EN-TASK: Energy-Temporal and Structural Kit

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***Abstract*—This paper concerns a novel modeling and software framework in support of future electricity and energy services. A broad vision for one such possible framework named Energy-Temporal and Structural Kit (EN-TASK) is described. It is explained why is this needed, and how would such framework facilitate Dynamic Energy Control Protocols (DECPs) of the future. The emphasis is on a framework which zooms in and out to assess potential of candidate technology and /or organizational change at the level where it matters the most.**

***Index Terms*—National Energy Model System (NEMS), Electric Power Grid Modernization, Performance Index, Dynamic Energy Control Protocols (DECPs), Distributed Generation (DG), Demand Side Response, Power Flow Control, Storage, Renewable Technologies, Electricity Service, Energy Service.**

I. Introduction

Much has changed in the electric power industry since the late 1960s when the infamous NY blackouts triggered R&D activities in the electric power industry. These efforts have led to the emergence of an entire field of electric power systems with well established modeling, analysis and control methods, and the supporting software for the control centers. The blackouts have also led to the formation of the North American Electric Reliability Council (NERC), and the regional coordinating councils such as the Northeast Power Coordinating Council (NPCC), and the Western Coordinating Council (WECC), and others. Much effort has gone to defining the operations and planning procedures for the industry as a whole, and for the separate regions comprising multiple utilities. Among other activities, the industry has pursued integrated resource planning (IRP) for ensuring long-term future power supply mix. Transmission planning has evolved around the planned generation to meet the anticipated load growth.

Similarly to the electric power sector, much has changed in the energy sector as a whole since the 1970s and the major energy crisis. Risks related to the hard-to-predict economic growth and to the fuel prices have created broader energy worries at the national level. In order to assess the high-level energy needs and options, a National Energy Model System (NEMS) was developed and has been in use as a means of communicating energy issues to the high-level decision makers [1].

The electric power systems tools used in control centers and the NEMS have largely been complementary to each other. We briefly summarize in Section II the inherent features of NEMS and the electric power systems planning and operations tools currently used by the industry. In Section III we identify why are these tools largely inadequate for assessing potential of various disruptive technologies and of organizational changes in progress, and, most importantly, for providing electricity and energy services as specified by the end users' needs. This is followed in Section IV by describing a possible new framework essential for meeting new energy challenges. Section V gives concluding remarks.

II. NEMS, MARKAL and the Electric Power Operations/Planning Software of Today

A. Brief Summary of NEMS and MARKAL

The NEMS projects the energy, economic, environmental, and security impacts on the U.S. of alternative energy policies [1]. NEMS projects the production, import, conversion, consumption, and prices of energy, subject to assumptions on macroeconomic and financial factors, world energy markets, resource availability and costs, behavioral and technological choice criteria, cost and performance characteristics of energy technologies, and demographics. The NEMS global data structure is used to coordinate and communicate the flow of information among the modules. This data is passed through common interface via the integrating module. The integrating module executes the demand, conversion and supply modules iteratively until it achieves an economic equilibrium of supply and demand in all consuming and producing sectors, as shown in Figure 1. Specific to the electricity sector, NEMS represents fifteen electricity supply regions (including Alaska and Hawaii) based on NERC regions and sub regions. It has an option to include: 1) Eleven fossil generation technologies: 2) Two distributed generation technologies; 3) Seven renewable generation technologies; 4) Conventional and advanced nuclear power; 5) Marginal and average cost pricing; 6) Generation capacity expansion; and, 7) Seven environmental control technologies.[1]

Moreover, in the 1970s another model named Market Allocation (MARKAL) [2] was developed by the U.S.

This work was supported in part by the U.S. National Science Foundation under award CNS-0428404, in part, by the National Energy Technology (NETL) under award entitled "Bundling Energy Systems of the Future". The author greatly appreciates this financial help.

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[1] The author greatly appreciates the help of Le Xie with reviewing the NEMS and MARKAL functions.

Department of Energy Information Administration Agency (EIA) for assessing: 1) What happens if a new technology

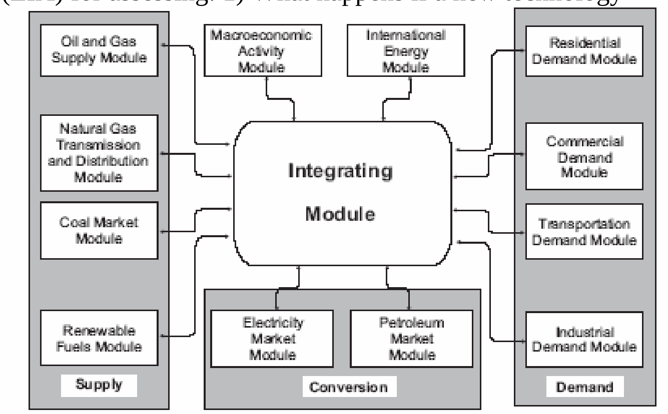

Fig.1 National Energy Modeling System (NEMS) [1]

becomes available, or if an old one becomes cheaper or more efficient; 2) The implications of a technology forcing policy (e.g., a renewable portfolio standard); and/or, 3) How do changes in technology, environmental policy, and resource availability/costs interact. MARKAL is basically a linear programming optimization shell shown in Figure 2 comprising: 1) A database that specifies the energy demand and sources of supply; 2) A set of linear equations is input as constraints; 3) A function of the variables (objective function) which is optimized subject to constraints; and, 4) Solution describing a set of energy technologies and energy flow that constitute a feasible and optimal energy system. MARKAL has the ability to assess electric technologies in particular, by simulating two types of scenarios: 1) A "Forward scenario" – Given expected technology cost/performance specifications, fuel price trajectories, etc., it assesses how are particular generation technologies employed to meet electricity demand and how does this profile affect emissions; and, 2) A "Backward scenario" – Given a fixed market penetration (e.g., for renewable generation by 2030), it assesses what routes get us there (e.g., high gas prices, specific technology assumptions for wind turbines).

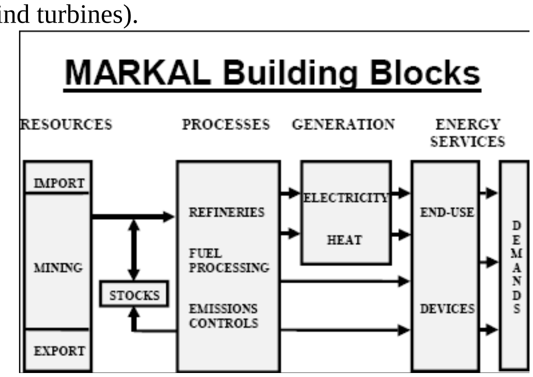

Fig.2 MARKAL Building Blocks [2]

B. Currently Used Operations and Planning Tools in the Electric Power Industry

Under the regulated-rate-of-return each electric utility and region has to plan its own resources in order to ensure quality of electricity service as determined by the state regulators in their geographical areas at the time of settling future tariffs. Current approach to providing highly reliable power depends on systematic Integrated Resource Planning (IRP) ensuring long-term investments in fuel mix for forecast demand, as well as ensuring sufficient capacity to supply demand under normal conditions and during major equipment failures. The basic objective is to provide uninterrupted service to the end users at the reasonable costs. Planning tools are largely utility specific. Nevertheless, they share the following critical common characteristics: 1) The long-term load growth is estimated by the system planners; 2) Generation is planned first, typically so that there is enough to supply the peak load plus enough reserve (in the utility itself or committed by the neighboring utilities at the regional planning stage); and, 3) Transmission is planned by using a deterministic power flow analysis to test if the power can be delivered to all customers during any of the single equipment failures, so-called (N-1) reliability criterion should be met. Planning studies are mainly deterministic the worst case scenario tools [3]. Generation planning is optimized with respect to total capital and O&M costs over the life time of the equipment considered to be built.

The planning is static in the sense that load growth is assumed to be deterministically characterized and by combining operator's expert knowledge and deterministic optimization tools, a generation investment is decided on. The generation planning is also subject to several formalized and less formalized constraints, such as fuel mix choice and acceptable locations (right of ways). Important for later arguments in this paper is the observation that current generation planning tools are inherently assuming economies of scale, namely that the larger power plant the smaller average cost per MW is. Generation planning also does not allow for much risk taking, since the prime objectives are to serve the customer even during the worst hour. This is of course, costly, yet, it is implied in the obligation to serve customers. Transmission planning is very difficult and there are no good tools for optimizing these investments. Instead, transmission cost is viewed as being much smaller than the cost of power plants and these have been built to ensure that power can be delivered. Nevertheless, every EHV electric power grid has delivery bottlenecks that prevent one from delivering the cheapest power to the customers. An excellent quantitative method for determining long-run-marginal-cost (LRMC) in the regulated industry and for finding a break-even point between the cumulative O&M cost of not investing, on one side, and the capital cost of investing, on the other, is known as a peak-load pricing method [4]. This method was extended to transmission and can be used to determine the cumulative O&M generation costs caused by the transmission bottlenecks [5, 6]. To the best of our knowledge, this assessment is rarely carried out at the planning stage. Because all evaluations are around the peak load as the worst case scenario, only that hour is typically used for planning.

Currently used tools for dispatching and adjusting available resources in the actual operations are primarily based on using so-called economic dispatch. This program schedules units in a cost-merit order. Short-term Economic Dispatch is done to minimize total short-run marginal cost (SRMC) resulting in the nuclear and large hydro plants scheduled at full capacity to supply base load, followed by scheduling the fossil fuel (coal) power plants scheduled up to their capacity minus reserve capacity, and finally, scheduling flexible, most expensive power plants used as peaking plants and for load following and frequency regulation. The SRMC economic dispatch is a strictly deterministic static optimization tool, and does not allow for optimizing uncertain load variations around the forecast. Also, there are very few utilities which schedule their power plants while optimizing the start-up, shut-down, maintenance and other cost unique to different technologies. There are several variations of SRMC dispatch with regard to how is transmission modeled, such as: 1) not observing the power flow constraints, but only attempting to optimize supply and demand, and using approximate formulae to estimate the power loss; and/or 2) observing only approximate linearized real power flow constraints. There are hardly any nonlinear AC OPF programs used by the utilities for optimizing O&M generation cost subject to all, real power and voltage constraints. There are even fewer, mainly only at the exploratory stages that rely on adjusting voltage and demand side resources in addition to optimizing real power produced by generators [7]. It will turn out that lack of these software tools is one of the fundamental obstacles to utilizing many promising distributed technologies, as described later in this paper.

Moreover, the operational and planning objectives and practices are vastly separated between the transmission and distribution levels of an otherwise electrically interconnected network. It is explained later in this paper how this disconnect of tools currently used greatly undermines the ability of the EHV transmission network to be helped by the actions at the customer side, and vice versa. In the extreme, distribution (local) electric power networks are hardly adjusting in operations. They are, instead, pre-programmed for the assumed loading profiles.

Last, but not least, most of the currently employed scheduling tools are not applied to the network whose details include automation, such as protective relaying and local controllers. This makes the result in a snapshot of what may happen, instead of providing simulations to reproduce what is likely to develop in operations. This void is recognized and there are efforts toward developing richer simulators to include the effects of relays and local controllers [8].

III. THE NEED FOR NEW MODELING AND SIMULATION FRAMEWORKS

As pointed out at the beginning, this paper is motivated by the need to develop adequate modeling and simulation frameworks capable of assessing technological and economic benefits of the evolving electric power technologies. More generally, simulators are needed for assessing effects of novel energy systems of the future. Many efforts are under way toward utilizing just-in-time (JIT) and/or just-in-place (JIP) technologies, both hardware and software [9]. On the hardware side, there are many new technologies such as the distributed generation (DG) technologies. What is truly missing are tools for assessing their integrated effects and their inter-dependencies. There are currently no systematic tools for quantifying potential of various novel technologies.

In this section we first pose the basic problem of diverse energy systems of the future, and then describe the new challenges facing energy resources, demand and delivery, as well as their interdependencies. We close by pointing out the inherent assumptions in both aggregate energy models, such as NEMS and MARKAL, as well as in the current operation/planning tools used by the electric power industry, which make it fundamentally impossible to assess many evolving technological and organizational changes adequately.

A. Basic Problems of Diverse Energy Systems of the Future

Given today's diverse energy systems, and their wide-range of customers and delivery methods, we view the problem of Energy Systems Design (EnSD)/Energy Systems Operations (EnSO) as a complex network system problem whose objectives are to:

a. Meet desired technical, economic, social and regulatory constraints in a sustainable way;

b. Catalyze the dynamic evolution of existing system as these attributes change in order to manage demand growth uncertainties accordingly;

c. Ensure high quality cost-effective electricity and energy services.

Following is a brief overview of some major intellectual challenges concerning energy resources, delivery and demand sub-problems, and managing their inter-dependencies.

B. Energy Resources

The sub-problem of energy resources has been extensively studied. Many believe that this is the major challenge for meeting future energy needs. Studies have focused primarily on future type of energy sources, and to a lesser extent on their spatial and temporal characteristics.

We are entering a cycle of seeking energy sources from outer space and creating acceptable forms of nuclear energy. In addition, novel ideas such as hydrogen and micro-, nano- and bio- energy resources are beginning to be considered. Matching these largely unknown resources with the needs of millions of energy consumers dispersed geographically and who require energy at different times will determine the ultimate impact of these new resources. Therefore a fundamental understanding is needed.

A major intellectual challenge concerns shifting from economies of scale to economies of scope. Economies of scope come from the ability to meet more than one objective with the same resource. In energy systems with little or overly expensive storage, economies of scope are measurable in terms of efficiency and sustainability that can be gained by the right temporal and spatial aggregation of available resources [10].

Optimal use of resources will require optimal temporal use given various technical constraints. For instance, a nuclear power plant is "natural" for serving a large average load. A smaller coal plant serves medium size loads well. A large number of many flexible power plants could serve highly varying loads. Production of some attractive energy sources, such as wind and solar can not be controlled. In order to match use of such energy with the customer needs some form of storage is needed.

However, resource planning and operations for a combined mixture of resources remains a serious challenge. This has become more pronounced in light of revisiting nuclear power issues, as well as in attempting to develop the futuristic hydrogen economy. The most immediate challenge is to understand the role of natural gas, including LNG, and the real potential of small-scale renewable energy resources, such as wind, solar, geothermal and tidal power.

The question of scaling is also critical. Is it possible to simply see the ideal world as one in which many magical technology micro-/ nano-resources replace huge energy resources, if these were to be made available? For example, how many tiny energy resources would be needed in order to avoid building one new conventional combustion power plant? What would be their cumulative environmental impact and how adaptable would they be to users' needs?

The technological problem of cost-effective energy storage remains a major unsolved problem, too. It is striking to realize that we still do not have long-lasting laptop batteries. Given this simple observation, we believe that a huge gap exists between what may be the dream for future storage technologies and what is practical and achievable now.

Storage economics have not been carefully studied and clarified either. It may be that with doing very little of something else on the system, such as demand-side response or using natural storage such as hydro, the need for solving large-scale storage problem would be almost eliminated.

A significant problem of regulatory economics concerns incentives for efficient energy production. It is much more common to pay only for energy used and "piggy-back" on others for economic effects of temporal and spatial differentiation. Some of these problems are beginning to be posed as game theoretic problems, but it has been recognized that they pose serious intellectual challenge to current knowledge in game theory because they don't lend themselves to the assumptions typically made.

The last, and very difficult challenge, involves managing risks associated with long-term investments, using regulatory and/or market-based mechanisms [11]. The non-uniformity of market signals for various forms of energy sources is puzzling: Electricity restructuring has been dominated by strictly short-term market design, while the fuel markets tend to be longer-term forward markets. Similarly, the whole sale markets do not observe impacts of small-scale DGs, unless their penetration is significant. This is despite the fact that these technologies could bring tremendous value to the distribution-level users with often unique needs. This has been one of the major roadblocks to higher penetration of future distributed resources, such as solar, geothermal, very small hydro, and the like. It is important to research what may be an adequate combination of diverse energy markets and for what purposes.

C. Customer Energy Needs

The energy needs of customers are a critical problem because understanding demand greatly determines what needs to be done. Often a highly accurate forecast of long-term demand forecast does not address, let alone solve, the problem at the utility, regional, or state levels.

There is a much better understanding of the characteristics of customer classes, but these are not straightforward enough to map into spatial, temporal, and energy systems characteristics. For example, while one knows in considerable detail the characteristics of individual air-conditioners, or even light bulbs, the characteristics of households they are in are not known after aggregating all appliances within the household. Further aggregation to the medium/high voltage level of utilities (such as cities, counties) leads to even poorer characterization.

Next comes the rich problem of customers' role in balancing energy supply and demand. The late work of Fred Schweppe put forward the vision of homeostatic control, which basically says that energy users adjust locally, and that this leads to a fully adjusted system as a whole [12]. These were the first ideas signaling the major role in customers' active adjustments to energy shortages and prices. The time has come now for working out the details of homeostatic control, since automation and its cost make this a truly viable concept. This represents a huge opportunity for using distributed sensors and controls. It is mind-twisting how slow this technology is being adopted, although control hardware is abundant and inexpensive. What is missing are the incentives to do this, including well-intended user aggregators, referred to in this paper as the Load Serving Entities (LSEs). [2]

The question of most effective load aggregation as a function of attributes desired is completely open. It is not clear what measurements and communications are needed for which groups of customers in order to adequately manage

[2] Different terms are used for energy providers in different parts of the world. The intent here is to distinguish the traditional vertically integrated utilities from what is referred to here as the LSE, whose key functions are described in Section IV.

inter-temporal dependencies, average shortages, and peak demand shortages. This design has direct implications on the risk and cost of not being served and on how flexibly customers can respond to overall changes in energy availability.

Without characterizing demand carefully, all other energy systems problems become meaningless. For example, recently Ernie Moniz discussed a major problem - supplying energy to future “gigacities” [13]. This is a huge challenge. The gigacities need to be characterized for their energy and utilities demand and utilities before a design of energy resources and delivery can become useful. Demand management also has a very unique role in balancing system-wide supply and demand because it is one of the least expensive storage technologies known. Much energy consumption can be adjusted to availability using techniques such as time-of-use and its more advanced versions, such as real-time price response.

D. Energy Delivery Problems

Only recently has it become clear that there are many diverse and far-reaching issues in energy delivery. These were exacerbated by the strong tendency to build gas-fired power plants and by recent ideas for hydrogen super-grids. Gas-powered plants could be located either close to gas tanks, and/or placed far away, where plants would produce electric power and delivery would be via electric wires. Or, gas could be delivered to closer-by power plants via pipelines. Similarly, ideas have recently been put in place to transport energy via hydrogen, instead of electrical wires.

While these ideas are in their infancy, they raise the major issue of finding adequate ways to deliver energy. Moreover, when one begins to examine multiple delivery media, the question of storage becomes potentially critical.

In order to move forward with comprehensive solutions, it is critical to model a heterogeneous, diverse network comprising gas/electricity/coal networks and their interdependencies in delivering well-defined source-sink nodes within this network. The question concerning hydrogen can not even begin to be posed outside the context of other delivery means.

The global delivery problem lends itself to the entire set of questions formally studied in other complex networks, such as Internet, Electric Power Grids, Gas/Fuel Delivery Systems and Healthcare. These involve routing for congestion, temporal and spatial (only harder, because there are no cost-effective electric switches on the electric power lines); relations between backbone, and local (distribution networks); top-down, vs. bottom-up network management; and management and cost of uncertainties.

Also, there are more recent questions concerning regulatory support for incentives to evolve the delivery system into the system with well-defined quantifiable attributes [14].

Inter-dependencies among energy resources, delivery, and consumption

It is fairly straightforward to demonstrate that as far as the customer is concerned, there is little, if any difference in providing inexpensive energy from distant suppliers or expensive energy from local ones. For providers, however, there are different implications.

Similarly, the customer needing heat is largely indifferent to the various types of energy sources providing it, as long as the cost is the same. That is, unless s/he cares about other attributes beyond cost, such as sustainability, flexibility etc. . . .

There are many examples of these substitutes in an energy system of the future. As the system evolves into new architectures and needs to meet new objectives, the possible number of options is huge.

These opportunities should be contrasted with what is in place today. Shown in Figure 3 is a schematic representation of the key energy and electric power operations and planning modules used to plan the energy system evolution and its operations. It can be seen from this figure that, as reviewed here, these are largely independent modules, or, at best, linked in a strictly top down manner. In other words, aggregate supply demand needs are assessed using the national energy models, such as NEMS and/or MARKAL, and this information is used by the electric power planners to plan their regional and or single utility supply. The results of generation planning are used to plan for transmission. It is emphasized in the brackets that the decisions are functions of technologies. However, without inter-relating these modules (dotted lines represent these missing interactions), technologies considered are typically only the proven once. The dotted lines show that at present the interdependencies between the criteria, candidate technology and the decision made by the existing modules are by and large not considered.

Moreover, shown in Figures 4 and 5 is schematics of today’s electric power operations modeling and software, for both transmission and distribution levels. It is striking that the approach is entirely top-down, hierarchical. This does not leave any opportunities to put the customer and her services into focus.

E. Inherent Assumptions in Today’s Energy and Electric Power Simulators

The basic challenge to the existing tools begins with the strong distinctions in current approaches to characterizing energy problems among:

1. Availability and type of energy resources;
2. Customer demand; and,
3. Delivery challenges.

The existing frameworks are generally clustered around the themes of energy availability and, to a lesser extent, around delivery. Customer demand, despite its fundamental relevance, is hardly ever posed as the central problem. Moreover, to date, the interdependencies among the aforementioned challenges have not been formally captured. In addition, interdependencies within each category are included only up to a certain degree, primarily in the area of energy resources. If this trend continues, many opportunities will be missed as technologies evolve in all three areas.

Such a piecemeal approach to providing energy cannot lead to the most effective technological or the economic policy solutions. Many predictions of energy needs and associated economic impacts suffer from the following problems:

1. not capturing the level of detail necessary to obtain even semi-realistic conclusions; or
2. making strong, implied assumptions about aspects of the problem that have not been modeled;
3. asymmetric top down risk management paid by the distributed users; and,
4. using almost exclusively deterministic tools.

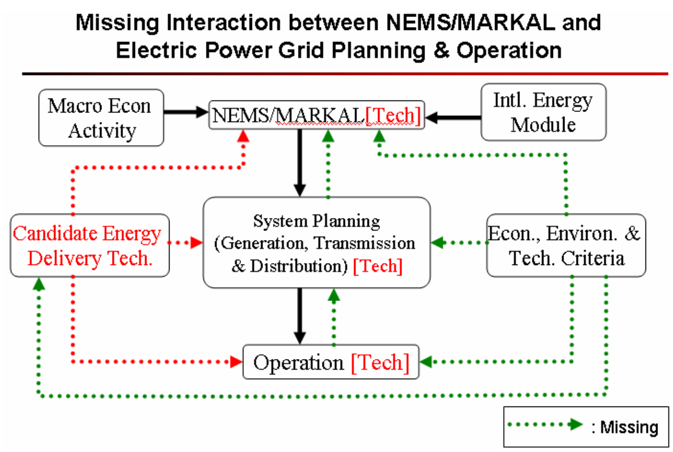

Fig.3 Missing interaction between NEMS/MARKAL and electric power grid planning & operation

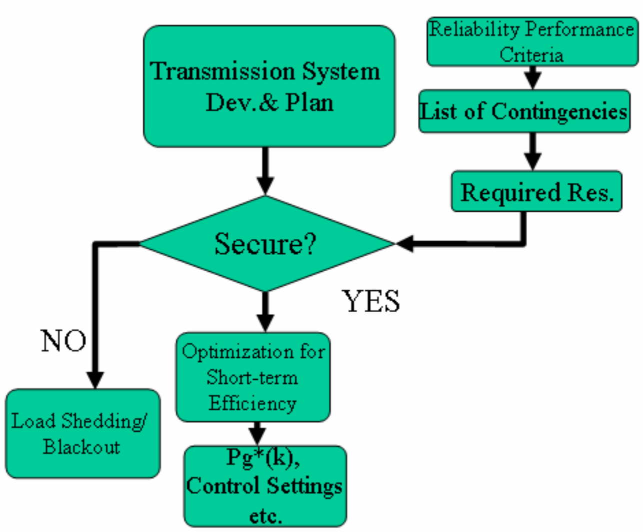

Fig.4 Operations in today's transmission industry (w/o ENTASK)

The solutions are often seemingly too complex and not easy to communicate. In particular, the question of modeling externalities quickly becomes an overwhelming issue. Initially, everything affects everything else. For example, production affects delivery, which, in turn, affects demand, environment, pricing. Therefore, if one studies production while assuming delivery to be externality, much can be missed [10], [15].

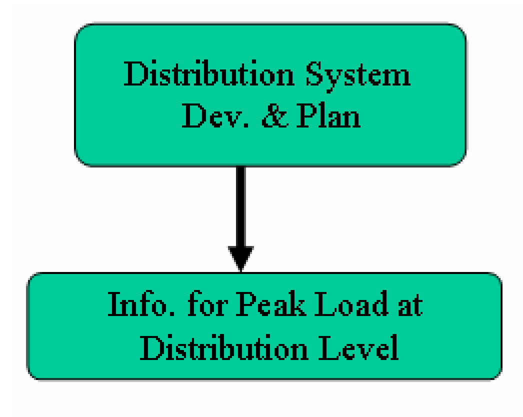

Fig.5 Operations in today's distribution industry (w/o ENTASK)

IV. EN-TASK: A POSSIBLE NEW MODELING AND SIMULATIONS FRAMEWORK

Studying energy system architectures and operational paradigms of the future requires systematic modeling, analysis and decision making tools that could capture attributes of interest. Significant overall dynamic (energy) efficiency could be achieved by assessing the problem as a complex, diverse engineering-economic-social network system for which analytic and software tools can be developed to drive it toward well-understood attributes. Ultimately, the system becomes a closed system in which attributes evolve in response to system performance [16].

Our current knowledge of engineering systems does not yet offer tools for adequately managing a diverse energy system. This very broad problem formulation requires extremely carefully posed modeling framework to capture critical inter-dependencies and attributes. Once this is conceptualized, formal methods for dynamic model aggregation (spatial, temporal and contextual) need to be introduced to facilitate quantifiable decision making and, ultimately, partial automation.

The dotted lines in Figure 3 depict the basics for information exchange in the envisioned EN-TASK primarily for planning and development purposes. Decision making is highly interactive and iterative. The EN-TASK framework under development is supported by the modeling and software tools both at each module level and for their interactions. While the interactions are self-explanatory, the major challenge is the underlying modeling and decision making for provable performance of the system as a whole, while lots of activity is taking place at the modular, agent-levels. A mathematical framework, which is a careful combination of statistical, learning and deterministic tools for large-scale dynamic systems is currently under development.

A very important observation is that the static and deterministic approach currently used by the industry EN-TASK relaxes into a highly dynamic, stochastic environment in which decision risks are distributed among the industry layers, and are managed by all by the continuous interactions and dynamic decision making under uncertainties.

The implementation of such a framework ultimately results in what one may call the Dynamic Energy Control Protocols (DECPs) [17]. It is fundamental to understand that as the distributed technologies are being deployed and the industry is re-organizing into non-traditional top-down structures, the process of distributed interactions and decision making is already part of the real-life system. The problem is that this is not captured by the modeling and software the industry currently uses, therefore a major disconnect.
This is needed, however, because the temporal, spatial, and contextual model simplifications must be carried out with full understanding of quantifiable inaccuracies and loss of initial attributes, as reduced-order models are derived and used. For example, given the very complex starting model, different model classes must be developed for assessing spatial effects of delivery on the needed new energy resources, more so than classes of models for assessing effects of environmental constraints on the need for new resources. Different classes of models will be needed for inducing efficiencies from managing temporal interdependencies than for other purposes. Similarly, computer-aided tools for decision-making will require the right model classes to meet predictable performance requirements.

The EN-TASK framework shown in Figure 6 requires the same as for planning and development, a high degree of multi-directional interactions at various temporal and structural levels of detail at the system level for operations. The detail needed, and the boundaries of the industry portions aggregated become simply a function of objectives (many distributed to meet the attributes such as flexibility, differentiated reliability at price, choice of sustainability criteria). The models evolve as the conditions change and new information is made available. Shown in Figure 7 is the same framework (zoomed in) for a specific Load Serving entity (LSE). One can see that an LSE of the future will have to interact dynamically with both its customers (lower layers) and the providers of service (higher layers). As a matter of fact, such interactive LSEs are likely to become the key decision makers defining distributed attributes on behalf of their members, and the early adopters of distributed technologies. If it is cost effective, technically attractive and it meets often unique attributes specified by its customers, it is the LSE which will see the benefits of implementing demand-side technologies, combined heat and power (CHP), storage units etc near for its customers. It is the LSE which would become a non-traditional control area [18]. Conglomerate of many such LSEs will co-exist and balance the system in highly unconventional ways using the distributed technologies for grid modernization. However, the LSEs must have their own sensing, monitoring and DECPs for interacting with the rest of the industry. It will have to learn detailed characteristics of its customers' loads by carrying out experiments generically referred to in [17] as the Electricity Demand Experiment (ELDEX), and shown in Figure 8. If there is room for managing uncertainties, the LSE will further aggregate its objectives with other LSEs, and/or it will lose customers to the other LSEs if it can not serve them "better" than the competitors.

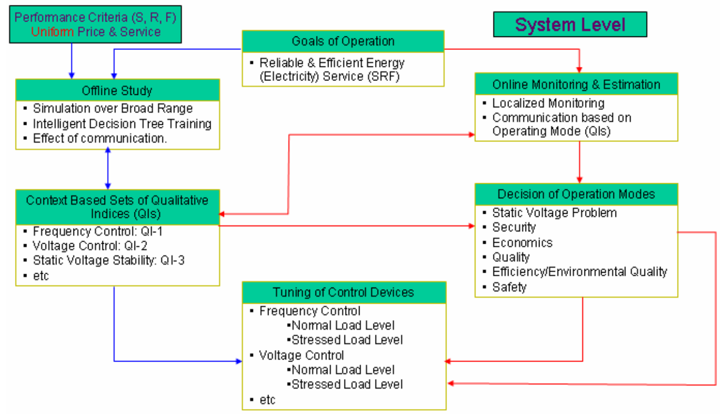

Fig. 6 Interactive operations (with EN-TASK) for transmission (system level)

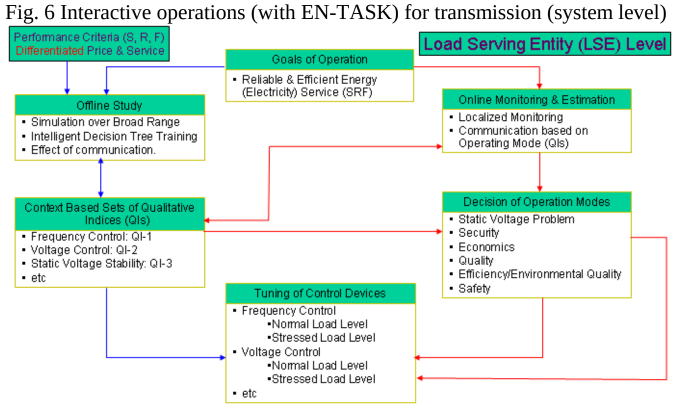

Fig. 7 Interactive operations with EN-TASK (LSE level)

The overarching intellectual theme underlying demand management of the future is that one could use much filtering, learning, and the like to model and identify customer characteristics, then design ways to manage them to meet customer's specifications [19]. Depending on how the aggregation is calculated, customers could be defined as either large individual loads with very specific power quality needs or groups of customers served by an entire utility. It could also include something in between, like a town served by a newly formed aggregator.

Many more examples can be given to illustrate the EN-TASK framework underlying potentially successful energy industry of the future [19]. This is not described here because of space limitations. We close by mentioning what we consider to be its major features. In particular, 1) The information about LSEs needs and the effects of the distributed technologies deployed by them on what still remains to be done at the higher industry, and/or national, levels must be taken into consideration when these levels plan and operate the system. As a simple example, depending on the amount of DGs, the need for large scale generation will change drastically; 2) Moreover, the information about LSEs needs will have to be taken into consideration very carefully when the new transmission and distribution enhancements are planned by the delivery modules. In other words, the transmission system will need less large-scale upgrades if congestion is reduced by the LSEs serving their users locally; 3) The provider of the last resort must be revisited. If there are many LSEs, it will become increasingly harder to plan for those who are served by the traditional utilities; and, 4) The interactive information exchange for managing risks created by the others is one of the major t fundamental challenges.

V. Conclusions

The basic premise in this paper is that the ongoing major technological and organizational changes in the electric power, and more broadly energy, sector require a new modeling framework and an associated software kit. We suggest that these are essential for assessing potential of changes under consideration, and explain why the existing industry tools fall short of providing a means for a fair assessment. To move forward, we describe a vision for one such possible framework and the software kit. This kit is capable of dynamically integrating the level of detail, both temporal and structural, as a function of performance criteria of interest and the system characteristics. We refer to this framework as the Energy Temporal and Structural Kit (EN-TASK).

A major novel aspect of the envisioned EN-TASK is its adaptive ability based on careful combining of statistical data with the more conventional deterministic models. Its particularly unique features are the ability to: 1) characterize more general energy objectives than solely the electricity service objectives; 2) incorporate the feedback control effects of the technologies considered; and 3) zoom in and out to capture the performance objectives of interest and the extent of the effect created by the change of interest. This paper describes the underpinnings of this basic framework and illustrates potential for its use on several key unconventional technologies.

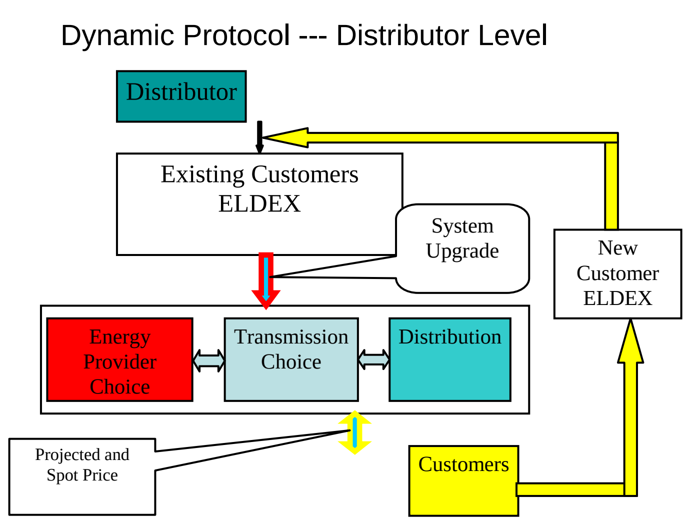

Fig. 8 DECP at the distributor level [17]

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