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Proceedings of the 18th International Conference on Sustainable Environment and Architecture (SENVAR 2018)

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The 18th Sustainable Environment and Architecture (SENVAR 2018) conference took place in Surakarta, Indonesia on September 5-6, 2018, with as theme 'Architecture and built environment towards future challenges'.

SENVAR is an annual conference series started from the year of 2001. It has been taking place in many venues, many institutions and countries, particularly Asian countries. The main focus of SENVAR as represented by the title is about sustainable environment and its connection to architecture.

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PREFACE

First of all, let us express our thanks to God the Almighty who gave all of us a chance to meet again in SENVAR 18. The International Conference on Sustainable Environment and Architecture (SENVAR 2018) is an annual conference series started from the year of 2001. It has been taking place in many venues, many institutions and countries, particularly Asian countries. The main focus of SENVAR is sustainable environment and its connection to architecture. This conference series has been focusing mostly on building sciences and technology. However, as the issue of sustainability has been widely accepted as the new 'normal', this issue in architecture always comes up not only in building sciences, but also in other subjects such as urban issues and tourism. SENVAR 2018 widened the focus from building sciences to those wider issues, which are represented in three panels: Building innovation and technology, sustainable tourism, and urban resilience and livability.

In SENVAR 2018, the conference offers main plenary session, panel discussions, and city tour. We also had the opportunity to invite six speakers from diverse cultural backgrounds to share their expertise and experience on the issues mentioned above. This year, we had received over 100 abstracts for presentation in the conference. After the screening process, there were 75 papers eligible to be presented in SENVAR 2018. The full papers were then being reviewed each by two reviewers in a double blind review process for publication. Out of 75, there are 30 papers selected for publication in this proceeding.

With this opportunity, we would like to express many thanks to everyone, especially all the faculties, staffs, students, at the Department of Architecture Universitas Sebelas Maret, Indonesia for their support and participation. We are also grateful to all the speakers who have dedicated their time to share their expertise and experience in this conference.

We give our greatest appreciation to all the participants of SENVAR 2018, as presenters and audience, without whom this conference will have no positive academic atmosphere. Last but not least, the greatest honor is given to our committee whose hard work has made this conference a success.

Ofita Purwani, S.T., M.T., Ph.D.
Chairperson Organizing Committee of SENVAR 2018

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Emmelia Tricia Herliana, Himasari Hanan, Hanson E. Kusuma

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Murtanti Jani Rahayu, Imam Buchori, Retno Widjajanti, Erma Fitria Rini

Street vendors choose locations in public spaces or state-owned spaces that are close to the main productive activities. In addition, street vendors also choose locations on roads that have a large quantity of movements. The city government then arranges the street vendors whose locations are often considered...

The Theory of Complexity : A New Opportunity to Optimize Green Energy Approaches for Achieving Sustainable Development

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Abstract— The worse impact of climate change on the life system shows that the implementation of Sustainable Development method has not been optimal yet. For more than two decades, environmentalists have adopted Green Building approach to achieve energy efficiency, resource conservation, high-performance design, and less negative impacts, but this approach seems to solve environmental problems ineffectively. This indicates that the issue lies on the way to see and think of ecology as a system inappropriately. The old ecological approach uses mechanistic-reductionist paradigm with linear and partial thinking, a causal conception running one-way, constituting a method simplifying the problem and offsetting the limitations with such assumptions. Hence facing a complex natural problem, its application has a significantly inadequate probability. Inspired with the successful information system in modeling complex problems, today there is a theory offering holistic, systemic, dialogic-synthesis and non-linear thinking. This approach builds on a new paradigm of viewing and studying modern science with a focus on dynamic network systems providing feedback to achieve the processes adapting constantly to the system evolution. It models the problem close to the real phenomena as well as the broader networks covering more disciplines. Based on these facts, the research was conducted using an intensive literature review method to verify and demonstrate the use of theory called complexity theory in solving ecological problems, particularly for energy in built-environment. The results show that the complexity approach could be used to conduct a more widespread and integrated review process. The theory of complexity described and distributed the existing problems more interactively so that perhaps the current energy problems can be solved more precisely. This approach could be used for optimizing the planning globally, but it must be supported by complete data and big network that can be built based on open system and open source.

Keywords: Holistic paradigm, Complexity Theory, Built-Environment Energy

I. INTRODUCTION

Climate change in the last three decades has shown that the earth's surface is getting warmer every decade since 1850. In Northern Hemisphere, the period of 1983-2012, is the hottest 30-year period in the last 1400 years. The combined global ground and sea surface data computed with linear trend shows heating of 0.85 °C (0.65 to 1.06) 2 during 1880-2012 [1]. Climate change has a broad impact on living systems on Earth [1]. Climate changes impacts can be classified by scale (large or small), mode of impact (direct or indirect), and effect on life system (positive or negative). The impact of climate changes includes weather change, polar ice melting, sea level rise, hydrological cycle change, wind cycles change, and etc. These impacts bring out such other problems such more extensive and frequent disasters, changing animal biological cycles, new epidemic incidence, human death and even individual species extinction. Climate change exerts a very significant effect on all aspects of life. The World Health Organization estimates that 600,000 people worldwide died from natural disasters related to weather conditions in the 1990s, and most of them are in developing countries [2]. The Global Humanitarian Forum's report since 2009 has estimated more than 300,000 deaths and about 125 billion dollars of economic losses occurring annually and identified most deaths due to worsening floods and droughts in developing countries [3]. In addition to exerting a direct effect on the loss of life, climate change also affects the cost of adaptation. It is estimated that adaptation to the increase of global average temperature by 2.0 degrees Celsius can cost between 70 and 100 billion dollars per year [4]

Experts have responded to these environmental phenomena since early middle age. Natural exploration is one of the mechanism-reductionist paradigms that can threaten the life sustainability on earth. In almost three decades Experts, practitioners, and environmentalist are still trying to find the effective solution to Sustainable Development, by looking at the development of environmental problems faced today. This approach seems to have functioned ineffectively. Pamela Mang et al's study found that the problem lies on two aspects: the harmonious relationship between human and nature and the more attention paid to how the world works [5].

Understanding and having a harmonious relationship between human and nature is essential to achieve sustainability; this is the first thing to encourage sustainability. Human depends on the natural life, and he must participate in natural preservation with each other. The wave of Sustainability thoughts grows continuously to generate new concepts and approaches based on ecological sustainability (after Sustainable Development). They are Biophilic, Biomimetic, Resilience, Restorative, Permaculture, Regenerative, Cradle-to-cradle, and Resilience. The second reflection acknowledged is Green Building and its measurement; for almost 20 years practitioners and experts have talked about it, but this concept only resolves the sustainability problems using technologically sustainability approach. Green Building approach only talks more about the aspects of strategy and method to achieve sustainability than understands and learns the essence of how this life system works. Nature is a big and complex system. It compromises many things from atom to cosmos. This system is interconnected to and interdependent on each others. Natural life has Autopoiesis Dissipative behavior. It has an ability of producing, regenerating and readjusting itself in the form of dynamic, absorbing energy and processing material from environment and simultaneously producing product and residue functioning as energy and material for other life systems. It continuously happens, and through that process, every organism and life system regenerates, forms and maintains themselves alone or together [6]. All components of life in the universe are viewed as one large organism in unity and interrelated. They support and allow the universe to develop, regenerate and form a new balance [7]. The relation between systems in universe allows for regeneration and adaption in dynamic behavior. Dynamic behavior follows dynamic balance (dynamic equilibrium) just as Heraclitus said in Ancient Greek Era. The balance tends to move forward and never stops at one point; the change itself is the only permanent one caused by the life activities on earth [8]. Following Homeostatic concept is one approach believing that the only thing to do is to survive by changing and adapting

The big complex problem, according to Capra, can be solved through understanding the non-linear way, and the complex network referring to Complexity theory. Complexity itself is a set of concepts and mathematical techniques related to other subsystems in a non-linear way, forming a complex network. System, sub-systems and every part of living systems cannot be understood using - reductionist mechanism because it cannot be fragmented. The universe is an interrelationship as a whole system [7]. It follows the holistic-systemic paradigm.

II. The aims and methods

The research is conducted to verify the use of complexity theory in solving ecological problems. This research is a preliminary study to identify and understand the concept of complexity concerning nature. It has demonstrated how to apply complexity theory in solving built-environmental issues, particularly for energy despite preliminary study. To achieve this aim, the study has been conducted using qualitative research with literature review method. Many kinds of literature such as journals, reference books, and articles have been examined. This theoretical research has been conducted in several steps: in early stage, the study had been oriented to finding the underlying theory and conceptual framework of the complexity theory. Then, it looked at the role and contribution of the complexity theory to coping with the environmental issues. This stage aimed to see the opportunities and ways by which existing approaches can be expanded into a sustainability approach, particularly in the case of energy. The final phase of the study had applied this theory in simple way to model the complexity of energy system in built-environment. The result has been in the form of a network diagram for explaining its function.

III. Result and discussion

A. *Understanding how the world works*

The human perspective on the world reality has been dominated by the Mechanistic-reductionistic paradigm for almost three decades. The Cartesian-Newtonian paradigm (in another term) was developed by two main figures driving modernism, Rene Descartes and Isaac Newton. Understanding the human civilization hegemony through a long historical process, starting with a belief in the separation of mind and body became the central concept of Descartes' ontology and epistemology called Dualism [9]. The power of human ratios and followed with philosophical bases results in an understanding on positivism and scientism culture. The characteristics of mechanistic-reductionistic paradigm are mechanistic, analytical, reductionist, and linear so that natural phenomena will be sorted out and isolated from diversity and dynamics. Rational analytic civilization leads to a compartmentalized movement of knowledge in their respective domains. This classical mechanics is related to Newton's laws of motion based on a simple causal approach, one linear action from one situation to another. Finally, Descartes arrived at the conclusion that earth and its environment were nothing but a giant machine. Nature works according to the laws of mechanics, and everything in it is material composed smaller parts. Universe is considered as having no purpose, life and spirituality. Universe is merely seen as a machine that dies without meaning, without value and is quantitative. This understanding has contributed to technological advances very helpful to human life. A variety of great physical and biological discoveries was born from this approach. However, in practice, this is impossible, because there is no mechanical system that is completely separated from other systems in the world. When these laws are applied to the universe generally, this single accuracy drives problems. Plural interrelated realities cannot be perceived and described by the paradigm. Instead of understanding the reality correctly, this inability results in bigger and more problems. Reductionistic understanding on the reality has implications to problem handling and solving that are inadequate and tend to be simplistic, which in turn leads to increasingly complex problems such as various major environmental issues faced today.

Looking at the history of philosophy, it seems that this realness of the mechanistic-reductionistic paradigm encouraging the development of new theories about revolutionary physics and biology. This progress unravels the foundation of modern science. The strong pressure overthrowing Newtonian mechanics was launched by Einstein, Schrödinger, Heisenberg and other scientists leading to the birth of Quantum Mechanics in early 20th century. Relativity Theory (Albert Einstein), Quantum Theory (Copenhagen Interpretation), Bootstrap Physics, Dissipative Structure (Ilya Prigogine) and the behavior of "elementary particles" cannot be explained using Classical Mechanics approach [10]. These were begun with scientist's investigation on knowing, learning and understanding its arrangement in atomic and subatomic objects. Every object is a collection of molecules and molecule comes from a collection of atoms and sub-atoms. On the other hand, through the theory of relativity, humans are offered with the reality of space-time as a relative concept. In Einstein's cosmology, time is no longer seen as absolute, but its degree is as same as relative space. Tested further, the very small subatomic particles come from a subtle vibration energy called quark. The motion appears as a random movement in space and time of subatomic particles, in unpredictable speed and direction. This phenomenon cannot be explained and resolved with old mechanical equations. Furthermore, with the various phenomena of rapid biological science progress such as Molecular Biology, Genetics, Neuroscience and Evolution Theory, the situation urges the emergence of a non-mechanistic, nonlinear, qualitative paradigm and encourages the new types of mathematics development [10].

In 1927, Werner Heisenberg revealed the uncertainty principle stating that it is impossible for us to determine the position and speed of a particle at the same time. The more thoroughly we determine the position of a particle, the more uncertain is the momentum, and vice versa. The philosophical implications of quantum physics produce uncertainty principles. The laws of physics are no longer a certainty, but the motion of particles is random and governed by probability concept [11] The theory of opportunity plays an important role and is an essential feature of quantum mechanics. In reality, quantum mechanics must be interpreted as a stacked combination of all possible paths of motion by a system. If there is enough time, various types of movement path combinations can be identified and one of the combinations will move the process in the same direction and release it from the influence of opportunity fluctuations, so that the path will eventually occur. If we want to achieve an infinite accuracy, we are asked to find many factors that will influence the results - and the more the factors found the greater is the chance of uncertainty being avoided. For instance, in the event of a shotgun precision are influenced by irregularities in the structure of rifles and bullets, various minor variations of temperature, pressure, humidity, airflow, and even molecular movements in all these factors [11]

In recent decades, static (random) interpretations on nature have been widely discussed. Heisenberg's philosophical interpretation is not only the result of an experiment but also a philosophical deepening. This situation contrasts the concept of necessity and opportunity regarded as two poles negating one another. In this view, it seems that the two are not enough to explain the complex and contradictory nature of universe's working mechanism. This debate then encourages the notion that the universe is seen as moving organically as characterized with the existence of interdependence between its dynamic and always changing constituent elements. This understanding shifts the old paradigm to the Holistic paradigm proposed by Sadra and Whitehead as an alternative paradigm. Holistic thinking means looking more at the overall aspects than at the parts. It is a basic thinking that is systemic, integrated, complex and dynamic. The core idea is to view the whole as greater than the sum of its parts as stated by Capra [7].

The holistic paradigm teaches that the universe is intertwined with each other which is inseparable, always dynamic, continues to develop without stopping, and at any time renews itself so that deterministic understanding can no longer understand the nature as a whole. The understanding on organized and logical classical mechanics only describes some of this nature. In the universe we see not only order but also disorder. Considering this, the concept requiring completion is a dialectic which will be used to determine the relationship between necessity and chance, to determine at what point the accumulation of small quantity changes can jump into largely and randomly. The law of dialectics is Hegel's tenet stating that everything existing in the universe results from a conflict between two things and results in another thing. Thinking of the transition from quantity to quality represents that the matter behaves differently at varying levels. Cause and effect are concepts of relationships only occurring in cases of individual correlation. When these correlations are seen in the condition and scale of universe as a whole, they seem to collide with each other, and become chaotic. This condition represents the chaos theory which is a universal action-reaction where cause and effect continue to exchange places, so that what is here and now is that the result will be the cause in the future, and vice versa. A chaotic scientist had found a basic mathematical rule describing the fractal geometry of a black spleenwort fir leaf. He entered the information into his computer, which also has a program to generate random numbers which when executed will produce a drawing process seeming to be random and complicated but produce a geometric form that is very similar to the leaf. A condition apparently indicating irregularity, chaos, randomness, or coincidence but actually proven to be subject to simple law, scientific laws, points to a deterministic causal basis on an individual scale [10]. At first glance, chaotic is the event that like being lost in a sea of coincidence, but this situation is only a mere appearance. The complexity of natural phenomena can disguise the causal process and make events apparently random and complicated, but it does not change the underlying logic. On the one hand, individual molecular molecules seem to move in an entirely random way, on the other hand, the large number of molecules composing gas is seen to move in a way complying with the clear mathematical laws.

Observing various paradigm shifts since medieval times, it can be seen that the journey of human thought in understanding the truth of universe reality moves like a wave arising and sinking but moving forward. The strong dualism of the Mechanistic-Reductionistic paradigm encourages human hegemony to master the universe considered as a complementary object of his life. If at first, humans more likely express technological thoughts and actions, it is reasonable as a result of the education of reductionistic thinking mechanism. This approach later also materializes into an attempt of achieving sustainability starting with an emphasis on technological sustainability approaches.

Strong linear causality has successfully encouraged people to find advanced methods and technologies that can help and facilitate their lives. However, the spectacular development of science and technology in the 20th century did not always have positive correlation with human well-being. The materialistic view deriving from its dualism is complementary to the emergence of human desire to explore nature excessively, which at this time results in negative environmental issues. In relation to the presence of this understanding, Arnold Toynbee mentioned that there had been a very large imbalance between science and technology developing so rapidly and not accompanied with positive developments of moral and humanitarian wisdom, otherwise it was said to be backward [10]. Humans become selfish, competitive and materialistic. The positivism paradigm on the one hand has successfully developed science and technology facilitating human life, but on the other hand it reduces complexity of human life itself. The idea of deterministic as an absolute principle and without slightest bit uncertainty is actually not in accordance with the reality existing in nature. Nature shows diverse conditions and ways of working and seems to run randomly as seen in atomic and subatomic phenomena. This weakness, among others, causes the attenuation of mechanism-reductionistic power. Classical physics has evidently failed to explain microscopic phenomena on an atomic scale replete with uncertainty. The successful Newtonian physics only applies to the macroscopic world limited to objects that are visible and moving at low speeds.

The paradigm begins to shift to explore a more diverse and irregular nature. Human thought has moved towards the essence and how the universe actually works. Quantum mechanical theory not only brings out the higher advancement of physics and biology technology, but also provides the opportunity for the presence of holistic philosophy that is organic, systemic, dynamic and non-linear. Natural phenomena seem to be based on causal processes and relationships understood incompletely so that they seem to be random and contain uncertainty. Originally, the situation of uncertainty is approached using opportunity theory supported with statistical methods, but then equipped with the understanding that behind the complexity there is actually a law of causality, that is, scientific law. Behind natural phenomena which at first glance manifest into irregularity and chaotic there are simple rules. We live in a universe governed by dialectical determinism. It is a new understanding guiding people to be able to understand better how the nature really works. The characteristics of the holistic-dialogical paradigm have an anthropological view that nature is a subject with pluralist characters (complex) and dialogic-synthesis (looking at all possibilities). Based on dialogue and synthesis, this holistic paradigm can determine the certainty underlying the opportunities to change. This understanding gets the people closer to an accurate idea of how the complex universe works. Eventhough, the present paradigm seems to shift from one paradigm to another, they not to eliminate each other but they complement each other. In the level of complex system, colaboration human-nature needs a holistic, systemic and dialogic-synthesis approach, but in the level of individual corelation, it needs causal law (mechanistic).

B. Conceptual Framework of Complexity Theory

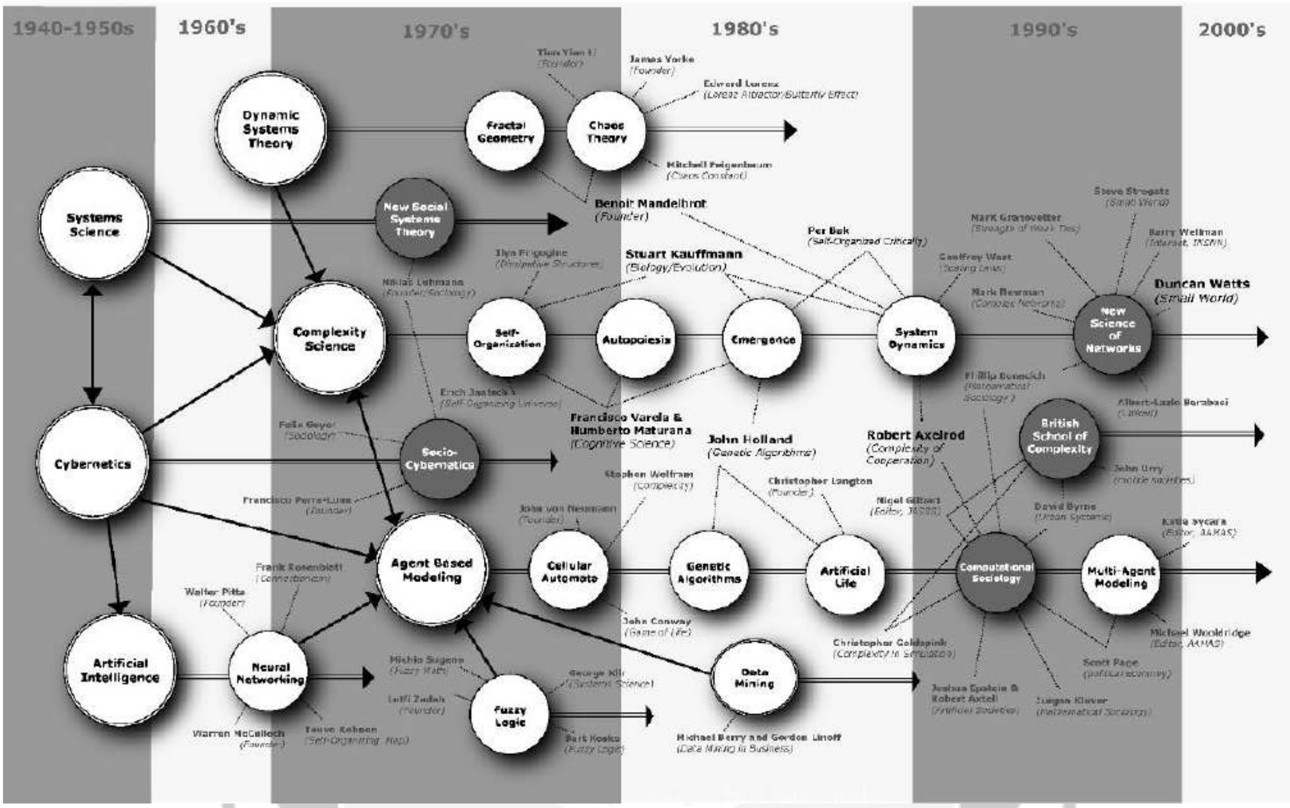
The present complexity theory is a response to holistic paradigm. Since the mid-1800s, many environmental and social experts have tried to find the right approach to obtain more empirical answers to the paradigm. Until 1984, scientists Cowan, Gell-Mann, Prigogine, E. O. Wilson have successfully brought theories together to supporting complexity theory based on network, dynamics and systems theory and proposed a theory called complexity science and founded Sante Fe Institute. Holistic paradigm then thrived and continued to be adopted by scientists along with the advancement of several other social sciences and computer science which also became the foundation later: cybernetics, network theory, and artificial intelligent as illustrated in Fig. 1 [12]. There is no rigorous definition of complexity system [13]. Complexity in general implies the dynamic interrelation and interdependence of multiple components engaged in self-organizing processes [14]. Complex issues are those issues that are messy, chronic and highly uncertain. This condition is different from simple, complicated and chaotic referring to the degree of difficulty ranging from low to high or unpredictable. Complex system refers to the degree of involvement of high elements interacting non-linearly. Considering the complicated and dynamic relationships between elements in a complex system, the basis of development will be oriented to System Theory. System theory is a theory describing the arrangement and relationship between many elements in terms of a model forming a whole and called a system. This theory begins to work by constructing an abstract concept of phenomenon and then applying to modeling a network to understanding the real conditions. A system exists within an environment and has a boundary distinguishing the system's exterior from its interior. A system can be replete with a set of interconnected elements or a set of sub-systems, a small system within a system.

Complex adaptive system is one of complex system varieties. This system contains the same elements interacting in multiple ways, later called agents. Agents interact nonlinearly to create networks where they act and react to their behavior. Agents have an adapting ability, the capacity to synchronize states or their activities with other agents locally. From this local interaction the system can do self-organization by constructing a pattern of developing coherent organizations globally, called emergence. Emergence can be defined as an overall functionality of novel and coherent structures, patterns and properties during self-organization process [15]. Structurally, in the system there will be an interaction of systems or system-to-subsystem or subsystem-to-subsystem as a reaction of changes from inside or outside the system (environment). Macro-to-micro scale will provide feedback to select agents, based on their contribution to the overall system functions or otherwise. The development of a complex dynamic between macro top down scale organizational systems and bottom up motivation of individual agents are often driven by different agendas but ultimately interdependent [15]. The system will always try to maintain its existence, but if there is a transformation, the system will make adjustments independently (self-organization). The transformation can be either positive disruptions benefiting the system or agents receiving it or negative disruptions detrimental to it. Disruptions can be on a small or large scale, but major disruptions will lead the system or individual to collapse due to abnormal adapting ability. When the condition of system is changing but the system still has adapting ability, it can be called Dynamic Balance or "on the edge of chaos" [13]. Some examples of complex adaptive systems are ant colony, hospital management, capital market life, human immune system, and any type of ecosystems.

The character of non-linear causality is different from linear causality where the relation always flows into one direction. Non-linear causality has essential characteristic of a feedback loop, in which the effect not only can be the cause, but also continue the last causality results turning back into the first system input. It is this feedback that makes non-linear causality the characteristic of self-drive and self-reference. In addition, feedback can also lead to self-reinforcement or self-deprivation process due to the potential incompatibility of initial cause to final effect. If the imbalance starts with a small event, and a later event, aggravated through each feedback iteration, it ultimately results in an enlarged causality called butterfly effect [15]. These effects must be observed because they can be excessive interference.

In addition to the domino or snowball effects making the direction and magnitude of relation effect less predictable, non-linear causality will also relate to almost unlimited interaction variables. Initially, nonlinear causality seems to lead to effect uncertainty, but when all the complexities of relation and many variables can be known, this will change uncertainty into certainty. Considering the varying complicated non-linear relations in a complex system, the solution requires appropriate approach and method, Cybernetics theory. Cybernetics has a lot of discussion and focuses on how a (digital, mechanical, or biological) system processes information, reacts to information, and adapts to accomplishing both previous functions.

Fig. 1. Map of Complexity Science



Source: [12]

Cybernetics was defined by Wiener as the science of control and communication, in animal and machine [16] This science includes a variety of studies including learning theory, cognition, adaptation, social control, emergence, communication, efficiency, efficacy and interconnectivity. Cybernetics brings these fields together to help postulate the general characteristics of machines and organisms in the fields of communication, feedback and control so that these behaviors can be understood better [17]

Summarizing the points aforementioned, complexity theory seems to be one of Holistic paradigm approaches. Complexity theory is a broad platform investigating a complex phenomenon. This theory is usable to understand chaotic system studies but behind every chaotic system there are behaviors and structures with simple basic rules. However, although complexity theory is a very broad and very diverse sets of models and methods, there is no proper formulation to structure and give definition to this framework [13]. The discussion of several studies talked more about the theoretical framework and its philosophical basis. Studies on how to apply it are still on the level of exploration to construct theoretical methods, rather than on the point of practical application. This indicates that this theory has not been stable yet and is still rigid, so the experts will develop theory and method continuously.

Adaptation variant in complexity theory has four basic characters: network, non-linear, adaptation and self-organization [18]. These four characters seem to be the transformation of various basic characteristics of holistic paradigm. The system will be based on connectivity, the components of which are relatively isolated, and focus on individual components (sub-systems or elements) to analyze their interrelations in order to obtain an understanding on how the natural system works entirely. The complex system has self-organization characters, the ability of generating new forms of order spontaneously just like the autopoiesis power reaction, a phenomenon to achieve dynamic equilibrium. In addition to having self-organization nature, it must be adaptive, having homeostatic abilities arising from the system's internal interaction to maintain the condition of system. A system can change due to external interference, but by itself the system will optimize or maintain its condition in an environment by modifying its state (condition).

The natural relationship is a form of nonlinear causality is governed by the dynamics of feedback aimed at finding the certainty of an event constituting a dialogical process in a holistic paradigm. Nonlinear causality (cause and effect) can flow into bidirectional or multidirectional pattern over times. Apparently, the form of the feedback relationship is very varying, but it can be classified into 3 patterns: the relationship of backward direction, the repetitive process relations (feedback loop), and the serial input-output processes, then the output becomes the input of the first system (circular reference). Thus, this requires two essential things. Firstly, it requires several types of control systems that will be used to determine various conditions that are desired in the future (according to purpose) or to influence events in the present based on the future. The control system involved will be approached by the cybernetic theory. Secondly, it requires smart iterative study, has the ability to process the results of the process output with the aim of self-organization and maintaining conducive system condition. The process should be supported with some smart tools having high and fast calculation capabilities. Considering the rapid progress of computer science today, especially in neuro-networks, artificial intelligence, and optimization fields, this need should be fulfilled urgently.

Another study [18] found that in addition to describing the complex phenomenon, complexity theory functions to measure the number of elements within a system, their degree of diversity, degree of interconnectivity and degree of adaptation that can be used to find simple change rules and to represent the certainty of change in order to achieve dynamic balance. The purpose of measurement is to maintain the emergence and the control over interference power (natural disruptive as a result of life processes) not to exceed its adaptation and self-organization capabilities. Control will be carried out with an iterative optimization process as a dialogical process so that a complete balance is obtained. The system will always change but under control thereby resulting in a relationship remaining to be harmonious between all its members, systems, and environment. It is a dynamic balance that results in a net positive impact, one of the goals of teaching concept.

C. Simple Model For Building a Complex Energy System

In this section, simple experimental results will be presented to construct a complex system model, particularly for the built-environment energy system. This case was selected with a simple consideration that energy is one of basic life needs and carries a complex network. This study is intended to look at opportunities or possibilities of utilizing the method rather than to test the precision of the method of complexity theory. The presentation will demonstrate simply how to build a complex system model starting with identifying elements and composing a network, representing the details of complex system morphology and finding strategies to compile a large net system.

The study of a complex system can be initiated by developing a network diagram. According to general holistic paradigm, complex systems must be approached with a synthesis thinking basis. Unlike the analysis approach of mechanistic-reductionistic paradigm dividing the system into small parts and then analyzing and reconnecting to gain understanding, the synthesis approach is oriented more to the components and their relationships, from couple to a whole. Synthesis method is a process of reasoning describing an entity through its overall context or function (emergence). Some differences in analysis and synthesis can be seen in Table 1. Based on the synthesis method, the stages of modeling can be done, according to [18], as follows:

1) Try to ask “To which context does it belong?” To identify the whole context to which the system belongs.

2) Try to understand the behavior of the whole.

3) Try to determine the function of system and how it is interrelated to other systems in performing that function

Based on literature review in this research, the modeling process was considered as less implementable. The adversity faced is the limited scope of energy system understanding. The process of identifying system, subsystems and components is long enough; secondary data from various sources need to be studied. After the data collection phase, the next process is to establish the relationships between components or subsystems. In this process, the perceived return is a difficulty due to the need for sufficient knowledge to establish interconnectivity. This process likely becomes easier and relatively faster if this process is carried out by those competent, so the way the team works is needed in this activity. As an example in the process of developing this energy system, there are four large systems appearing: energy resources, energy cultivation, national electric generating systems and energy distribution [19]. The four systems require electrical experts with their respective subspecialties. Their presence will certainly contribute precise and accurate information about how each system works.

The next step is to break down each system into its subsystem levels. The experiment was taken in energy distribution system. There were apparently three subsystem levels: high voltage, middle voltage, and low voltage. This process is then resumed for the existing levels below to meet its components (the lowest level) as seen in the Fig. 2 and complete flowchart as seen in Fig. 3. Based on this experience, it seems that the process of modeling the complex system will be run more easily following additional rules below:

1) Synthesize it from large to small, from macro to micro, system to system, and then down.

2) Building an interconnection base on the input-output function as an interaction.

3) At the basic level (component), it is a linear - causality - f (x) - equation that facilitating the identification process occurring.

The second part of modeling is to determine the type of relation between components, subsystems and systems. Literature study conducted found no clear method for doing so. For this purpose, the steps are carried out with an experimental table of material used to identify the type of relation and the possible effects. The interrelations of components in artificial lighting and ventilation subsystems can be seen in the Table 2. From the table, it can be seen that this method is effective enough to compile the relationship of system. The table can be developed further using other varying criteria to complete the information needed, for example the criteria for variables involved, function of relation occurring, the parameters used to measure adaptation limits and others.

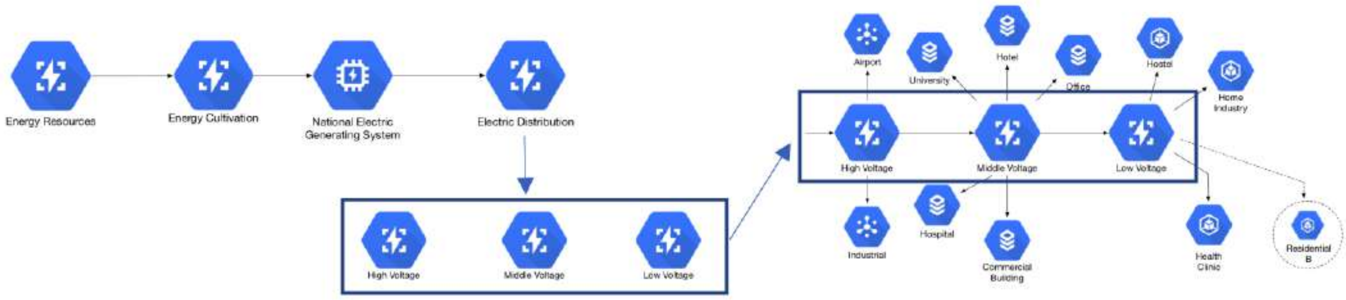
The process of representing the details of complex system morphology has been done by developing a flowchart imaginatively. This model can be seen in detail in Fig. 4. This picture illustrates a network with two subsystems interconnected in backward, feedback loop, and circular references.

Table 1. Different Between Analysis and Synthesis

Analysis	Synthesis
Analysis breaks things down to understand them (bottom-up proses)	Synthesis does the reverse building them up so as to gain an understanding of the whole systems and then defines an individual entity in terms of its function
Analysis focuses on sets of things	Systems thinking focuses on whole systems
Analysis is focused on a small part	Synthesis is focused on relations between componen
Analysis looks for linear cause and effect relations	Systems thinking looks more at non-linear feedback relations
Analytical thinking searches for a direct line in the relation between cause of an event and its effect, thus we call this linear thinking	Systems thinking is more inclined to see events as the product of a complex of interacting parts where relations are often cyclical with feedback loops.
Analysis starts from a component based view of the world and builds a description based upon the properties of these components.	Synthesis focuses upon the relationships between parts, thus from a systems thinking perspective we are often interested in connectivity i.e. answering the question what is connected to what.

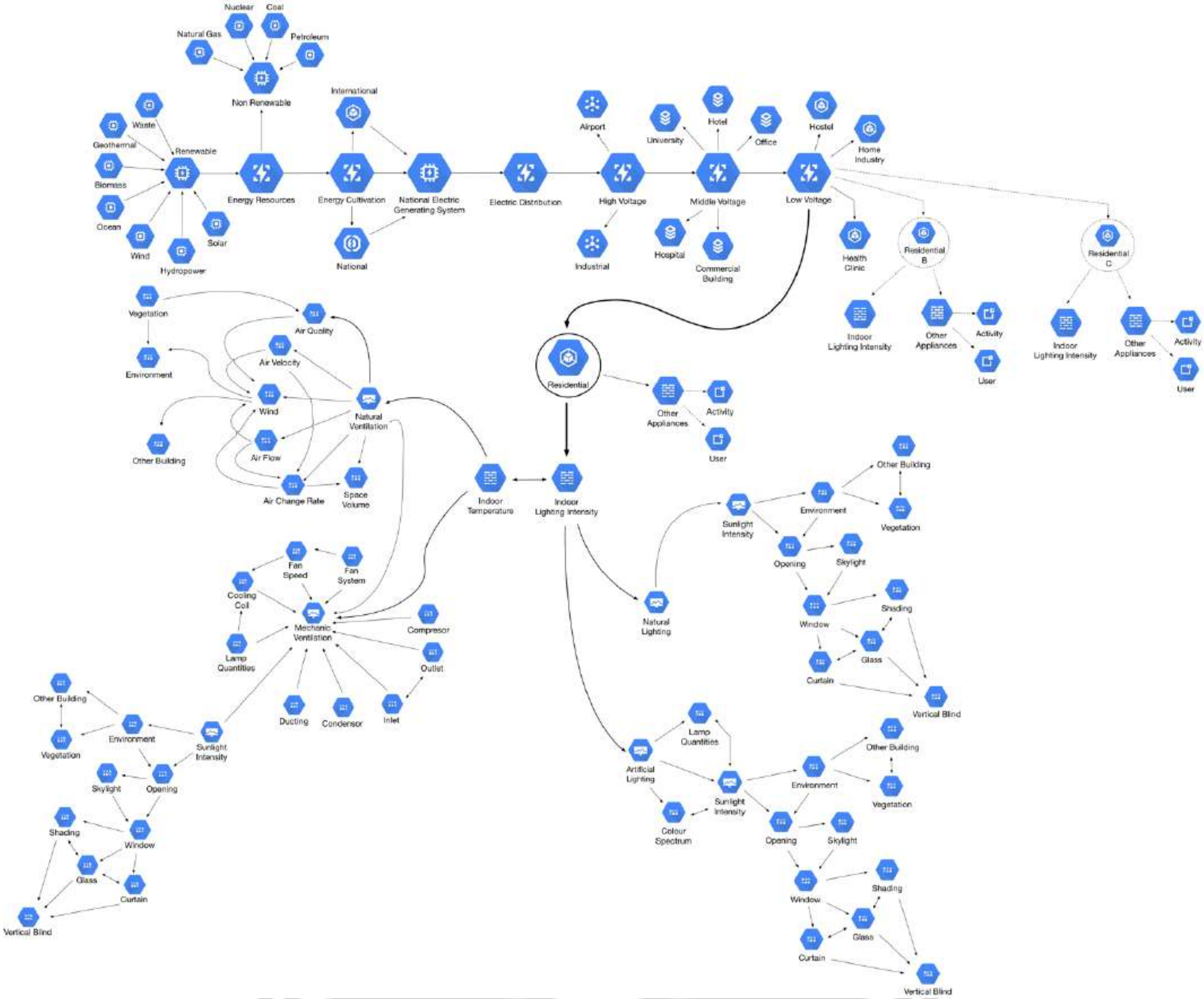
Source : [18]

Fig.2. Hierarchical Analysis of Network



Source: Researcher, 2018

Fig. 3. Network of Energy System in Built-Environment



Source: Researcher, 2018

Each of sub-systems builds one emergence and interconnects with another subsystem or environment. When a perturbation occurs in sub-system B, the system will make internal adaptation called homeostasis. The system will try to contrast and to involve significant interruptions to change the condition of its components so that the autopoesis process will take place to get into environment remaining to be within the power range.

This event changes the balance despite under control, unless there will be a collapse. Complex adaptive events due to discussion with a large number of elements, degree of interconnectivity and degree of variability, will require control processes by networks designed with cybernetics theory and artificial intelligence. The complexity of model and the smart capacity possessed will determine the certainty level of adaptation method. This is related to holistic-dialogical method. The result of dynamic co-evolution is an emergence with a new state, where the achievement goal is greater responsibility (net positive impact). The changes affecting each component or sub-system are still positive.

Table 2. Interrelationship between lighting and ventilation subsystems

		SV	ACH	AV	AQ	SI	OP	WD	CR	GS	S02	
		+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	+ -	
SV	+ -		+	+	+	0	0	-	+	-	0	
ACH	+ -	+		+	+	+	-	+	+	+	+	
S01	+ -	-	-	0	+		-	-	0	+	-	
Etc.												

SV : Space Volume　ACH : Air Change Rate　AV : Air Velocity　AQ : Air Quality　GS : Glass
SI : Sunlight Intensity　OP : Opening　WD : Window　CR : Curtain

Backward Direction (orange)　Positive Impact +
Feedback loop (green)　Zero Impact 0
Input Output (yellow)　Negative Impact -

S02 : Artificial Lighting System
S01 : Ventilation System

Source: Researcher, 2018

From the discussion above, it can be seen that network modeling (flowchart) is needed to facilitate the researchers to describe and to examine the work system. The figure serves as an explanatory model. A programming and software development can be developed from this flowchart functioning to simulate the system's working mechanism. This development serves as a confirmatory model. It is useful for predicting and controlling the changes occurring in complex systems. The controlling method will adopt optimization technique. It not only shows the feedback but also prevents a large distortion. Its main function is to maintain co-evolution in the corridor of system's adaptation power. Modeling will optimize all components and subsystems involved completely (globally optimization). This Optimization is different from what happened in the mechanistic-reductionistic paradigm. It is conducted for one sistem only (internal isolated system). Its side effect on external system (other systems) has not been considered yet. This situation is dangerous if it produces the negative and vital results. Various environmental issues today are most likely due to adverse side effects not detected and indicated during development of built environment so far.

The next step is the most important and critical part of doing the iterative calculation process. This process is excluded from this research because its implementation process will require programming stages and the preparation of complex computer simulation tools that are out of the research's scope. However, by observing the morphology of modeling as shown in Fig. 4, it can be identified that building this complex system is a complicated activity because all components and their relationships must be built ideally so that a holistic-dialogical and globally optimized process can be achieved.

If this is done by an expert alone, it is certainly very unlikely to be achieved. Therefore, the way of building it needs to be collaborative, where many experts contribute to completing the network. Such working method is very possible because there are actually many experts very competent in each field. They can create a small network according to the scope of expertise, then donate and connect to the main network. The networks will increase with the addition of small systems, by either expanding one system with increasing sub-systems or components involved or extending the environment by entering new systems. This process follows the concept of human fetus development from one cell to many cells and building one organ and another organ, forming a small body, developing into an adult body completed with all of its behaviors. Complex systems build on the growth concept.

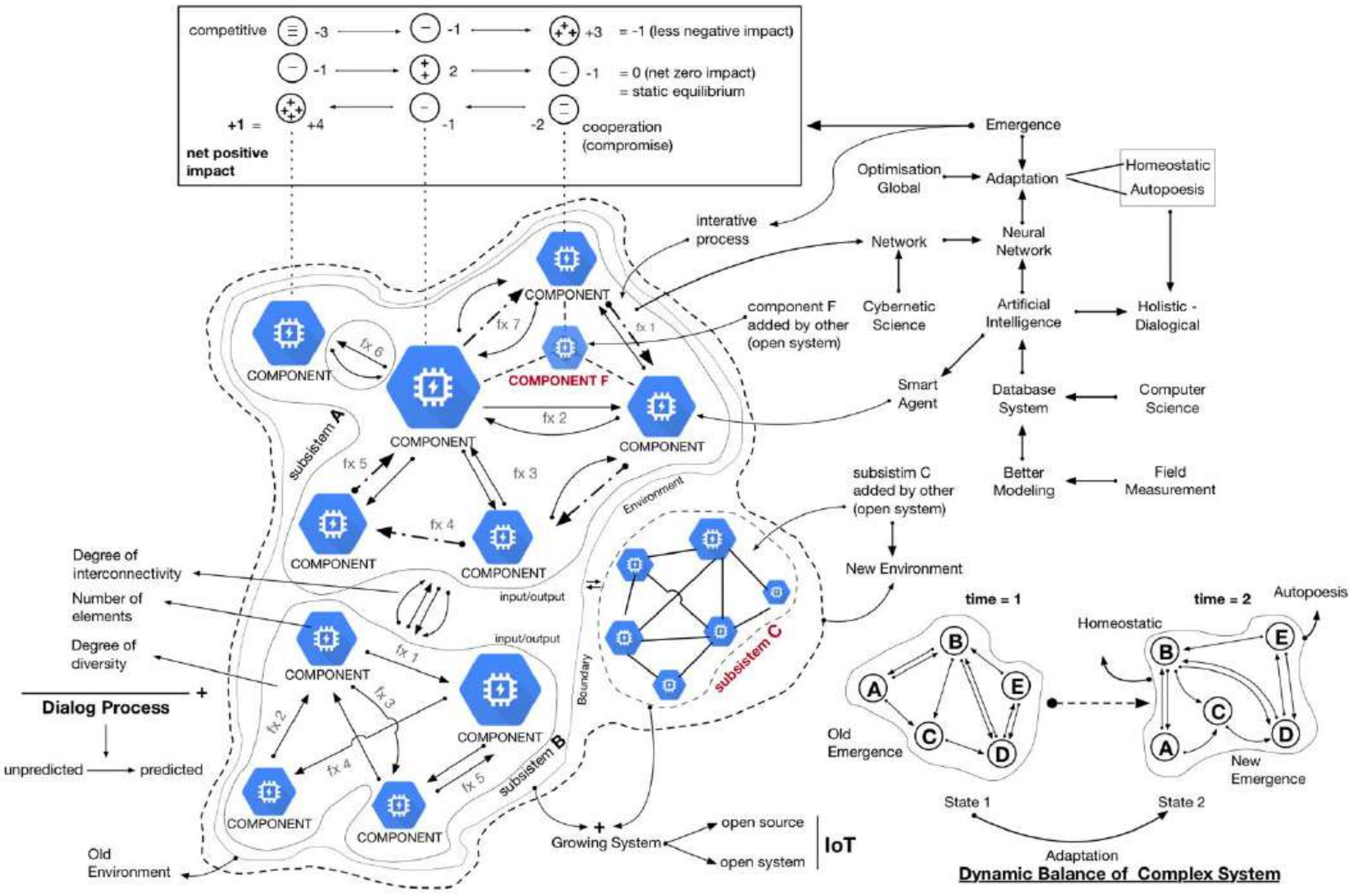
The development of complex systems is, of course, not easy because the nature has its own complexity and must be developed in a growing manner, involving many parties. Based on Computer science, especially network theory, the conditions aforementioned can be completed in two ways: open system and open source. Open system is an integrated network and technical approach to acquire and assemble interoperable components using a modular system design. This technical approach breaks down the system into components interacting with each other through key interfaces according to interoperable formal specifications. Interoperability is the process of combining various systems to enable data sharing, to coordinate control actions, and to integrate user interaction [20]. Open source is a software that is open and provides the source code to be seen, used and developed freely by others [21] The development of open source software will involve many people and become unlimited when put onto the internet. The use of both methods seems to be one solution to the development of a complex system. Open system will be used to provide templates and methods for building compatible systems. Every expert will get convenience and will be guided to develop the system according to their competence with the modeling results that can be ascertained to be interconnected and used together.

The addition of the system scope is presented in Fig. 4. This modeling represents the addition of component F and subsystem C making the model more complex. This addition can be done later by other experts to develop the current system. The thing needed is the existence of templates, forms, protocols and tools that must be developed in general that cover all disciplines, so that open source methods can be applied. Source code for open software that can be developed will make the system faster and open the system. Each characteristic of per-disciplinary needs can provide direct suggestions by developing software exclusive to itself and contribute to developing a complete and integrated source code. The contribution of computer science seems to be required to build complex systems including the need for sharing in the internet network. Complex systems need IoT or the Internet of Things, a concept aiming to expand the benefits of internet connectivity so that the work process is connected continuously.

IV. CONCLUSIONS

1) Nature is a complex system, so the resolution of environmental problems should be approached appropriately using holistic, systemic and dialogic-synthesis paradigm.
2) This research has revealed the nature of Complexity theory. The Holistic paradigm is the basic thinking of this theory.
3) This research has shown that Complexity theory is a theoretical approach useful for presenting complex networks, identifying network functions and understanding how complex systems work. Complexity theory is a new perspective to solve complex problems.
4) Based on complexity theory, this research has successfully demonstrated how to build an energy network that can show the complexity of the problem, the relationship of the network (systems, subsystems, components) and identify their functions, although this practice is preliminary modeling.

Fig. 4. Conceptual Framework of Complex System



Source: Researcher, 2018

5) The theory of complexity described and distributed the existing problems more interactively so that the current energy problems could be solved more precisely.

6) Recalling that natural system is a complex, extensive, and broad network, including multistage, multiscale and multidisciplinary, its modeling should be done with Open Systems and Open Source that placed on IoT system, so that all experts can contribute to building the system anytime and anywhere. The system will grow up.

7) More intensive studies need to be conducted to obtain a more rigid methodology to apply complexity theory to solve environmental problems.

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