

A Developed Framework for Energy Technology Sustainability Assessment



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Abstract: *Technology assessment has reformed in nature over the last four decades from an analytical tool for technology evaluation, which relies extensively on quantitative and qualitative modelling methods to strategic plan tool for policy creation regarding satisfactory new technologies, that based on participative policy problematic investigation. The aim of assessing technology today is to make policy choices for solutions to organizational and social problems. which, at the workable level, use innovative technologies which considered publicly acceptable, that is, practical policy decisions.*

This paper concentrates on the progressing of a framework that joins a technology valuation method, namely, system dynamics, inside the larger opportunity of technology growth for sustainability. The framework, called system method to technology sustainability assessment (SATSA), joining three main fundamentals: technology progress, sustainable progress, and dynamic systems method. The article after that determines the framework of integrating the system dynamics procedure in energy technology assessment philosophy and exercise inside the framework of sustainable growth. The framework offers for technology sustainability assessment, which can direct the upgrade of sustainable energy technologies at a policy class. Additionally, it can support the technology inventors to understand the possible effects of technology, therefore allowing them to decrease technology transmission hazards.

Keywords: *Technology sustainability assessment; Organization dynamics; Supportable development; Workable technology; Sustainable technology.*

I. INTRODUCTION

The development of technology is considered the main tool in managing the energy area [1]. The progressing of technology improvement is measured as a collaboration of the technology with the system in which the technology is surrounded [2], [3]. Despite having the positive advantages of technological developing in the economic and social sides, it has a special benefit in reducing the negative impacts of environmental nature. The environment and technology relationship is, though, multifaceted and inconsistent [4][5] technology friendliness. On the other hand, technologies may result in more well-organized usage of capital and less pressure on the environment.

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The last method is mentioned as maintainable technology growth [6], [7]. Meanwhile supportable technology advance is not autonomous, its administration is essential. One of the significant restraints in technology organization is technology assessment (TA), which has regressed above the past four eras [8], [9]. TA allows the estimation of the collective technology be able and simplifies the strategic technology preparation [10], [11]. Though TA does not essentially afford policymakers and bosses “the answer”, it may advance the probabilities that the extreme assistance of technology will be attained [12], [13].

TA may decrease the dangers integral in the modest procedure by adding the info in the provision of decision creation and can be significant in shaping investigation and enlargement path. New technologies acceptance, incremental upgrading in prevailing technologies, level of best expenses of wealth apparatus capitals, and market divergence [14], [15].

Technology-associated difficulties, there is a robust necessity of discovering extra functioning approaches of valuation [8], especially in Africa. The result is due to the lack of having this feature in some of the African government policies [16]. In South Africa, even though, a Technology Innovation Agency (TIA), which is a public form, was newly recognized [17]. The agency has three censoriously significant objects [10], [18]. Initially, to activate the improvement of technology advancement; next, to motivate the expansion of technical enterprises; and, lastly, to arouse the wider manufacturing base [19]. Although, in case of no official understandable or well-arranged TA instrument to assess the technological and sustainable info, the policy creators, machinery creators, and judgment producers are encountered with trouble concerning the suitable machinery choices. Adding the care for the growth of supportable energy novelties so leftovers a problematic chore for decision making with an essential to impact the progression of technical modification [20], [21]. This paper consequently advances a theoretical framework of systems approach to expertise the sustainability assessment (SATSA) by a goal of adding the developed valuation performs model for renewable energy technologies in the developing countries. Furthermore, the framework can also guarantee that machinery growth schemes to join a wider variety of attentions for attaining the required sustainability performance. Over and done with the framework, the foundation of consuming system dynamics demonstrating the technology sustainability valuation is discovered, and the administrative phases for ideal growth are added utilizing renewable energy skills as a Case.

II. PROPOSED CONCEPTUAL FRAMEWORK

As shown in Fig. 1, a diagram illustration of the planned theoretical framework for technology sustainability evaluation. The goal of the framework is to validate the connections among the important components which are projected as significant for developed practices of the sustainability technological assessment. These are technology improvement, sustainable progress, and active systems. A combination of these fundamentals reduce the thoughtful of workable technology improvement, technology valuation, and sustainability calculation. On the other hand, mixing the three basics provides the base for SATSA.

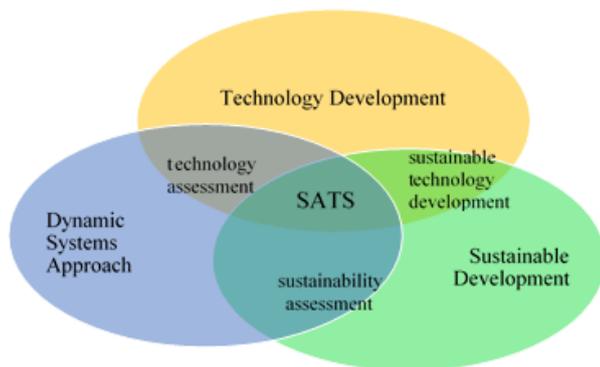


Fig. 1. Schematic representation of a systems approach to technology sustainability assessment (SATSA)

III. TECHNOLOGY DEVELOPMENT

The term technology has impacted society and its surroundings in many ways [20]. In numerous cultures, the technology subject has smoothed the progressing of some progressive economies, such as the present global economy, and the increase of a leisure course. Nevertheless, some technological methods make disagreeable by-products, for example, pollution, and reduce usual assets, together with the impairment of the ordinary atmosphere. Also, many operations of technology affect the values of civilization and innovative technology which frequently rises fresh moral problems. The latter 300 years have knowledgeable extra significant technical variations than any other age and is measured as the “period of technology” [4]. Anthropologists, historians, and philosophers were the earlier to have attention in accepting the role technology shows in shaping societies and cultures. Persons from other branches such as finances only monitored former to study technological variation [16].

Torstein Veblen and Joseph A. Schumpeter founded the thoughtful on technology [4]. Veblen, 1904, Veblen, 1921 and Veblen, 1953 were the initial to concentrate on the communications between persons and their objects from an institutional perspective and to concern a technology as a part of substantial and social relationships. The technology was

believed to be industrialized and molded by social performers whereas at a similar time influencing communal principles and manners.

Schumpeter (1911), proposed that the bases of technical modification is endogenous to the economy. This is clarified deeply by Schumpeter's waves as in Fig. 2. While the time of using modern technology skills impacts the properties of improvement of economy reducing. Which are produced from the availability of new technic methods advertising struggles, and free enterprise [4]. Now, many types of research on learning the response circles the impacting of the improvement of technology with a communal decision that the technical improvement is neither simple nor lined are communal. [4] recognizes four significant features of technical improvement which are applicable in managing the growth of the enhanced technical sustainability valuation. Technical hesitation existed due to many solutions to gain a definite task. Technological indecision rises as a result of numerous explanations to attain a certain duty. It is therefore inexact which of these answers could be the “best” once wholly financial, common, technological, and ecological features are occupied into the explanation. Ambiguity also happens at all phases of technical enlargement, from the preliminary strategy selections to achievement or fail in the marketplace. Then, technology is lively indicating that it displays as S shape curve and varied per time according to developments or adjustments.

These are (i) development after indoors and (ii) the intrinsic energetic and no equilibrium environment of technical modification, which the motionless and steadiness methods are unsuccessful to detention.

IV. WORKABLE IMPROVEMENT

The idea of workable improvement has respected extensive reportage in the works and deliberations at varying stages [22]. The Brundtland Report, Our Mutual Upcoming [23] and [24], The power which is used for a maintainable world, is occupied as a preliminary opinion in the specified research. The most extensively used description of workable enlargement mentions the three measurements of sustainability: environmental, financial, and societal schemes. The conception of workability rises from a move in viewpoint, starting a concentration on the monetary enlargement which is frequently well-defined as the extension of consumption and GDP to a novel opinion of expansion named workable [25], [26]. Additional researches discussed that maintainable enlargement is neither an immovable condition nor a last viable state-run then is integrally an active method [27]. Kemmler and Spreng (2007) [28] demonstrated this opinion by disagreeing of upcoming generations, superior information and progressed skills with changed needs, will describe maintainable enlargement in their method together with a dissimilar set of improvement objectives. Nevertheless, the discussions and opinions about the idea of workable

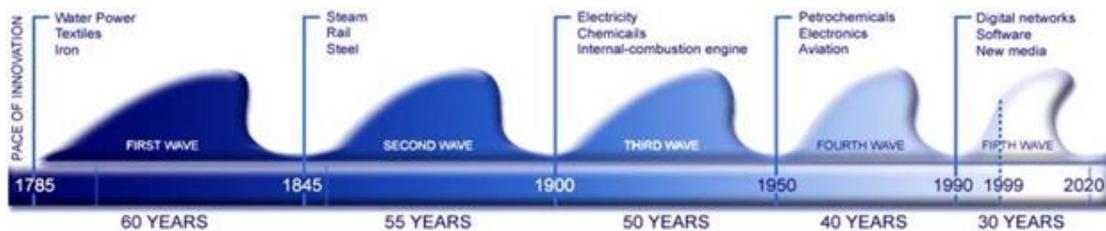


Fig. 2. Schumpeter waves of impact of the technological change on the economy.

improvement and the intangible significance are primarily nourishing the social order and not surroundings and the economic sector [29].

However, the permanent organized interdependencies showed as in Fig. 4. The atmosphere as existence the functioning precedence. This is due to both the development and low-cost are dependent on the environment as the provider of the wanted resources. The period boundary for practice when preparation for tolerable enlargement is also debated in the study.

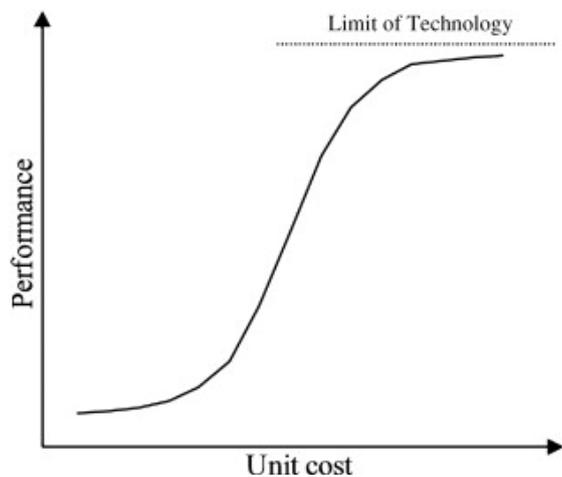


Fig. 3, Technology S-curve

V. DYNAMIC SYSTEMS APPROACH

The method of active scheme is a computing compound model. The purpose of the system usage method is understanding the way which the system work and the concerns that might keep an eye on it. It is the result of the connection between system situations [30]. Variations covering the place in one part of the system might have obvious influences on others. System dynamic is the method projected in the specified research. It is a mix of disciplines method that is founded on the concept of scheme arrangements [31]. System dynamics symbolize the difficult methods with analyzing their active performance per period [32]. Up to [25] Coyle (1996): “system dynamic confirms through the dependency time manners of achieved classifications to define the organization and thoughtful through the qualitative and quantitative representations. The way info response oversees its performance and designing of vigorous info reaction arrangements with controller strategy over imitation and optimization”. Consequently, there are three major types of dynamic systems are: (i) To explain the endogenous organization of a specific scheme of attention below training, (ii) to classify the relationship of various basics of the scheme below research, and (iii) to excuse for

diverse replacements for imitation and discover the variations in the organization under deliberation. The early stage in system dynamics presentation is to regulate the system structure producing of positive and negative relations among variables, response circles, system models, and interruptions [31] and [25].

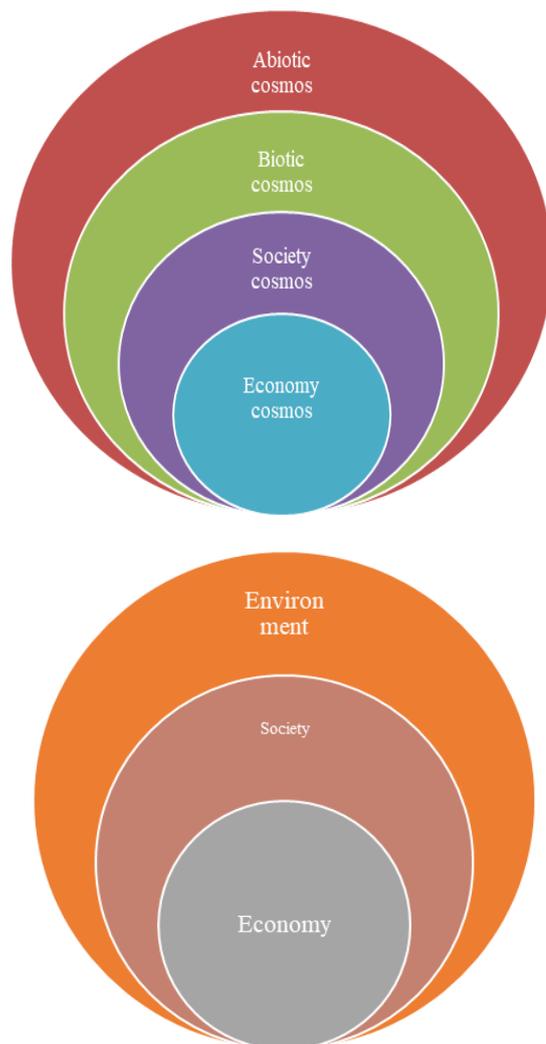


Fig. 4, (a) The cosmic interdependence (b) operational priority of sustainable e development model.

System dynamics models are made up of qualitative/conceptual and quantitative/numerical demonstrating methods [14], [33]. Qualitative modelling contributes in using the fundamental circle drawings or hexagons [34], which monitors in enlightening the empathetic of the theoretical system. Quantitative modelling suggests the practicing of stock-and-flow models.

Quantitative modelling also needs making obvious reports about assumptions underlying the model, classifying reservations around system assembly.

A. Combined Elements

Technology Evaluation

Eriksson and Frostell (2001) [35] express the evaluation of technology as “the object assessment, occupation, or categorization of tasks made via humanoid culture helping by accomplishing an aim with considering the sustainability according to additional responses adding a similar task(s)”. Technical Evaluations improvements are essential, particularly for big-scale technical, meanwhile, a big quantity of wealth sources is essential for their progress. Balanced and reliable evaluation applies for typical investigation due to the difficult features of technical improvement. System dynamics are among the approaches recognized by the study of technical assessment [36], [37]. The major interest of employing of system dynamics in the evaluation of technology is surging the assessment itself. The classification of other technical assessment might not captivate difficult practical attitude of uncertainties outcome of not linear response, like teaching arcs [37]. Forming the organization of any system dynamic technical devices that resulted in the compound performance of technology enlargement might develop the precision of technology evaluation. One more positive impact of a dynamic system of technology assessing is its elasticity in describing compound response methods and discrete random impacts. It is necessary and useful, specifically in the time once allocating with various and possibly interrelating bases of vagueness. Additionally, classification the distribution of ambiguity about dynamic system indicators is instinctive [31]. Ultimately, scheme dynamics offer purer visions to the leaders of strategic activities special impressions in the progressing of technology [37]. The amount of lessons which practice a scheme dynamics approach in the technology valuation inside the agenda of maintainable progress is inadequate. [38] as an example, use planning dynamics towards examining the Australian elements, fuels, and energy manufacturing.

Recently, although, the study of technology evaluation has progressively documented the aids of utilizing system dynamics. [25] defines a universal and active process built upon scheme diminuendos demonstrating the initial assessment of machinery at a middle and well-adjusted class. This study offers an additional instance of an understandable approach about the way that the technology valuation can be combined into system crescendos replicas for a middle-level valuation.

VI. SUSTAINABILITY ASSESSMENT

A major goal of sustainability evaluation is to add the judgment producers by an assessment of international to the local combined atmosphere of social and economic directions from short- and Long-term viewpoints [39]. A purpose of a specific evaluation is to offer regulation on the policy activities which are proposed to attain the workable advance objectives. Meanwhile, it's the initiation, the conception of the supportable enlargement has stimulated politicians to

articulate innovative plans. As a result, they contribute in achieving the stable monetary and technical ways that might defend the surroundings, not just here and now but similarly in another place of upcoming days [40].

Innovative technologies might touch full dimensions of maintainable improvement magnitudes due to their impact on the usual atmosphere and social and economic growth [39].

Additionally, workability is considered status-definite and can eventually establish due to the prerequisites and chances in a particular area measured as a portion of a wider longitudinal organism. [41] add an introduction of some various approaches to the purpose of sustainable assessing. They acknowledged some subsequent methods as a combined evaluation of sustainability: theoretical, scheme dynamics, multi-feature, risk examination, uncertainty, susceptibility, cost-profit, and influence evaluation. All the approaches which are characterized as incorporated methods, just a dynamic scheme could excuse the dynamic with the essential difficulty of maintainable growth sub-schemes. The identified criteria of scheme dynamics of sustainable evaluation are likewise debated by [42], [43], whereas, they demonstrate the suitability of the system about the difficulties of workable improvement. Justifiable skill enlargement regulates a great range which appeal fresh resources, when they request extra transportation with substructure, bulk flows of materials, radiations with other unwanted kinds.

The main feature of the innovative system is technology and effective success. Exhaustion forms, way of life, communal relationships, and national improvements. Technology may similarly progress the ordinary environment in any place that injury has happened. Consequently, the enlargement, fabrication, usage, and removal of mechanical schemes consume effects beside the profits of the environmental, financial, and public with other proportions of workable progress.

Technology is continuously surrounded in the monetary sub-system, culture (and its organizations), and the ordinary atmosphere, which is with viable progress. The characteristic fundamentals of technical system contain usual capitals, administrative objects, mental relics, and governmental relics [44], which involve workable progress sub-systems. Accordingly, in attendance of no deterministic association among the technical system and the workable enlargement subsystem. Deriving from the evaluating works [42] and [45] this could be observed as the technical evaluation in a defensible improvement system. In its place, the approach is difficult somewhere technologies and the maintainable growth sub-systems equally affect each other, including numerous various features. One such relation is occupied into account, it is rapidly comprehended that environmental, monetary, communal, and technical sub-systems are (total) compound methods. While the relation of these sub-systems could be investigated in minor borders by describing borders, trying for any improvement step of technology continuity considered useless only when an investigation is independent of the dependency.

Systematic methods to (SATSA) of management technology enlargement is a “terrific” problem, meaning that there is no specific preparation which there is no decisive preparation of workable improvement and additional so no “greatest” technology resolutions. Additionally, the difficulties connected to justifiable improvement are frequently varying. In spite of these implications, to be capable to form technologies to workable improvement, it is significant to start with sustainable improvement aims.

The description of Eriksson and Frostell (2001) [35] of the idea of technical evaluation proposes that technology must be evaluated by a perception of a convinced distinct regulation, inside that it is invented to activate. The result clarifies that the technology assessment is significant relative to the operative class of continuity since, in its applied wisdom, sustainability demands measurement and enactment contrast [22]. The paper of [46], [47] used to conclude the theoretical bases of sustainability, determines that together theoretic (meanings) and applied (operationalization) assist the idea of continuity included since being stationery/absolute to dynamic/relative.

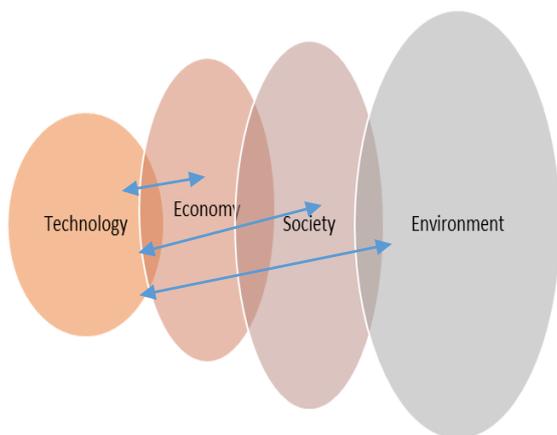


Fig. 5, Interrelationships between energy systems and sustainable development sub-systems

The stationary subject undertakes no variation in actions per time passing with the topic item itself and among other articles. The system dynamics method, therefore, adds an appropriate stand for investigating technology improvement inside the maintainable improvement outline. Since a technical continuity valuation viewpoint [22], that dynamic system distinguish sustainability focused on human activities similar to the entire scheme in the circumstance of certainly happening structures. This add the bases and bowls for the movements of materials with energetic connected with them. It likewise displays the capability of those systems to withstand humanoid actions in the upcoming days, containing more machinery improvement [48]. The significance of the schemes method to (SATSA) of technical power. Whereas technical power valuation is not innovative, then it becomes further applicable in exemplifies such communication as in Fig. 5. Maintainable improvement sub-systems and modern technology [46].

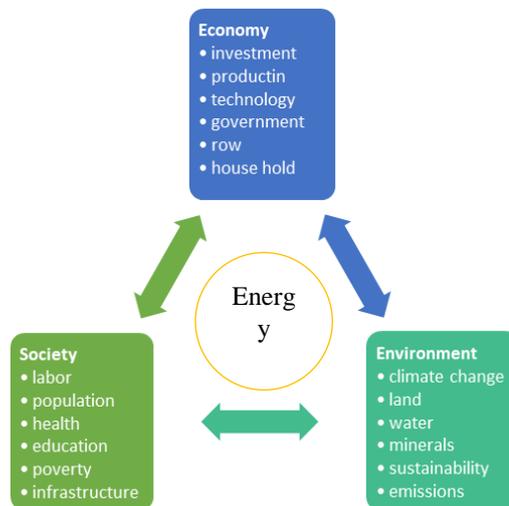


Fig. 6, Inter-relationship between energy system and sustainable development sub-systems

The technical progress of the energy is a reduplicate and automatic procedure demanding amassed information joined by the use of together usual and humanoid prosperity. Workable improvement of technological energy necessitates the deliberation of the subsequent features: a) Supportable technical improvement of energy essentially burdens longstanding preparation. This is for the reason that the essential modification is tough to attain inside a short-time setting as a result of a great degree of difficulty of the collaboration of the energetic system by the maintainable improvement sub-systems. The Millennium organization enlargement shows the difficulty which could not be condensed to linearity, which is surely related to energy. Technical improvement. c) The evaluation method is obligatory to comprehend the special impacts of collaborations compelling together inside and amid the energy technology growth to stimulus alteration. d) Both the technology improvement and supportable progress thoughts are energetic. So, the supplies and features for supportable technical technology improvement will alter the above period.

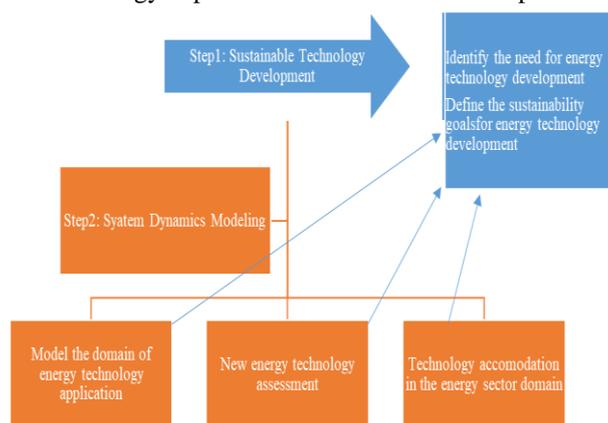


Fig. 7: Guiding process for SATSA : energy technology case.

The results from modern info and knowledge which are congregated and altered established inside the technical improvement of power with maintainable growth sub-systems. e) Fundamental alteration at vigor technical level is obligatory.

This is principally affected by the sustainable increase of the system.

To commence an vigor technical valuation that considered for justifiable development system, the method, or instrument taking a part must thus be able of (i) adding a longstanding reporting; (ii) studying the difficulty; (iii) commerce by co-evolutionary variations together as a outcome and reason; (iv) permitting endless response, reexamination, and modification to overcome with the lively features besides varying necessities of workability idea; and (v) adding an imaginative image to monitor the technical improvement in the direction of the radical modification. The scheme dynamic forces a lively schemes method able in secretarial for the overhead stated subjects. Therefore, scheme subtleties offer an energetic part for the technical advancement of energy such as preparation for maintainable progress. Procedure explanation of the scheme's method to information.

B. Workability Evaluation

SATSA for Technical Energy

Taking the discussion with the significance of SATSA of technical power, the specified part offers the superintendent method with stages of SATSA technical power as shown Fig. 7. The method lets evaluation a technical power enlargement for supportable improvement sub-systems and the applicable workability been displayed. Step 1: workable technical improvement STEP 1, which is represented as "workable technical improvement", composed of two central actions. Firstly, is the documentation of the necessity for liveliness knowledge improvement. For instance, if energy technical production is measured, this action will involve gathering info about the obtainable power generation technology choices in a specific republic or area.

VII. CONCLUSIONS

The study sophisticated the comprehended structure of technology sustainability assessment, which, the researchers considered as a systems approach to technical sustainable assess (SATSA). Accomplishing sustainable expertise progress needs developing approaches or methods that measure the features of the technical improvement and supportable improvement sub-systems. System dynamics is the planned dynamic system method that can guide in adding a technical sustainable assessment. SATSA based on the cross-section of technology improvement, sustainable growth, and energetic systems method. This point indicates that a dynamic system could add the desirable regulation in accepting the system limits for long-term technology enlargement inside the perspective of sustainable development standards. A guiding process for SATSA, by the power technical usage valuation as an instance, was offered.

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