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Dynamic energy distribution system for a smart grid

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Abstract
This paper focuses on the direction of improvement of integrity and applicability of building energy distribution systems (BEDS) using smart grid. The research also focuses on the efforts to overcome certain lacks of modern simulation applications. The system is developed using new modelling schemes which helpful in environmental control systems. The system is the combination of advanced simulation setting thus can be applied in practical. The detection of advanced architectural plans and the progress of original and combined energy conversion, storage, and distribution technologies presents a challenge for BEDS tools.

Keywords
Building energy Distribution system (BEDS), Smart grid, Environmental Systems Performance- research (ESP-r) simulation program, differential and partial differential equations, MATLAB TOOL Fuzzy Logic Control.

1.Introduction
BEDS uses Environmental Systems Performance, research (ESP-r) simulation program for the analysis. ESP-r is a tool to simulate the energy program [1-3]. It also calculates the performance of existing or proposed building designs with including traditional and innovative energy structures'-r tool is developed using numerical methods that can solve the athematic, algebraic equations along with differential and partial differential equations [4]. These equations are building blocks of any system equations like heat equation or mass equations can be represented in the form of differential equations [5-11]. The designed structure is not building type but it can holder any type of system providing the necessary element of the system are installed. One of the property of the system is detailed analyse the designed system or any other controlled system performance's-r designed with new mathematical structure for real-world energy simulation and flow-path [12]. In 1947 the research of ESP-r was started and get completed in 1977 by Clarke. He introduced numerical and mathematical equations in ESP-r energy model and compared with various building energy flow. The heat energy exchange in building, dynamic interfaces and numerical processing are represented by the state space equations. Building and plant modelling approaches are theoretically compatible. The heart of the system designed by the Clarke was customised matrix equation processor, it can handle variable time-stepping, composite distributed control and treatment of rigid systems with large time constant [12-15].

Further various researches were done on building energy flow and heat exchange like air flow modelling by Cockroft in 1979, Hensen in 1991 and Negrao in 1995. The modelling tool were designed by various researchers like McLean1982, Tang 1985, Hensen 1991, Aasem 1993, Chow, 1995 and Kelly 1997, they are capable to handle different problems. One such adaptive multi-gridding technique is designed by Nakhi in 1995 which have capability to enabling explicit modelling of three dimensional phenomena such as thermal bridging and constructional edge effects.

2.Methodology
ESP-r works in graphical, intelligent modes by menu driven order choice. The framework has a measured structure containing a few interrelated projects, as delineated in Figure 1. Basically, it is made out of three principle modules, the Project Manager, the Simulator and the Results Analyser. Since the quantity and diversity of information required by simulation makes the human-computer interface especially difficult, a project management tool, pry, exists [Hand 1994] which manages the description of buildings, occupancy schedules, HVAC plant, control systems and related technical data. Severity, event profiles, plant components, pressure coefficients, window properties, etc.) and utility modules (shading and insulation, view factors, etc.). By relieving the user of much of the burden of managing the potentially large sets of descriptive files, the model creation process is more productive. The Simulator, bps, performs prediction of building/plant energy and fluid flows according to the problem defined. Several modules, which are responsible for individual

technical aspects of the simulation, comprise bps, such as control, fluid flow, plant system, power systems, etc. Figure 1 shows the simulation environment.

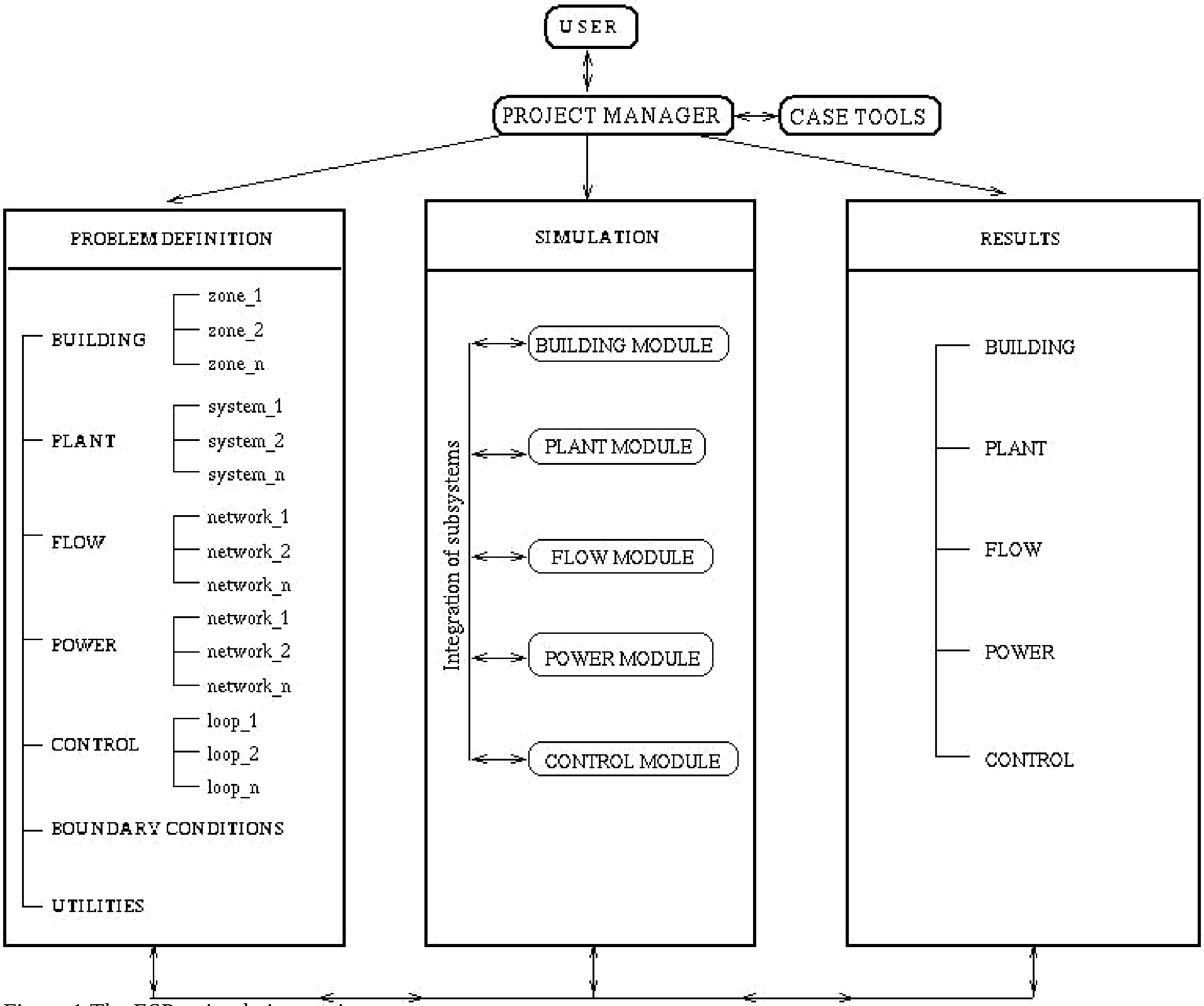

Figure 1 The ESP-r simulation environment

3.Recent ESP-r Developments

Recent ESP-r program developments include the following.

- Combined heat and moisture transfer modelling. To model constructions and/or thermal properties which change over time or as a function of hygroscopic phenomena, ESP-r offers various features with respect to nodal placement (including automatic adjustment) and time-dependent (and non-linear) modification of properties such as conductivity. These facilities form the basis of a combined heat and moisture transfer modelling capability. Via this option, the thermal conductivity of any layer can be defined to be a linear function of temperature and/or moisture content. An extra choice for nonlinear canteen physical properties enables the properties of layers to be characterized as polynomial elements of temperature and dampness content.

-Electrical power stream displaying. ESP-r is blessed with a power displaying module which encourages the demonstrating of photovoltaic exteriors and joined warmth and power frameworks, and permits the burden of an electrical matrix consolidating loads (lights and so forth.) and generators on the warm/stream systems speaking to the building and its plant.

-Modeling and reenactment of sustainable power source frameworks. Since its initiation, ESP-r has been prepared to display sun powered warm frameworks. The above power stream demonstrating improvements infer that it is currently conceivable to show (sustainable power source) electrical parts, for example, PV (Photo-Voltaic) cells, wind turbines and so forth.

-Detailed air flow modelling. ESP-r now incorporates a CFD (computational fluid dynamics) module which enables prediction of detailed air velocity and temperature distributions within a zone. The module can be operated in isolation and/or in fully integrated mode.

- RADIANCE interface. ESP-r now permits fare of issue portrayal information to different bundles; for instance, RADIANCE †. Also, ESP-r highlights a "Brilliance work area beat" which is an interface for running RADIANCE.

-Plant Component Taxonomy by Primitive Parts. Another project has established mathematical models for each of the physical processes that occur within plant components (boiling heat transfer, flame radiation, etc) and used these to explore the possibility of automatically constructing component models from primitive parts. This allows all component models to be synthesised from a small number of primitive models rather than each component requiring a unique mathematical model.

4.Numerical approach adopted in ESP-rHeading

The continuous building, its contents and plant system are translated into a corresponding discredited nodal network. The building and plant are then composed of a number of interconnected finite regions possessing uniform thermo physical properties. The following conservation principle is observed within each control volume, CV, with control surface, CS:

[Storage rate within CV] = [net flux through CS] + [generationratewithinCV] (1.1)

Equation 3.1 for the finite region p can be written in the following mathematical form:

$$(1/t)\ (r_{p*}\ v_{p*}\ f_p) = (\ J_f{*}\ A)_{CS} + S_{fp}{*}\ v_p \qquad (1.2)$$

where f represents a transport property such as temperature, moisture content, etc. r_p is the density of the region (kg/m3),v_p is the volume of the region in (m^3), J_f is the flux of the transport property f through the control surface is kg/m^2s, ACS represents the control surface area m^2 and S_{fp} is any energy or mass injected directly to the finite region (kg/m^3s). The vehicle property flux through the control surface is the consequence of the vitality trade systems between the limited districts in lively contact, through conduction, convection, radiation and liquid stream. As the flux at the control surface is usually difficult to estimate, it is treated as a function of the transport property differences. Therefore, the product $(J_f\ A)_{CS}$ is expressed as the sum of all inter-volume interactions concerning control volume p:

$$(Jf\ A)_{CS} = \overset{n}{\underset{j=1}{S}} K_{j,p}(f_j - f_p) \qquad (1.3)$$

Where j is a finite volume in contact with the volumes p, n is the total number of finite volumes in contact with p and K j, p is the (often non-linear) conductance coefficient (representing conduction, convection, mass flow rates, etc.) between volumes j and p. The flux through the control surface can now be communicated as the vitality connections between limited locales. The technique necessary to obtain all coefficients related to the different energy transfer processes (conduction, convection, radiation, etc.) is described by Clarke.

5.System matrix generation

Integration of Equation 1.2 over a finite time interval, d t gives:

$$v_p\,[r_p f_p - r^*_p f^*_p] = S\,K^z_{j,p}(f^z_j - f^z_p)\,d\,t + S^z{}_{(}f\ p)v_p\,d\,t \qquad (1.4)$$

Where the superscript * speaks to the property toward the start of at some point interim (present time push esteems) and the superscript z shows the qualities inside the time interim. The symbols without superscript are the values at the end of the time interval (future-row values). Variation of properties at z may be approximated by present time-row values (explicit scheme), future time-row values (implicit scheme) or a weighting factor, g, may be applied. In ESP-r, the weighting factor is user-specified with a default value of 0.5 assumed (Crank-Nicolson formulation).

Equation 1.4 may be rearranged and expressed only in terms of future values (unknown) and present terms (known values) before it is solved. This gives:

$$f_p\, a_p - S^{a}\, j^{f}\, j{=}^{n}\, b_p \quad j=1 \qquad (1.5)$$

6.Solution procedure

At each limited timeframe, the interrelated arithmetical vitality conditions gotten from Equation 1.1 are set up and assembled by a connecting convention as a (meager) framework grid. The grid documentation of the relating condition set can be composed as:

$$\mathbf{A}T^{(n+1)} = \mathbf{B}T^{n} + \mathbf{C} \qquad (1.6)$$

Where An and B are the particular future and present time coefficient lattices, T is the temperature and plant flux vector and C is the limit conditions vector. Boundary conditions define climate, ground conditions and known conditions (e.g. another zone not participating in the simulation). Since the right-hand-side of Equation 3.6 is known at each time-step, it can be written as:

$$\mathbf{A}T^{(n+1)}=Z \qquad (1.7)$$

Where T is the vector of obscure nodal temperatures and warmth infusions and A will be, a non-homogeneous scanty lattice containing the future time-push coefficients which are state subordinate. The matrix holding the present values and the known boundary excitations at the present and future time-rows is represented by the column matrix Z. Because of the implicitness of the equations, the set of Equations1.7 must be solved simultaneously at each time-step. However, A is a sparse matrix holding many non-zero coefficients and its inversion by a direct method is computationally expensive. Since the matrix, A is composed of groups of equations referring to different subsystems; an efficient solution process consists of partitioning A into a series of subsystem matrices. Each partitioned matrix is then processed separately by using a direct reduction method and information is exchanged between each solution stream in order to allow the global solution to evolve.

The influence of control on the building-side and plant-side subsystems of ESP-r has been covered. Some other ESP-r control subsystems are:

Fluid flow control
Sensor and Actuators
Climatic Zones
PID controller

7.Fuzzy logic controller

Fuzzy logic Controller is the hottest area in the field of research. The application of Fuzzy logic controller is used in building control systems design. It has intensive application on the use of building energy control so-called fuzzy logic controllers. The benefit of fuzzy logic controllers lies in their skill to match the performance of a user's. It is based on vagueness or linguistic moderately. For this purpose, the presentation of fuzzy control techniques is beneficial whenever a well-defined control objective has been achieved. Fuzzy work on the past simulation data and it predicts the future data.

System models designed in MATLAB using fuzzy logic controllers can be mounted in ESP-r for all purposes building, plant, building energy and network flow control.

The control action of the fuzzy logic PID controller is made up of four stages as follows.

Step 1: The first step is the data collection and establishing of data files for input to fuzzy controller. Some predefined parameters such simulation time period, error and change of error.

Step 2: The second step is known as Fuzzification. Here, transformation of real input values into fuzzy values takes place. It happened in the quantised universe of discourse (Figure 3). Now the simulation input requires mapping of the error and change of error values for membership function. As shown in the Figure 4, the error signal, S1, is plotted with the error fuzzy membership function E1 and E2.

The error signal, S2 is plotted with the change-of-error fuzzy membership function DE1 and DE2.
The rule which is used in fuzzy logic is as under:
IF S1 is E1 AND S2 is DE1 THEN output U1
and IF S1 is E2 AND S2 DE2 THEN output U2

Step 3: All enthusiastic rules add to the fuzzy controller and its output signal. According to this output signal the smallest degree of fulfillment cut of every fired rule. The same is represented in the Figure 2.

Rule 1 (IF E1 AND DE1 THEN U1) is 0.4;
Rule 2 (IF E2 AND DE2 THEN U2) is 0.2.

Step 4: Calculation of the resulting defuzzification. The fuzzy logic output connection set resulting from Step 3 is concentrated to a numerical value of single variable. This signal representing an actuator signal. The methods used to achieve this signals of single numerical variables include the centre of area or mean of max approaches. Figure 2 shows the flowchart.

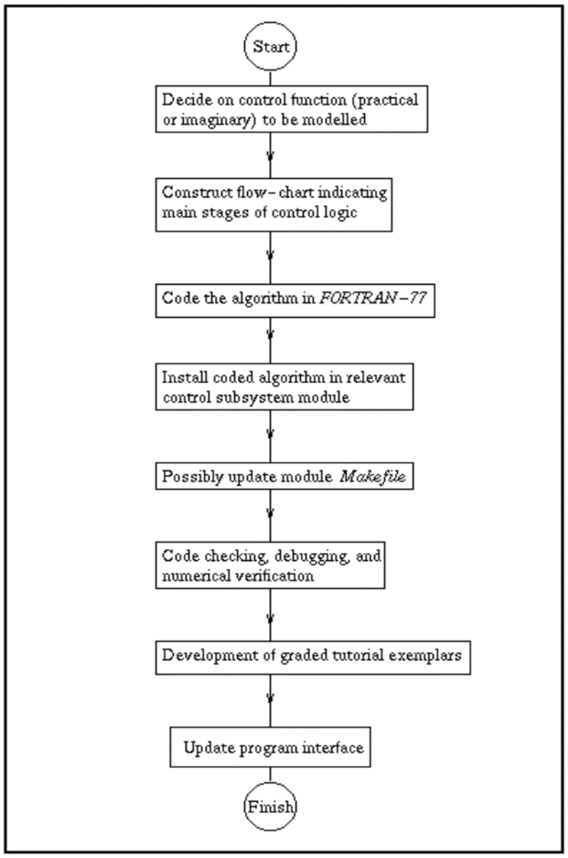

Figure 2 Flow chart for Control system in ESP-r

8.Result and discussion

Modelling and program development process is not at all the easy task. It is based on numerous assumptions and concessions which are inevitably through and, as a result, the exact replication of reality is not achieved. But instead different industrialists, modellers, practitioners and researchers all have to concern themselves with issues of accuracy and applicability. It is because the modelling and simulation developed is vital. Therefore, the researchers and modellers can replicate similar results and at the same time as it is recognised that the perfect simulation model is impossible. It is however important thus the results to fall within an acceptable margin of error. The results are shown in Figures 3,4 and 5.

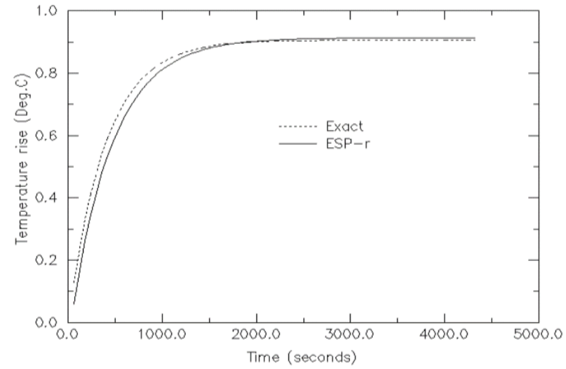

Figure 3 Result with proportional time delay

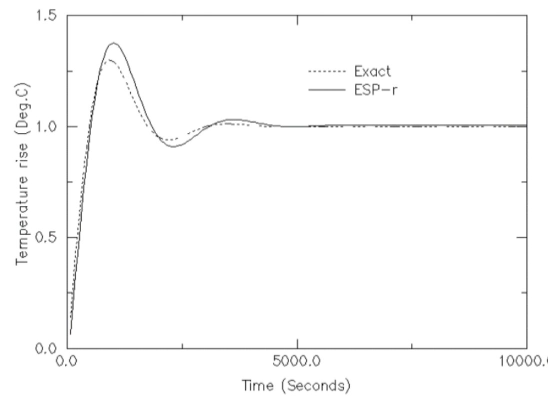

Figure 4 Result with PI actuator delay

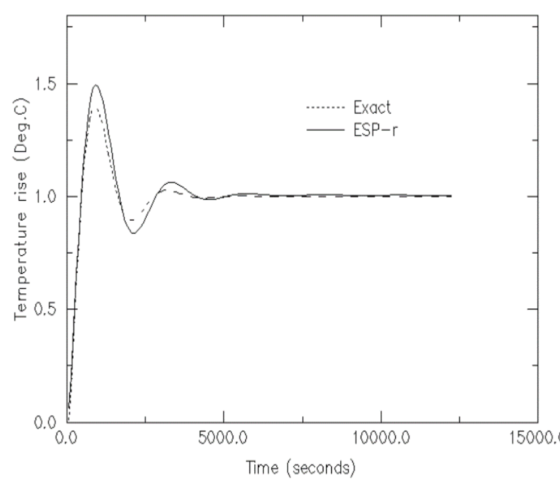

Figure 5 Result with PID controller delay

9.Conclusion and future scope

Optimization of building control system is design and working approaches has expected greater position not only for reasons of economy and environmental impact. But is also occupant comfort and safety of the habitant. Building system is made complex via applying control system they are making any optimisation attempt non-trivial. The complexity is used to provide effective design and decision support system. It is used for building recital simulation program that can be engaged.

Although various modelling assessment of simple building control methodology, hereby no services for the modelling and simulation of innovative hierarchical, Multiple Input, Multiple Output (MIMO) control scheme. The central objective of the present work is to permit the modelling of innovative control system inside a completely integrated, whole building, active energy model program in order to enable high integrity control system modelling.

The field of control classification and its simulation needs for a generalised control system. It ensure that the data-base has been verified and certified. Models for non-ideal sensing and actuating elements were added to account for installed and operational characteristics.

Matrix solvers have been developed to allow the effective practical duplicate of complex control systems. This involved the development of a controlling matrix processing technique well-matched with the techniques already active in ESP-r. A library of total control algorithms have been added to ESP-r. Control systems of a hierarchical nature can now be handled, allowing a range of BEMS strategies to be investigated. Various new zone control capacities have been added to ESP-r's control work database. An environment suitable for the installation of Artificial Intelligence (AI) based control system models has been produced.

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