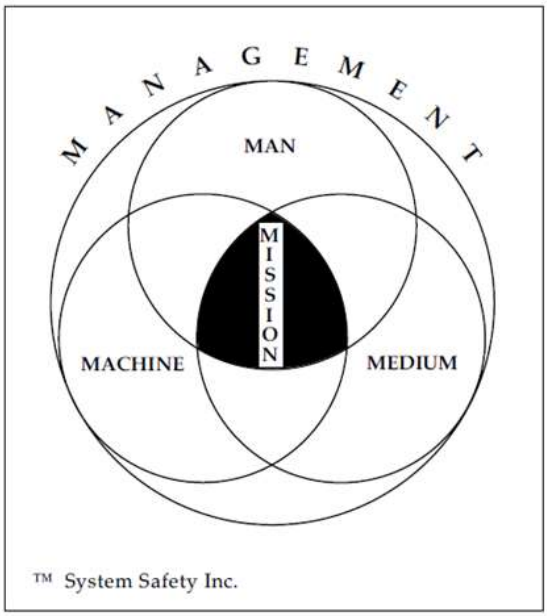

Fig. 4. 5-M Diagram (source: Fight Safety Foundation; Flight Safety Digest, May 1991)

1.2 MDMP and Joint Doctrine for Military Operations Other than war, Joint Pub 3-07

"Know what…Think sharp and fast…Act precise on time". From 5 M model that is used to identify what/where the threat is from. The next step, analyzing deeply how to maintain operational assurance by answering the question 5W1H (What, Who/whom, Where, When, Why, and How). The requirement of smart grid algorithms must have time-constrained, information advantage, two-way communication, flexible, and contingency plan (Plan B, or more) to support the operational needs. The Implemented Idea was coming from the Military Decision Making Process (MDMP) and Joint Doctrine for Military Operations Other than war, Joint Pub 3-07 that are the well-known Military Standard.

MDMP [46]-[47] as well as the decision-making process in a time-constrained environment. That is a United States Army process for military decision-making in both tactical and garrison environments. It is indelibly linked to Troop Leading Procedures and Operations orders. Decision making is knowing if to decide, then when and what to decide. It includes understanding the consequence of decisions. Thus, if the smart grid algorithms are supposed to maintain grid efficiency, the community energy management system (CEMS) shall manage the energy to the right place and the right time including with a flexible alternative plan. But it's not robust enough, the CEMS shall maintain all sensors to observe and orient the essential information and transmitting two-way communication to command and control (C2) center to conduct the HADR Recovery Operations. For example, in case of the disaster Recovery Operations. The smart algorithm must support energies to the DR of recovery operations cell and able to conduct search for (Joint Pub 3-07, Command and Control (C2) page IV-4IV)(18), locate, identify, rescue, and return personnel or human remains, sensitive equipment, or items critical to national security. Similarly, energizing the DR of Command and Control (C2) cell keep working best for all MOOTW. Sustaining the interoperability of communications systems is critical to the success of the operation.

During a disastrous situation, the routine communications may be disordered. The civilian systems may be unserviceable, the military may only one hope to have the communications equipment available. Accordingly, the smart grid must have its own artificial intelligence algorithm that is able to rearrange energy supporting flexibly between demand and supply under most likely and most dangerous scenarios.

1.3 Altered five ring model and Sixth Ring model

Lastly, using the altered five ring model [8] as figure 5 to identify and strength what is the essential infrastructure of the NCO's center of gravity (COG) and creating the mobility and invulnerability features into the smart grid. During the wartime and peacetime, the important COGs are always the sources of energy supplies (such as large scale power plants, runway, or tank farm) which will be distracted or shut down to reduce opposite combat capabilities. At the other disastrous crisis time, the command and control headquarter, emery medical center, and ICU room are very essential demand response for maintaining the positive humanitarian assistance. Nevertheless, Thailand grid-feeders have the typical characters that are often created non-stabilized voltage, especially when during severe weather conditions. These may create the cause of blackout, brownout, surge or transient situation in the grid. For this reason, the weakness was analyzed from 5 Ring model was the key infrastructures, these were designated as main DR of OODA loop system (Sensor, Shooter and Decision making chain).

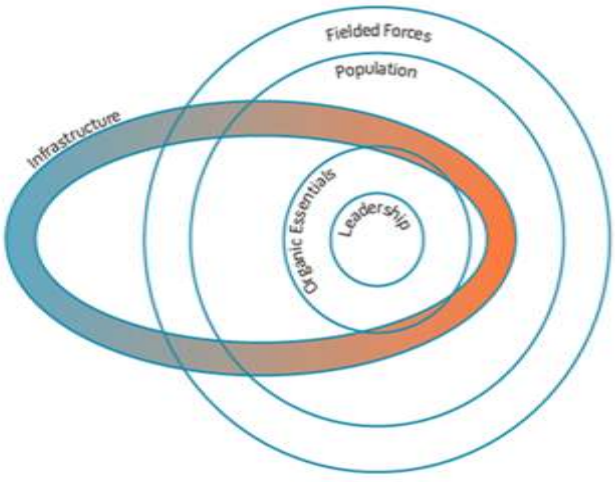

Fig. 5. Altered Five Ring Model (Source: Michael W. Pietrucha, Ref. [8])

Pietrucha (2014) [8] described this modified model from the traditional Five Rings model that defined energy and fuel as system essential on a second ring, but the energy is the Sixth Ring as fig. 6 is instead the modified model brings

energy from the second ring and transmission infrastructure from the third ring, summarize them into a single output and distributing to connecting layer. Intending to project the power to support the capability of the on-scene forces.

Tips: Consumption and distribution of energy change during wartime. The energy usage is shifted by a modern military is essential part and virtually instantaneous. In the event of a disaster, the energy ring is likely disrupted. A country's energy generation and distribution were incentive away from their steady state, are vulnerable to further disruption by a preplanned algorithm.

Fig. 6. Six rings as Energy Production (Source: Michael W. Pietrucha, 2014, Ref. [8])

STEP 2 Regulation and Policy Restriction (Case study in Thailand)

"Keep moving forward with awareness". From Thailand Investor Review (TIR) (2016)[48], It is a timing of renewable energy business to substitute instead of existing energy resources. Especially for solar energy in Thailand, the solar rooftop market rises, and offers exciting new market opportunities as well as one of the fastest growth of solar markets in Southeast Asia. It means a change moment of energy consumer behavior is begun. In this step, the pre-process of researching will advise the awareness areas to prepare algorithm design without conflicting state regulation and policy restriction. This step benefit will help the smart grid investor to optimize the direct cost, reduce indirect cost and prevent firm lost from illegal violation. Case study in Thailand, the design must be considered the areas as follows:

2.1 Government Roadmap and Policy

General Prayut Chan-o-cha (2014) [5], the prime minister of Thailand had delivered Policy Statement of the Council of Ministers to the National Legislative Assembly on 12 September 2014 (B.E. 2557). Some keyword of policy was concerned about the renewable energy developing projections which are related to drive the smart grid technology development to power enterprises and users indirectly without the impact of environment and community's way of life as follows:

1. Developing and Promoting the Application of Science, Technology, Research and Development, and Innovation; 1) Supporting the integration of science, technology, engineering and math education to expedite the creation of an innovative society as well as developing skilled- shortages personnel to meet the need of sectors. Especially for the investment opportunities of technology development, encouraging SMEs to obtain new technologies through cooperation between public sector agencies and academic institutions. 2) Looking forward for self-sustainable. The innovation in national investment projects, including projects in clean energy, transportation, and environment is supported by using the Thai research and technology. Promoting the domestic tools, materials and other products in order to cope with inbound technologies.

2. Maintaining the Security of the Resource Base and Creating Balance between Conservation and Sustainable Use; the immediate phase focuses the protection and restores conservation areas, and promoting conservation and sustainability in order to create economic and social value by managing the country in all aspects as well as quantitative and qualitative management.

From all of above, the first awareness is the unspecific policy for smart grid development provision from statement of the government. The progress plan was dedicated to Ministry of Energy

2.2 Ministry of Energy, Royal Thai Government (Policy and Planning Office)

Tracking the policy statement trails from 2.1 as above. To create the enlargement of the smart grid drive in all energy industry dimensions that expedites in production, transmission, and sell-distribution, including with producing human resources in shortage area as smart grid. In particular area of smart grid infrastructure improvement, Energy Policy and Planning Office of Thailand (EPPO) delivered the blueprint of Thailand smart grid B.E.2558-2579 (2015-2036) [49] that was the directive plan to achieve the smart grid roadmap. The important awareness was related to pre-process SG design was the relationship between stakeholder and cooperated-organizations as the example on figure 7. In term of societal and economic imperatives, that agreement was usually composed with National Policy Maker, Local Government, regulator, NGO (Non-government organization), vendor, consumer, utility and new entrants/telecoms.

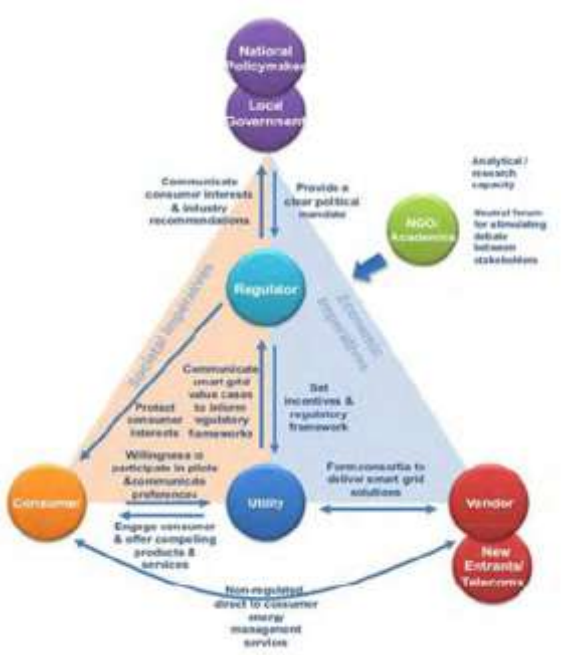

Figure 7. The example of relationship between stakeholder and cooperated-organizations [55, page 16] (Source: World Economic Forum)

Subsequently, the human resources development had started up from 7 January 2016. That was the first year of EPPO [49] announced to provide the domestic scholarship in lack of resource segments like as smart grid that was identified to the shortage of specialist in Science and Technology-Power system design and management. The focus of the human resources developing area is the technically skilled in Decentralized technology.

By the way, the ultimate goal of the Thailand's SG blueprint is the embedded and distributed intelligence for the smart grid developments [49] from hardware, software and peopleware which match with reasonable technology. That key of technology components is Information and Communication Technology (ICT), Distributed Generation and Transmission, Distribution Automation, Advanced Metering Infrastructure (AMI), Demand Response (DR), and Energy Management System (EMS) in HEMS, FEMS and CEMS. The future pathway of talent projects is screened by prioritizing the possible scenarios for smart grid with possible combinations of budget, policy and regulation, and technology which are divided into three classes as 1. Bright future SG – Best case, 2. Most likely future-Moderate case, and 3. Gloomy SG-Worst case. The key performance indicators (KPIs) are measured from the impact factors of 9 dimension evaluation criteria [55] as table 1. The end-state objective is fulfill the Thailand SG infrastructures to be better by Smart system, Smart life and Green Society.

Table 1. The impact factors of 9 dimensions evaluation criteria from Ministry of Energy, Thailand [55] (Source: the blueprint of Thailand smart grid B.E.2558-2579 (2015-2036), Page 21)

Fact	Level of Impact to SG development	Scenario		
		Best case	Moderate case	Worst case
1	Progress of technology development	Better	Better	Better
2	Capital of technology	Cheaper	Cheaper	Bheaper
3	Structure of electricity fee/price is related to capital	RTP Promotable	RTP Promotable	Non-Promotable
4	Budget supporting Policy from government sector	Sufficient	Insufficient	Insufficient
5	Consumer Awareness	Interested + Accept	Neutral to Against	Neutral to Against
6	Policy of renewable energy and efficiency	Serious + New Implementation	Serious + New Implementation	Not serious + No new Implementation
7	Specific Policy of Environment	More Incentive	More Incentive	More Incentive
8	Balancing between demand and supply	More difficult	More difficult	More difficult
9	Level of EV inbound marketing	Significant	Significant	No Significant

The conclusion from above, the second awareness is the SG product developing shall meet KPIs from the Energy policy of state regulators. It will created more opportunities and benefit

2.3 Law and Licensing Approval

Energy Regulatory Commission (ERC) is the organization in Thailand who responds the energy regulation, licensing process and power development fund as well as Feed-in-Tariff (Fit). Commentaries of Law related to Energy Industry [50]. The ERC responsibility are; 1. Regulating technical standards and safety in Energy Industry Operation 2. Regulating service fees 3. Giving instructions on the Power Development Plan, Energy Industry Investment Plan, Natural Gas Acquiring Plan, and Energy Network System Expansion Plan 4. Protecting power consumers and 5. Issuing minor legislation to regulate Energy Industry in compliance. On 9 October 2016 [51], ERC released the Solar PV Rooftop

notice for interested applicants to join the 100 MWp pilot project. The ERC commissioner and announcer Viraphol Jiraoarditkul [52] explained this pilot project will be signed the agreement on October 2016, studying the FiT pricing option that shall be connected with MEA or PEA, and collecting data for 6 months by subtracting the volunteer's net-metering, so the experimental solutions will be concluded in June 2017. This project is parallel with

As a result, the third awareness of smart grid self-developer shall keep in touch with the updating ERC regulation closely. The current solutions are still no more FiT adder contract, and connecting only PV base loads into a grid and not produce more than actual DR for preventing the electricity flows back into on-grid feeder authority.

STEP 3 Safety

The next step, Step 3 is "Safety above all…Smart grid is not just plug-in and play". In terms of aviation business, its aim is to transport passengers and/or goods from place to place with safety [43]. Likewise, the Smart grid design for aviation shall be concerned with the international and local aviation safety standard as well as the implementation of international smart grid stand design and local authority. As below, the researcher will advise the minimum safety consideration of pre-process issues that needs to be concerned before algorithm design in Thailand.

3.1 ICAO doc 9859 3rd Edition 2013; Safety Management System

Before upgrading to annex 19 in 2017, International Civil Aviation Organization (ICAO) has updated the recent doc 9859 Safety Management Manual (SMM) 3rd Edition on 2013 [53] to supervise the ICAO aviation organization memberships shall follow compulsory to make own Safety Management System (SMS) for formal and proactive approach to own system safety. The one of guarantee level of safety is referred to the achievement of organization safety performance indicators (SPIs) and Safety goals. Normally, the organization safety performance objectives shall be located at Component 3 Safety Assurance. The 4 keys of aviation systematic role-players [43] are air operators, airport, air traffic controller and maintenance, or defining as "3A1M" for remembering tip. During disaster, some facilities may not able to work fully function, and the power supplies will be limited. The Algorithm design shall manage and prioritize the power distribution to essential system. From air evacuation experienced in Tsunami 2004 (B.E.2557) [54], finding the first priority was the communication establishment, then the minimum essential system was prior as 3A orderly and 1M was the last priority. Day and night time had a difference requirement as well, such as the minimum airport lighting system for taking off and landing safely.

3.2 CAAT's Airworthiness

In Thailand, The CAAT (Civil Aviation Authority of Thailand) is the state of regulator who is assigned from ICAO to supervise the operational safety standard and certify the operators are safe for flight with airworthiness. The process to approve the air operators are meet the standard criteria that is AOCR (Air Operator Certificate Requirements) issued 8 July 2015 [55]. Hence, the smart grid algorithm design shall be concerned with Chapter 2 - Operations Manual in AOCR that is not effected by deviation from safety standard. For example, if the smart grid system use the WiMax (Worldwide Interoperability for microwave access) for WAN (wide-area network) connectivity in air operation area, the most significant is the radio wave transmission must not be effected to communication and radar system.

3.3 IEEE standard Design

IEEE standard Association (IEEE-SA) responds the technology standards to ensure their products and services execute as planned. In addition, handling interoperability, create uniform design, installation and testing methods, protect users and their environment and enhance the life quality of innumerable communities and unique worldwide. The pre-process algorithm design of researcher selects the IEEE standard review [56] for a minimum starting up because of their solid fundamental step by step [57]. The IEEE is the world well-known largest technical professional organization and their journals continue to maintain rankings at the top of their fields and high impact.

3.4 Ministry of Energy Standard installation requirement, Thailand

Although the final solutions will be launched after 2023 when completing SG roadmap phase 2 short term strategy for the demo and pilot projects [27][30][31]. The SG developers shall respond self-updating the coming associated standards. Now, the new standard was released on March 2016 that is named the Building Energy Code (BEC) standards [58] [59] made by Thai-German Programme on Energy Efficiency Development Plan, TGP-EEDP). The purposed objective of BEC standard is the initial guideline compulsory for the building investors and architectures whom are really able to design the effective energy conservation building. This guideline provides design concepts which are; 1. Overall Thermal Transfer Value (OTTV), 2. Roof Thermal Transfer Value (RTTV), 3. Lighting Power Density (LPD), and 4. Coefficient of Performance (COP) of air condition system for supporting 3 categories of building as Office, Department store, and Condominium. The expectation looks forward the Energy Efficiency (EE) value is more than BEC value.

STEP 4 Security

In the current day, the most critical infrastructure is power grid [60] where is the attack target from cyber threat. Besides modern grid, the WAN systems are connected to the internet, disclosing itself to cyber-attack. Furthermore, the two-way communications is the heart of the smart grid is [61] throughout the grid, from consumer to utility. This step 4 projects some idea from interesting literatures review as follows:

4.1 Cyber security

From United States Army War College (2012) [61], 46 percent of the electricity sector respondents found the virus Stuxnet on their computer systems. Cyber threat hides underlying into smart grid communication by physical

access, wireless smart meter and lack of cyber defend technology. For example case, hacking a smart meter and injecting software virus into the whole advanced metering infrastructure (AMI). The minimum security needs [44] to protect the SG system must have "defense in depth" and contingency plan. The trend of connecting electrical control systems to the Internet shows up whole of system layers are possible to be attacked. Computing layers that must be considered include: personnel, networks, operating systems, applications, and databases.

4.2 ABB Grid-Connected for Defense segment

From lecture at Bangkok by Dr. Britta Buchholz (2016), Global Product Manager Microgrids & Distributed Generation of ABB [62], the future trend is Grid connected microgrid what benefits are Grid resiliency, power quality, self-consumption and lower environmental impact. ABB Deployment design of grid-connected for defense segment enhances the package of Reliability, Security and Sustainable into smart grid system. One of reengineering idea came from grid stalibilisation concept was called "The 7S Applications in Microgrids". It means the additional algorithms of cyber security to defend in depth which are able to monitor and track the stabilize values automatically as follows; 1. Stabilizing: Frequency regulation, 2. STATCOM: Power quality, 3. Spinning Reserve, 4. Standalone: Island mode, 5. Smoothing: Capacity firming, 6. Shaving: Peak lopping, 7. Shifting: Load leveling.

4.3 Cyber Warfare Enable

"Buying time for defend". Cyber security and interoperability are two of the key challenges of the smart grid transformation. Cyber-trespassers always advance toward the current defend technology. The critical case study from AMI security in northern California communities [44], the utilities trend of standardize protocols are used the internet Protocol (IP)–based systems for wide area communications. This reason brought serious privacy concerns, as enormous total of energy use information will be stored at the meter. Hacking into this data could expose customer habits and behaviors. The trial of researcher idea is redesign the proactive scan pattern to detect cyber invader habits. Refer to the Cyber Security Working Group of the U.S. National Institute of Standards and Technology (NIST) addressed the outline of several key privacy [44], So, the preventive algorithm feature from cyber-attack must be included threat model [60] as adaptive Markov strategy (AMS) with: 1. Personal profiling, 2. Real-time remote surveillance, 3. Identity theft and home invasions, 4. Activity censorship, 5. Decisions based on inaccurate data, and 6. AMI systems to protect WAN associated with software and hardware aging.

STEP 5 Quality Assurance

Finally, becoming to last step that step 5 is purposed to quality guarantee during disastrous time. Refer to U.S. Air Force Energy strategic plan 2013 [10], defined energy is essential for air force operations and a key to national and economic security. National security requires significant amounts of energy to maintain the critical airpower contributions. Moreover, impossible to enhance mission capability and readiness without smart management between existing of demand and supply. Therefore, energy security means the dynamic abilities to access the reliable energy supplies as well as protecting and providing sufficient energy to meet the current operational needs.

For energy assurance program, needs to create a framework for energy management like as roadmap to ensure the organization be succeed the goals and continuous utilization improvement with maximized efficiency from the renewable energy platform. The algorithm design approach to energy is built upon four priorities are Improve Flexibility, Reduce Demand, Assure Supply, and Promote an Energy Aware Culture. To sustain DER balancing between DR and PV output whenever blackout, brownout, surge, and transient. But also the people culture is one of important parts to assist the goal of energy assurance not only the robust systematic.

Last but not least, after completing the pre-process RRSSQ 5 steps, the outcome of algorithm will be ready to next process which is Transmission System Operator (TSO) and Visual Power Plants (VPPs) Design, and following by simulation and on-site test to approve this design concept.

VI. RECOMMENDATION AND CONCLUSION

The conclusion of this paper, the RRSSQ 5 steps model is the first smart grid algorithm design which is integrated with military operational concept is specified for enhancing the NCO's Energy Assurance model as well as maintaining MOOTW capabilities.

The Methodology is integrated the IEEE standards of smart grid design with government policy, regulation, Thailand smart grid plan 2015, traditional and altered five ring model, UN HADR guideline, USAF Energy Strategic Plan 2013, and Local Private IPP Sector policy to ensure the core of NCO capabilities are able to operate safely with island and hybrid mode under any energy crisis situation as well as cyber security enable. Thus, the end-state of smart grid employment will be impact to big picture of energy management in national strategic level (macro-level) during critical situation, That RRSSQ represents for R-Risk Assessment, R-Regulation and Policy Restriction, S-Safety, S-Security, and Q-Quality Assurance.

Future work for this paper, to approve the RRSSQ 5 steps concept, the next study will be proceeded experimental in simulation by HOMER@Microgrid Software and small-scale on-site testing.

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REFERENCES

[1] T. L. Freidman. "The Ten Forces That Flattened the World", The world is flat: A Brief History of the twenty-First Century, Straus and Giroux, 5 April 2005, pp: 51-136

[2] H. Lehmann, R. Schlenk, D. Prantl , M. Schlosser , T. Jungel, "Communication Network-Centric Smart Grid Services", ISBN: 978-953-290-040-8, Date of Conference: 18-20 Sept. 2013, Electronic INSPEC Accession, Date Added to IEEE Xplore: 21 November 2013, Available from http://ieeexplore.ieee.org/document/6671859/?reload=true

[3] United Nation, "Framework Convention of Climate Change", FCCC/CP/2015/L.9/ Rev.1, Online 15 December 2015, Available: https://unfccc.int/resource/docs/convkp/conveng.pdf

[4] C. Bread, Logica, "Smart grids for Dummies-Logica Limited Edition", John Wiley & Sons, Ltd. England, Printed 2010, Retrieved 12 May 2015, pp: 10, Available from https://www.smartgrid.gov/files/Smart_Grids_for_Dummies_201005.pdf

[5] P. Chan-o-cha, Prime minister. "8. Developing and Promoting the Application of Science, Technology, Research and Development, and Innovation 9. Maintaining the Security of the Resource Base and Creating Balance between Conservation and Sustainable Use", Policy statement of the council of ministers to the national legislative assembly, 12 September 2014, pp: 15-17, Available from http://www.mfa.go.th/main/contents/files/policy-20150205-103332-009818.pdf

[6] Ministry of Energy, Thailand, "Smart grid Plan", Retrieved February 2015, Available from www.appp.or.th/imgadmins/document/11335609.pdf

[7] Energy Regulatory Commission (ERC), "Section 3: Regulation of the Energy Industry Operation", Commentaries of Law related to Energy Industry: Volume 1, 1 February 2008, pp: 18-49, http://www.erc.or.th/ERCWeb2/Upload/Document/CommentariesOfLawRelatedToEnergyIndustry.pdf

[8] M. W. Pietrucha, "Airpower and Globalization Effects Rethinking the Five Rings", National Defense University Press, JFQ 73, 2nd Quarter 2014, 1 April 2014, pp: 68-75

[9]United Nation, "Humanitarian and Disaster Relief Assistance", Global Issues, Retrieved May 2016, Available from http://www.un.org/en/globalissues/humanitarian/

[10] U.S. Air Forces, "A Strategic Approach to Energy in the Air Force", USAF Energy Strategic plan 2013, Effective March 2013, pp: 8-17

[11] N. Hoonchareon, "Briefing: Thailand Smart Grid Policy Plan and Roadmaps", Mae Hong son Pilot project, PowerPoint, 15 February 2013, pp: 13-17, Available from www.cigre-**thailand**.org/tncf/events/**smartgrid**.../cigre_**smart_grid**_by_naebboon.pdf

[12] D.S. Alberts, "Information Age Transformation: Getting to a 21st Century Military, Washington, DC, CCRP Publications, Republished 2002, First published 1996, pp. 7-8.

[13] Wikipedia, MOOTW-Military Operations Other Than War, last modified: 22 April 2016, Available from https://en.wikipedia.org/wiki/Military_operations_other_than_war

[14] H Segal, "Geopolitical Integrity", Montreal: Institute for Research on Public Policy, March 2005, pp: 275.

[15] Federation of American Scientists (FAS), "MOOTW". Air Force Doctrine Document 2-3 -GlobalSecurity.org, Released 5 October 1996, Retrieved June 2016, Available from https://fas.org/man/dod-101/usaf/docs/afdd/afdd2-3.pdf

[16] New Zealand Defence force, "HADR-Human Assistance and Disaster Relief: Aide-Memoire", J8 – Continuous Improvement, September 2012, Available from http://www.nzdf.mil.nz/downloads/pdf/public-docs/hadr-aide-memoire-2012.pdf

[17] A. org, "About ASEAN", published 2008, Online 15 August 2016, http://asean.org/asean/about-asean/

[18] Joint Chiefs of Staff, "Joint Doctrine for Military Operations Other Than War", Joint Pub 3-07, published 16 June 1995, Available from www.bits.de/NRANEU/others/jp-doctrine/jp3_07.pdf

[19] V. Bernard, "Is it time for a peacekeeping force for ASEAN", The Asia Foundation, Retrieved 3 February 2016, Available from http://asiafoundation.org/2016/02/03/is-it-time-for-a-peacekeeping-force-for-asean/

[20] D. K. Williams, "What A Fighter Pilot Knows About Business: The OODA Loop", 2 February 2013, Available from http://www.forbes.com/sites/davidkwilliams/2013/02/19/what-a-fighter-pilot-knows-about-business-the-ooda-loop/#6035dee76650

[21] B. Harris, "Big data and the OODA Loop What a military theory teaches us about big data and analytics", Director of Cyber Analytics R&D, SAS Institute Inc., Retrieve 18 August 2015, Available from: http://www.sas.com/en_us/insights/articles/big-data/the-ooda-loop.html

[22] C. Wilson, "Network Centric Operations: Background and Oversight Issues for Congress", Retrieve 15 March 2007, Available from: https://www.fas.org/sgp/crs/natsec/RL32411.pdf

[23] J. Dong, Tian-tianFeng, Hong-xingSun, Hong-xinCai, RongLi, YishengYang. Renewable and Sustainable Energy Reviews. "Clean distributed generation in China: Policy options and international experience". ScienceDirect Journal. Renewable and Sustainable Energy Reviews 57, 7 January 2016, pp: 753–764

[24] Royal Thai Government Gazette, Energy Regulatory commission of Thailand, "Buying trade laws for rooftop PV system", Released 2013, Retrieved September 2015, Available from http://www.ratchakitcha.soc.go.th/DATA/PDF/2556 /E/111/1.PDF

[25] Energy Regulatory commission (ERC) of Thailand, "Solar PV Rooftop: feed-in tariff licensing", 13 August 2013, Available from http://www.erc.or.th/ERCWeb2/Front/StaticPage/StaticPage.aspx?p=200

[26] Provincial Electricity Authority-PEA, "Cancelling SCOD from Rooftop PV system.", 11 July 2016, Available from http://www.thai-german-cooperation.info/download/20130918_giz_translation_solar_rooftop.pdf

[27] Ministry of Energy, Thailand, "Thailand Power Development Plan 2015-2036 (PDP2015)", 30 June 2015, Available from http://www2.eppo.go.th/power/PDP2015/PDP2015_Eng.pdf

[28] Ministry of Energy, Thailand, "Draft Energy Efficiency Plan: EEP 2015", Retrieved December 2015, Available from http://www2.eppo.go.th/encon/EEP2015/Draft-EEP2015.pdf

[29] Ministry of Energy, Thailand. "Alternative Energy Development Plan: AEDP2015", Retrieved December 2015, Available from http://www.dede.go.th/download/files/AEDP2015_Final_version.pdf

[30] EGAT, "EGAT Smart Grid Roadmap Development Working Group", EGAT Smart Grid, 14 February 2013, Available from http://www.cigre-thailand.org/tncf/events/smartgrid_15feb2013/egat_smart_grid_roadmap_rev2.pdf

[31] N. Hoonchareon, "Smart Grid Roadmaps: PEA", Thailand Smart Grid Policy Plan and Roadmaps (PowerPoint), 15 February 2013, pp: 12-17, Available from http://www.cigrethailand.org/tncf/events/smartgrid_15feb2013/cigre_smart_grid_by_naebboon.pdf

[32] Sena Group, "Sena solar energy", 29 October 2015, Available from http://www.senasolarenergy.com/en/, and http://eightsolar.com/news-detail.php?id=1

[33] Netherlands Embassy in Bangkok, Ministry of Foreign Affairs, "Solar Power in Thailand", May 2016, Available from http://thailand.nlembassy.org/binaries/content/assets/postenweb/t/thailand/embassy-of-the-kingdom-of-the-netherlands-in-bangkok/import/factsheet-solar-power-in-thailand.pdf

[34] K. bank, "The K –Energy Saving Guarantee Program (Solar Rooftop)", Retrieved August 2016, Available from: http://www.kasikornbank.com/EN/Corporate/Credit/SpecialProduct/Pages/SolarRooftop.aspx

[35] Nattipol Kanokchote, General, the Assistance's Minister of Ministry of Energy, "4 Phase of Smart grid Develop plan", 15 September 2016, Available from http://www.energy24hours.com.

[36] N. Hoonchareon, "Mae Hong son Pilot project", Thailand Smart Grid Policy Plan and Roadmaps (PowerPoint), 15 February 2013, pp: 18-24, Available from

http://www.cigre-thailand.org/tncf/events/smartgrid_15feb2013/cigre_smart_grid_by_naebboon.pdf

[37] K. Pakchotanon, EGAT Governor. "EGAT confirms that Krabi and Thepa power plant projects are key to electricity system development in the southern provinces and the country", 14 September 2016, Available from http://www.egat.co.th/en/index.php?option=com_content&view=article&id=12&Itemid=153

[38] HOMER Energy LLC. "The HOMER® Microgrid Software", Retrieved June 2016, Available from http://www.homerenergy.com/

[39] G. Creech , NASA Dryden Flight Research Center, "Digital Fly By Wire: Aircraft Flight Control Comes of Age", 17 December 2003, Available from https://www.nasa.gov/vision/earth/improvingflight/fly_by_wire.html

[40] R. lee, "5M model for aviation risk management", International aviation safety office course 2010, Directorate of Defence Aviation and Air Force Safety (DDAAFS), August 2010

[41] Air war college, United states air force, "War gaming Steps", Chapter 5 The Military Decision Making (MDMP), FM 101-5-1, Air University, Retrieved June 2016, pp: 5-17 to 5-24, Available from http://www.au.af.mil/au/awc/awcgate/army/fm101-5_mdmp.pdf

[42] S. F. Bush, "Chapter 1 Introduction to Power Systems Before Smart Grid", Smart grid: Communication-enabled intelligence for the electric power grid, ISBN: 978-1-119-97580-9, Institute of Electrical and Electronics Engineers (IEEE), Reprinted March 2015, pp: 3-10

[43] Global Air Training (GAT), "SMS Component 4: Safety Assurance", ICAO Doc 9859 3rd Edition 2013. SMM-Safety Management Manual, April 2014

[44] S. M. Amin and A. M. Giacomoni, "Smart Grid—Safe, Secure, Self-Healing", IEEE power and energy magazine, February 2012, Available from http://magazine.ieee-pes.org/january-february-2012/smart-grid-safe-secure-self-healing/

[45] Air university, "Military Management level", Three Levels of War USAF College of Aerospace Doctrine, Research and Education (CADRE) Air and Space Power Mentoring Guide, Vol. 1 Maxwell AFB, AL: Air University Press, 1997, Available from http://www.cc.gatech.edu/~tpilsch/INTA4803TP/Articles/Three%20Levels%20of%20War=CADRE-excerpt.pdf

[46] C. E. Walach, MAJ, "Chapter 1 NTC decision making; The dilemma Success", MDMP. , Retrieved June 2016, Available from http://www.globalsecurity.org/military/library/report/call/call_01-7_ch1.htm

[47] Air war college, United states air force, "War gaming Steps", Chapter 5 The Military Decision Making (MDMP), FM 101-5-1, Air University, Retrieved June 2016, pp: 5-5 to 5-11, Available from http://www.au.af.mil/au/awc/awcgate/army/fm101-5_mdmp.pdf

[48] The Board of Investment of Thailand (BOI), "Growth Opportunities Abound In Thailand's Alternative/Renewable Energy Sector", Thailand Investment Review (TIR) vol.23 No.1, Jan 2016, pp: 6-7

[49] Energy Policy and Planning Office of Thailand (EPPO), Doc พน 0606/ว 48. "The request registration of the smart grid scholarship supporting", Documented in Thai, 7 January 2016, Available from http://www2.eppo.go.th/index-T.html

[50] Energy Regulatory Commission (ERC), Energy Regulatory Commission (ERC), "Section 3: Regulation of the Energy Industry Operation", Commentaries of Law related to Energy Industry: Volume 2, 1 February 2008, Retrieved December 2015, pp: 52-61, Available from http://www.erc.or.th/ERCWeb2/EN/Front/StaticPage/StaticPageEN.aspx?p=25&Tag=Volume2&muid=13&prid=15

[51] Energy Regulatory Commission (ERC). "Announcing Feed-in Tariff (FIT) Process for registration acceptance and sale proposal from renewable energy B.E.2558-2562 (2015-2019)", 9 October 2016, Available from http://www.erc.or.th/ERCWeb2/Upload/Document/ประกาศเรื่องโครงการนำร่อง(Pilot%20Project)การผลิตไฟฟ้าพลังงานแสงอาทิตย์อย่างเสรีและเอกสารแนบท้ายประกาศ.pdf

[52] V. Jiraoarditkul, The ERC commissioner and announcer, "The 100 MWp Pilot project announce", 11 April 2016, Available from http://www.manager.co.th/iBizChannel/ViewNews.aspx?NewsID=9590000036971

[53] International Civil Aviation Organization (ICAO), "SMS Component 3: Safety Assurance", Safety Management Manual (SMM), ICAO DOC 9859 AN/474 3rd Edition 2013 Final, ISBN 978-92-9249-214-4, 2013, pp: 5-21 to 5-25

[54] Wikipedia, "Effect of the 2004 Indian Ocean earthquake on Thailand", Last modified 6 September 2016, Available from https://en.wikipedia.org/wiki/Effect_of_the_2004_Indian_Ocean_earthquake_on_Thailand

[55] Civil Aviation Authority of Thailand (CAAT), "Air Operator Certificate Requirements", 8 July 2015, Available from https://www.aviation.go.th/upload/download/file_641845a3b69cda9d389c5618 bb7777af .pdf

[56] IEEE standards association (IEEE-SA), "Find Standards: Technology Standards & Resources. Institute of Electrical and Electronics Engineers (IEEE)", Retrieved August 2016, Available from http://standards.ieee.org/findstds/index.html

[57] S. F. Bush,, "Chapter 10 Standards overview", Smart grid: Communication-enabled intelligence for the electric power grid, ISBN: 978-1-119-97580-9, Institute of Electrical and Electronics Engineers (IEEE), Reprinted March 2015, pp: 333-353

[58] Thai-German Programme on Energy Efficiency Development Plan (TGP-EEDP), "Building Energy Code (BEC) Standards", March 2015, pp: 7-12

[59] Bureau of Energy Human Resource Development, "Energy Conservation Building Pilot project", Ministry of Energy, Retrieved August 2016, Available from http://www2.dede.go.th/bhrd /displaycenter/

[60] J. Hao, E. Kang, D. Jackson, and J. Sun, "Adaptive Defending Strategy for Smart Grid Attacks", ACM 978-1-4503-3154-8/14/11, Scottsdale: Arizona, USA, 7 November 2014, Available from http://dx.doi.org/10.1145/2667190.2667195

[61] B. L. Magnuson, Colonel. United States Marine Corps, "DoD Installation Energy Security: Evolving to a Smart Grid", Strategy Research Project, United States Army War College Class of 2012, Carlisle Barracks, Pennsyvania, 20 March 2012, pp:14, Available from www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA561398

[62] B. Buchholz, Global Product Manager Microgrids & Distributed Generation, ABB, "Briefing: Affordable renewable microgrids for robust power supply Experiences and trends (PowerPoint)", Bangkok, 14 June 2016, pp:11-17, 21, and 32