

Real-Time Ratings for Transmission Systems

CEC/CIEE Research Program Plan

Overview

Currently, typical capacity ratings for transmission systems are of the “static,” i.e., non-time-varying, type that are estimated or calculated based on seldom-seen worst-case conditions. These ratings are conservative by design, and have the effect of underestimating the actual capacity most of the time while ensuring generally high reliability in operations. These days, as transmission system constraints are becoming more acute, “dynamic” ratings that depend upon knowledge of actual system conditions have the potential to enable higher capacity ratings. Implementing real-time monitoring and communication technologies that enable dynamic rating is expected to result in cost-effective increases in capacity required to meet growing demands, and will improve transmission system stability and thermal management operations and economics.

This Research Program Plan is intended to be a strategic framework for the use of real-time ratings (RTR) in the California transmission system. The basic elements of the Plan include an assessment of the current status of the California transmission system, a vision of what we are trying to achieve with the optimum implementation of RTR technologies, the strategies to be employed in achieving that goal, and an action plan for carrying out the strategies.

Objective

The objective of this Research Program Plan is to provide a management framework for the research and development activities necessary to achieve the optimum implementation of real-time monitoring, information and reporting technologies in California’s electric transmission system.

Implicit in this objective is the realization that real-time rating technologies may not be the ideal answer to every problem involving capacity constraints in the transmission system. Nevertheless, the goals of this program are to determine when and where real-time ratings are a cost-effective and practical solution, and to perform the appropriate research activities to enable their use and realize public-interest benefits.

Strategies

Strategies for achieving this objective include:

- Establishing a stakeholders group to provide support, direction and oversight to the research program.
- Developing the “Business Case” for use of RTR technologies in the California

transmission system. This will be a white paper that develops the methodology for analyzing the applications of RTR technologies, their costs and benefits, and addressing the barriers to their implementation.

- Achieving a comprehensive knowledge of the real-time rating (RTR) technologies that are available, their estimated costs and potential benefits, and their implementation barriers and issues (i.e., the “State of the Art” in RTR technologies). This will be a white paper that will be updated periodically to reflect new knowledge and experience as it develops.
- Developing an RTR technology R&D “roadmap,” with the assistance and guidance of stakeholders and industry experts. The roadmap will assist in identifying and prioritizing research activities that will enable RTR technology products to be economically implemented in a given timeframe in California.
- Developing and managing a CEC/PIER RTR technology development program that accommodates end-user and consumer needs, and collaborates with other public and private sector development programs where mutually beneficial.
- Providing close coordination with the Transmission Research Program Director, the Policy Advisory Committee (PAC) and the California Energy Commission (CEC) PIER Program.

These strategies are described in more detail below.

Stakeholder Support, Direction and Oversight

A Technical Advisory Committee (TAC) has been established, composed of stakeholder representatives (PG&E, SCE, SDG&E and CAISO); its purpose is to provide technical input and research direction to the RTR Research Program in a collaborative, consensus-driven environment. Specifically, the TAC will help develop business objectives and priorities, research priorities and project proposals; provide project prioritization and funding guidance; monitor project progress; evaluate project results; and assist in technology transfer and implementation strategies. To date, two TAC meetings have been held. It is anticipated that the TAC will meet 3 to 4 times per year.

In consultation with Transmission Program Management and the Policy Advisory Committee, the TAC may decide to add additional members to its core group, as necessary to enhance its activities and add value to new project efforts.

Business Case

The goal of this strategy is to develop the business rationale for RTR technologies in California. The resulting white paper, titled “The Business Case for Dynamic Ratings,” is intended to be a guide for the use of RTR technologies in the transmission system from the potential user’s perspective. It will propose a set of standard definitions for **applications** of RTR technologies to the transmission system, a general guide to estimating the costs of implementation, and a description of the types of benefits (both qualitative and quantitative) that may be expected and how to calculate them.

Applications are expected to include, but are not limited to, the following:

- Contingency Management – Mitigation or modification of remedial action schemes necessitated by unexpected outages.
- Congestion Management – Alleviation of constrained transmission paths.
- Economic Generation Dispatch – Increased availability of economy generation, or efficiency of operation.
- Clearance Management – Monitor or estimate the sag or clearance of transmission line spans to maintain positive safety margins.
- Maintenance Management – Facilitation of scheduled outages of equipment for the purpose of performing maintenance.
- System Reliability – The California Independent System Operator (CAISO) can use real-time data from utilities to manage the overall reliability of the California transmission system.
- Static Upgrading of Equipment – Re-evaluate equipment static ratings by analysis of actual line loadings using historical real-time data.
- Emergency Response – Alleviate the need for rotating outages or brownouts with knowledge of actual transmission line limits during periods of high power demand.

The **costs** of implementing RTR technologies will include capital costs of purchasing a system, licenses, engineering, installation, operator training and periodic maintenance and replacement.

The **benefits** of successful application of real-time rating (RTR) technologies to the transmission system could include:

- Increased asset utilization, resulting from higher capacity limits on existing lines and equipment.
- Cost savings, e.g., from deferral of capital investments in new transmission facilities, more economic generator dispatch, access to economy generation, avoided congestion payments, etc.
- Increased operational flexibility that will enable utilities and the CAISO to better manage changing system conditions.
- Increased reliability and safety that results from better knowledge of system status, and improved access to resource options and reduced need for remedial actions in emergencies.

Once the costs and benefits of implementing a particular solution are identified, a benefit/cost analysis should be performed using accepted financial parameters and accounting techniques, so that the RTR technology can be compared to the traditional solution on an equal financial basis.

The **barriers** to acceptance and implementation of RTR technologies will need to be identified and analyzed, and strategies for overcoming those barriers developed. While research, development and demonstration of real-time ratings have been proceeding for over 20 years in numerous utilities and other organizations, actual acceptance into industry standards and practices has not been widespread. Some of the factors that need to be considered when forming research efforts in RTR technology:

- cost; especially how to compare the total owning cost of the technology to the standard utility alternatives
- complexity of the technology, in installation, operation, calibration, maintenance, etc.
- risk (actual or perceived), either of the technology itself failing (reliability), liability resulting from damages caused by failures while operating outside traditional engineered margins, or failure to achieve the hoped-for benefits
- regulatory disincentives or lack of clear regulatory treatment
- uncertain benefits, or uncertainty as to whom the benefits will accrue
- institutional inertia: unfamiliarity with new technology, or resistance to new, “not invented here” solutions
- personnel training issues and requirements

The results of research efforts should be used in devising effective strategies for the development and acceptance of the technology by the target market, and for monitoring the use of the technology to verify that the expected benefits are in fact being achieved.

The Business Case white paper is posted on the PIER Web site at [*link TBD*].

Status of the Technology

In this strategy the goal is to collect the most up-to-date information on what RTR technologies are available, or might soon become available with appropriate developments, their associated capital and maintenance costs, and their performance parameters. Of special interest is knowledge of what has been tried elsewhere and could be transferred to the California transmission system, what needs to be further developed and demonstrated, what new and promising technologies are on the horizon, etc. A white paper describing the “State of the Art” in RTR technologies is currently being drafted by the Research Coordinator, and is intended to be a living reference document, to which new information will be added as it is acquired.

Instances in which other researchers or utilities have achieved success in applying RTR technologies to their systems may provide opportunities to interview those entities and learn from their experiences, and possibly collaborate with them on further research and development efforts.

RTR Technology “Road Map”

A technology roadmap can be a useful tool for providing a basis for an R&D action plan;

it provides a logical analytical process for determining what research activities are needed to get from the current state of technology deployment to the desired state. Roadmaps are generally structured as follows:

1. Describe the end-state of the technology product.
2. Describe the current state of development for this technology product.
3. Identify the gaps between the current state and the desired end state of the technology.
4. Develop the technology development and test activities and sequences of execution (pathways) to close the identified gaps.

For the RTR Research Program, Step 1 will require a consensus-driven effort to describe the “end-state” in more detail: what the electric transmission system should look like with the optimum implementation of RTR technologies. Step 2 will be fulfilled by the State of the Art white paper. Step 3 can then be addressed in the form of a “gap analysis” that shows where the R&D needs are; the prior work by Navigant [ref.] can be used as a starting point. Finally, Step 4 will use the results of Step 3 to re-assess the current technology development plan (see “Technology Development” below).

Technology Development

Integrate Existing CEC Projects

The CEC has conducted a number of research efforts in real-time monitoring prior to the establishment of the Transmission Research Program, some of which are ongoing. These projects are being monitored closely, and their results will be evaluated by the TAC to determine the appropriate next steps. In some cases further research may be warranted; in others the results may be incorporated into a technology transfer plan so that the benefits of the research can be achieved by the marketplace. These projects include:

- Sagging Line Mitigator (SLiM). A mechanical device that counteracts the sag of a transmission line with temperature. This device has progressed from successful laboratory demonstration to a field demonstration on an actual transmission line.
- Contingency Limitations on Path 15. Analysis of the feasibility of using RTR to modify the remedial action schemes that limit pre-contingency power transfer in the Path 15 corridor.
- Dynamic Thermal Circuit Rating (DTCR) Project. Analysis of the feasibility of using RTR to improve the utilization of an economic energy source (generating plant) that is constrained by transmission line thermal limits.
- EDM Sagometer Evaluation. The Sagometer is a monitoring system that directly measures transmission line sag (clearance from conductor to the ground below). This project evaluated the first-generation system for feasibility; the next-generation system needs to be evaluated for applications in California.
- Multi-Area Real-Time Rating Evaluation. Real-time data from several transmission lines in the Sacramento valley will be analyzed to determine the

potential for generation re-dispatch, voltage profile enhancements and predictive ratings on an area-wide basis.

Develop New Projects

With the guidance of the TAC, new projects will be developed based on the priorities of the California transmission system. If appropriate, Requests for Proposals (RFP) or Research Opportunity Notices (RON) will be issued, to solicit the best possible research projects to be considered for funding. These solicitations can be either narrowly focused, e.g., for follow-on projects that build on the successes of previous projects; or more general, so as to solicit the widest possible input of technology solutions, including those that may not have been evaluated in California to date.

The knowledge gained from the State of the Art report (see above) will help to identify the gaps in current knowledge of these technologies in California, and the opportunities for collaboration with other researchers, utilities outside California, and industry experts, to leverage their efforts and maximize the resources available for this Initiative.

A key strategy is to work with the California utilities, the CAISO, technology experts, and other stakeholders, e.g., regulatory experts, institutional change professionals, or educators, in a collaborative framework. The objectives are to define research priorities, to ensure the participation of personnel within those organizations to guide the research and champion the use of research products by their organizations, and to facilitate the transfer of the developed technologies into company standards and operating practices. Where appropriate and feasible, managing and hosting of research projects by the utilities or the CAISO themselves may be the preferred method of performing some research activities.

As an example of a utility-driven research effort, PG&E and the CAISO are involved in a project to integrate real-time data into the operating environment that was driven by the need for better operations coordination between PG&E and the CAISO. This project will integrate real-time data from numerous monitoring systems into PG&E's EMS, develop graphical interfaces for PG&E operators' computer systems, and develop a common utility data protocol for sharing the real-time data with the CAISO.

New projects are anticipated to include:

Evaluation of new sensor technologies. Use of real-time ratings implies or demands the use of some kind of sensing technology in order to acquire the appropriate data, which is then used in real-time operations, analytical models, historical analysis, line standard reassessment, etc. Data can include weather parameters; transmission line tension, sag or temperature; transformer oil or tank temperature; transmission cable temperature or backfill moisture content; and so forth. New sensor technology is developed constantly for many other technical fields, and research to adapt them for use in transmission systems can be very cost-effective.

Application of real-time systems to constraints. There are a number of vendors and developers with RTR systems on the market. "Systems" comprise sensors, data storage, telecommunications, and software, in an integrated package. Projects can be developed to

demonstrate/evaluate the application of a given system to a utility or ISO transmission constraint. Some of these technologies may be new to California utilities, necessitating a feasibility study; others may be known, but tried in only some applications.

Reassessment of static ratings. Transmission line static ratings are known to be very conservative, because in most cases very extreme assumptions were used so that the ratings were conservative. This was probably wise, given that real-time information was not available and operators needed to maintain capacity margins for reliability reasons, and probably cost-effective until recently. But the need to find more capacity economically leads to the suggestion that by analyzing the actual conditions surrounding a transmission line, the assumptions that went into the line rating can be reassessed, and possibly changed if the perceived risk of doing so is judged to be acceptably low.

Data integration. As in the PG&E-CAISO project described previously, issues of integration of RTR data with utility communication systems, energy management systems (EMS), databases and control centers can be barriers to successful or economical implementation of RTR technologies.

Model development. New overhead conductors, along with existing equipment such as transformers and cables, present special challenges in that the required thermal or mechanical models may be inadequate or nonexistent. Also, ratings are directly dependent upon weather parameters, and weather models may need to be developed.

Predictive Ratings. In order for dynamic ratings to be practical for use by the ISO, it will be necessary to develop predictive ratings, i.e., ratings that can be used in the hour-ahead or day-ahead markets. This will require some sort of analytical software, typically a neural-network-based weather and/or loading model, to perform the predictions.

Program Coordination

The RTR Initiative is managed by a Research Coordinator, who is responsible for coordinating with the Transmission Research Program Director, the Policy Advisory Committee (PAC) and the California Energy Commission (CEC) PIER Program. The goal is to maintain consistency between the goals and strategies of the RTR Initiative and those of the TRP as a whole. In addition, liaison with the US Department of Energy's Transmission Program has been established through the PAC. Collaboration with other research organizations, utilities, RTOs or ISOs will be explored through a combination of technology scanning activities and industry networking, to find opportunities for leveraging research funds with organizations with common interests in the RTR area.

Action Plan

1. Establish a Technical Advisory Committee of California transmission stakeholders to provide guidance and oversight for the RTR Initiative. (Ongoing).
2. Update the assessment of the State of the Art in real-time rating technologies: what technologies are available, who has used them, what are the applications, what is appropriate and applicable to California, what are the gaps, etc. Due date: August

2004.

3. Develop a Business Case for real-time ratings, i.e., define the specific applications in utility situations, and develop a methodology with the appropriate metrics for evaluating and quantifying the costs and benefits of implementing the technology in California. Due date: September 2004.
4. Develop new research projects that fulfill the goals and priorities established by the Program. (Ongoing)
5. Monitor results of existing PIER projects and integrate into the program Plan as appropriate. (Ongoing)
6. Solve Data Integration Issues: interfacing the monitoring systems with utility and CAISO communications and operations systems, developing useful operator displays, getting the right data to the operators in timely fashion, etc. (e.g., the PG&E-CAISO data integration project). Due date: June 2005.
7. Provide periodic progress reports to the PIER Program, through the TRP Director. (Ongoing)

References

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