Driving Performance Improvements with the Use of Key Performance Indicators

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Introduction

U.S. Nuclear Power Plants have dramatically improved performance in many areas of plant operation, including operating capacity, unplanned automatic reactor trips, and collective radiation exposure. The ability to track and trend key performance data with the use of integrated data management systems has contributed to these improvements. Overall, the development and management of key performance indicators has been the key to driving performance improvements at nuclear power plants.

Evolution of Performance Indicators in the Nuclear Power Industry

The Institute for Nuclear Power Operators (INPO) developed the earliest plant performance indicators to strengthen and support utility efforts in attaining high levels of performance after the accident at Three Mile Island, Unit 2. INPO realized that the Nuclear Power Plants (NPP's) with high availability, small number of forced outages, few unplanned scrams, few significant events, and low personnel radiation exposures were generally well managed overall. Such plants were more reliable and could be expected to have higher margins of safety. In 1985 ten INPO performance indicators were adopted by all US Utilities.

By 1986 the Nuclear Regulatory Commission (NRC) developed the Systematic Assessment of Licensee Performance (SALP), as a prescriptive measure in the reactor oversight process. In the SALP, the NRC used judgment to evaluate a plant's performance, assigning a performance category in each of four areas; operations, maintenance, engineering and support. A plant's overall SALP rating was derived from the four plant performance category ratings. While the SALP process maintained safety at NPPs, the difficulty with these ratings was that they were not measured or evaluated objectively.

The World Association of Nuclear Operators (WANO) was established in 1986 after the accident at Chernobyl. The goal of WANO was to implement nuclear safety at every NPP worldwide. By 1989 WANO adopted a refined set of INPO performance indicators, and in 1990 utilities had begun to collect and share WANO indicator data. WANO indicators are based on individual unit goals and current industry performance.

By 1990, deregulation and restructuring of electric utilities, particularly in the United States, created fierce competition, producing an environment that gave utilities a stronger incentive to operate their plants more safely and efficiently. Specific utility performance indicators were developed at each plant site in recognition of the many plant management and organizational factors that influence plant performance. Plant specific Key Performance Indicators (KPIs) at Nuclear Power Plants are many and varied. While site KPIs supplement the INPO/WANO indicators, they also recognize that there are other objectives, such as economics, in addition to safety that ensure safe and efficient operation of NPP's. Site specific KPIs have a broader spectrum than either the NRC, or INPO/WANO indicators.

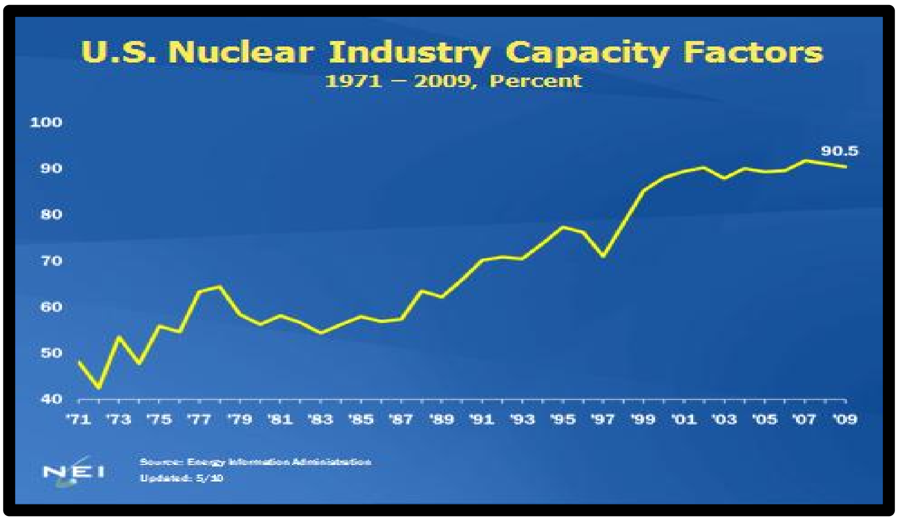
In 2000 the NRC implemented a Revised Reactor Oversight Process (RROP), eliminating the SALP ratings. The new RROP implemented a risk informed process which included seven safety cornerstones reflecting the essential safety aspects of facility operation, including emergency planning, security, occupational and public radiation safety. Objective performance indicators were developed for each important safety area cornerstone. The RROP includes evaluation of three cross-cutting areas in problem identification and resolution, human performance, and safety culture. The baseline inspection procedures supplement the RROP performance indicators. For each performance indicator a few thresholds were set, so that licensee performance could be evaluated objectively and regulatory action could be taken when appropriate. An increased level of regulatory engagement is used where appropriate in each cornerstone. The NRC's intention is that this enhanced regulatory oversight process will prod the correction of problems before an incident occurs. [3]

Industry Progress with the Use of KPI's

The performance indicator data compiled by WANO is analyzed by the Atlanta-based Institute of Nuclear Power Operations (INPO), which promotes excellence in U.S. nuclear power plant safety and operations. INPO uses the data to help set challenging performance indicators of excellence against which safety and plant operation can be measured. Described below is progress made on a few of the performance results for U.S. nuclear power plants.

1. U.S Nuclear Industry Capacity Factors

A plant's ability produce electricity is a good example of progress made in the US nuclear industry. In the 1980s, a typical US nuclear reactor would produce about 63% of the maximum possible power in a year. Today the figure is around 91%, which has saved the construction of over thirteen 1000 megawatt plants. [1]

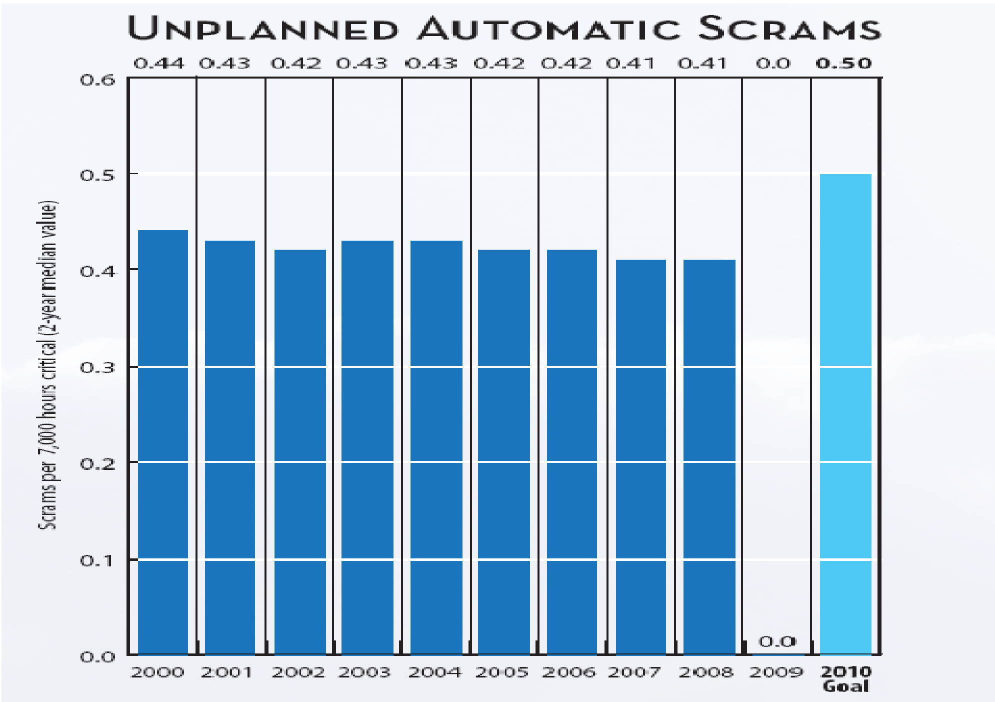


U.S. Nuclear capacity factor, a measure of efficiency, outpaces all other forms of electric generation in the U.S. Coal, for instance, which is the leading source of U.S. electric generation, had a capacity factor of 63.1 percent last year, natural gas 43%, hydro 29%, wind 28%, and solar 24%. [2]

U.S. Nuclear capacity factors have enabled America's nuclear power plants to produce 798.7 billion kilowatt-hours of electricity last year, nearly equaling the combined nuclear energy generation of the next three big WANO member producers France, Japan and Russia. Overall, nuclear power plants operating in U.S. states provide one-fifth of U.S. electricity supplies; and they provide about 70 percent of the nation's electricity generation that comes from carbon-free sources, including hydroelectric power plants and renewable technologies.

2. Unplanned Automatic Scrams – INPO Indicator

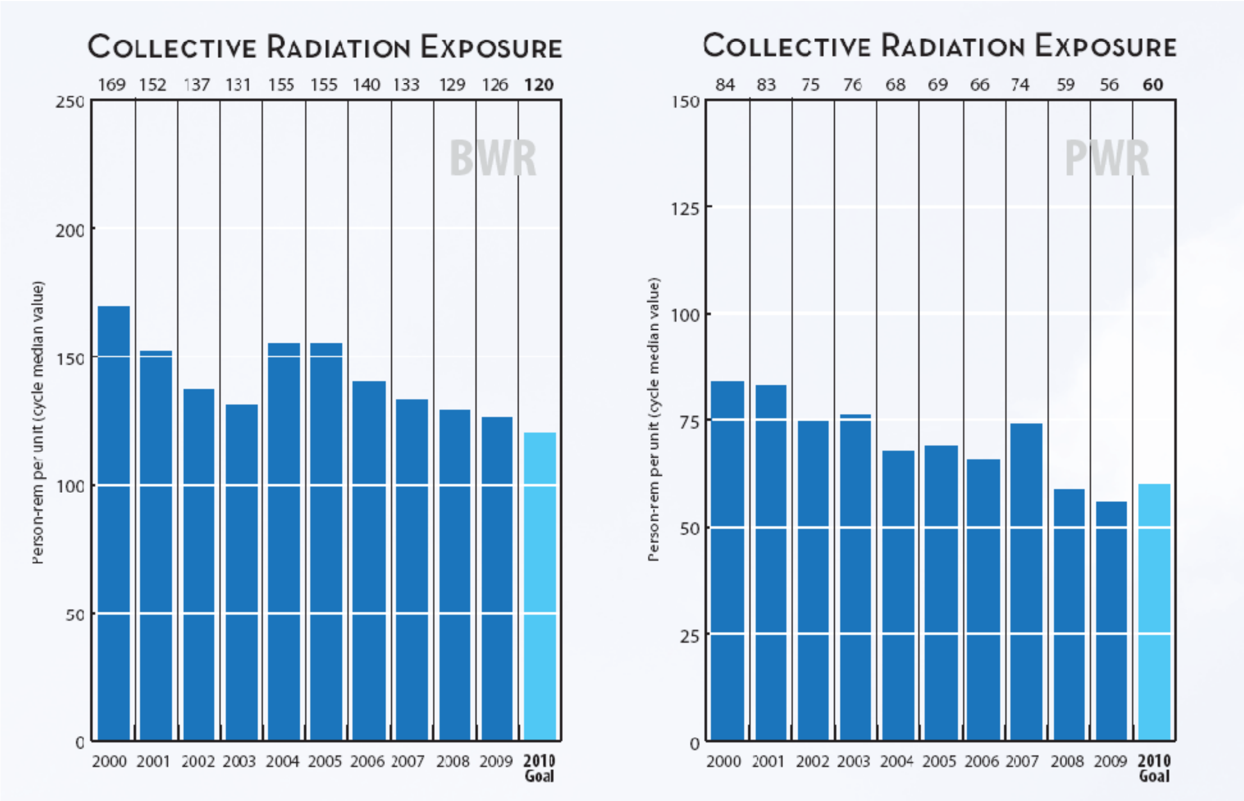
The bar chart below shows the median rate of unplanned automatic scrams in U.S. Plants over the years 2000 through 2009. Plants with low scram rates typically have effective operations, engineering, maintenance, and training programs. The scram rate continues to improve well below the 2010 industry goal. [1]



In the 1980's there were about seven automatic shutdowns per year. In 2009 there were so few unplanned automatic reactor shutdowns in U.S. NPPs that the median unplanned automatic scram rate value was zero. The total number of unplanned automatic reactor shutdowns in the nation's 104 operating plants was 34, the lowest on record

3. Collective Radiation Exposure – WANO/INPO Indicator

Significant progress has been made in reduction in collective radiation exposure at U.S. NPP's. Since 1980's collective radiation exposure has been reduced by a factor of six. When 2009 came to a close, Boiling Water Reactors (BWRs) were 6 rem above the 2010 goal, and Pressurized Water Reactors (PWRs) were below the 2010 goal. [1]



Progress has been made towards meeting other indicators. Total industrial safety accident rate has achieved the 2010 indicator goal. Statistics from other industries through 2006, as compiled by the Bureau of Labor Statistics, show that it is safer to work at a nuclear power plant than in the manufacturing sector and even the real estate and financial sectors. In 2009, 93 percent of the key safety systems at U.S. NPPs met their availability goals—the 11th straight year this rating has exceeded 90 percent. Other indicators that improved, but have not yet met the 2010 goals were forced loss rate, unit capability and fuel performance. The median chemistry effectiveness indicator has shown improvement over 2008 performance, but not met the 2010 goal. INPO and U.S. Nuclear Utilities continue to work closely together to meet the 2010 indicator goals.

Long-term U.S. industry goals for performance indicators are established at five-year intervals to keep pace with performance improvements and industry changes. 2015 Industry goals have been developed for median Collective Radiation Exposure of 110 rem for BWRs, and 55 rem for PWRs.

Specific U.S. NPP Performance Indicators

With NRC and INPO/WANO Performance Indicators firmly established, individual U.S. NPP's modified, or in some cases created lower level KPI's at their sites. Sites usually have KPI's that supplement, or further clarify components that make up the INPO/WANO indicators. These indicators allow the incorporation and tracking of individual site goals into site KPI's. For instance, for the WANO indicator for Collective Radiation Exposure, sites establish individual indicators for refueling outage dose and plant on-line dose, each tied to site dose goals. U.S Site Performance Indicators usually include KPI's for personnel contaminations, and indicators to allow tracking of incidents that involve NRC ROP indicator occurrences. INPO in 2010 began tracking personnel contaminations, radioactive material control, high radiation area controls and unplanned exposures, which had typically been NPP site lower tier indicators.

A system of performance assessment is needed by each site to periodically analyze a variety of source data including corrective actions, observation data, benchmarking, self assessment, operating experience, performance indicator data and effectiveness reviews. This data feeds site lower tier performance indicators and aids in early identification of signs of changing performance.

There are two ways to analyze the data. The first method is called cognitive trending. This is a way of trending that requires an individual involved in day-to-day activities at the site to maintain a mental awareness of current and past department and station issues, and to "connect the dots" to identify similar or repetitive trends. The second method integrates data into an electronic database so that more formal, in-depth analysis can be performed. This method is often more accurate, because it does not rely exclusively on human memory, and it more rigorously highlights problems and causal factors that have generic implications. Both methods of trending and assessment identify performance gaps, and the site creates or adjusts action plans, and communicates organizational alignment to ensure site understanding of priority issues.

Overall performance monitoring with lower tier performance indicators should be flexible. Individual performance indicators may be added, deleted, or modified as needed to monitor areas with identified performance weaknesses, or changes to programs and processes. The key to success of lower tier indicators is that when gaps are identified managers take aggressive action to investigate and address the causes of declining performance at the individual indicator level. Constellation Energy Nuclear Group integrates the INPO model for "Excellence in Performance Improvement", INPO Guideline 05-005, with the use of an integrated database called ePIC.[1] A model of the system integration is provided below.

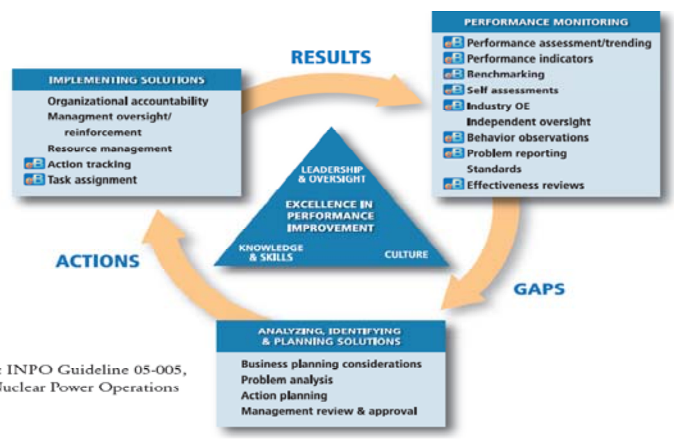


Figure 1 Source: INPO Guideline 05-005,
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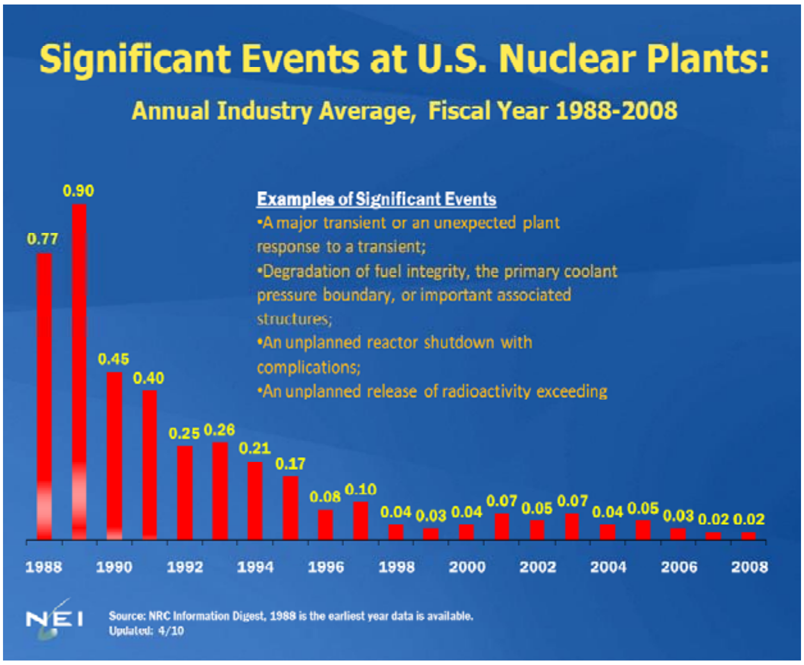
This automated integrated system incorporates all condition reports and field observation data to allow effective tracking and trending of individual pieces of performance data, and to identify performance gaps early. Individual human performance issues are documented with a Human

Performance Clock reset. The days between clock resets are tracked. A quarterly trend report is developed in each department at the site. All trends identified as “gaps to excellence” are documented with a condition report, and a corrective action plan is developed to prevent reoccurrence. These improvement plans include measures to implement changes in work practices and human performance, as applicable. In this way performance improvement becomes a core business function at NPPs.

Performance Indicators Result in Improved NPP Performance

The effectiveness of INPO/WANO performance indicators is in part due to their ability to exert peer pressure on member sites. INPO actions are supported by its board of directors, which is composed entirely of nuclear utility executives. These executives set the industry goals for performance indicators once every five years. The numerical value assigned to a plant’s performance is a consideration in the reactor's insurance costs with the industry's collective insurance company.

INPO and WANO organizations were established after significant emotional events in the Nuclear Industry. The best way to show results of how performance indicators have improved performance at U.S. NPP’s is to show a visual representation of the significant decrease in the rate of significant events at U.S Nuclear Power Plants. [1]



Conclusion

The nuclear industry learned a long time ago that being good enough is simply not enough. Excellence is the place to be. Use of Key Performance Indicators has aided the Nuclear Power Industry by enabling sharing of information between utilities around the world. Knowledge of another NPP's performance in a particular indicator area leads to inquisitive determination to model, or learn from that performance. This type of leaning is evident throughout NPPs worldwide. Higher performance in the U.S. NPP capacity factor indicator was partly due to comparison and modeling to the Finnish model. US Utilities knowledge of EDF's issues with reactor vessel head stress corrosion cracking enabled them to implement inspection programs to identify problems prior to a catastrophic event.

Where are industry KPI's headed in the future? With evidence that 80% of accidents involve culture, management, and/or human performance issues, it will be important to include more indicators that identify precursors to poor performance. INPO held a meeting in 2008 to begin development of human performance indicators. In 2011 new INPO indicators will be implemented for Emergency Planning, Work Management, and Corrective Actions. In 2012 INPO will implement a new RP Index that includes a weighted compilation of collective radiation exposure, high radiation area controls, unplanned dose events, radioactive material found outside the RCA or protected area, and personnel contaminations.

The interconnectivity of some of the indicators will be vital to industry improvements. For instance the current Chemistry Effectiveness Indicator (CEI) is primarily focused on impacts of plant chemistry on equipment reliability, even though there is a direct impact of source term on the Collective Radiation Exposure (CRE) Indicator. One of the five components that make up the CEI partially addresses this. Condition 5 of the index includes cobalt and zinc control during plant operation, but does not address source term during outages and its impact on CRE, even though this is where plant chemistry can have the greatest impact on CRE. This is an area where expansion of the INPO performance indicators is indicated.

The nuclear industry is unique in that we are an interconnected, interdependent, international community. We are only as strong as our weakest link. Promoting excellence rather than regulatory compliance, and close relationships with utility members is fundamental to INPO and WANO role in helping to improve nuclear power industry performance. One of the primary methods for achieving improvements is with the tracking of nuclear power plant performance with the use of performance indicators. We cannot be complacent in the effort to share information openly and promote the highest levels of safety, reliability and excellence at nuclear power plants worldwide. If we see a downturn in a member's performance, or if a nuclear operator is not participating, or if a member's participation is declining, we should be concerned. We as nuclear power plant operators have a dual responsibility: an *individual* responsibility to guarantee the nuclear safety of our own plants and a *collective* responsibility to work together to improve performance and continually upgrade the safety of operating plants worldwide. The use and sharing of performance indicator data helps the industry to accomplish this responsibility.

References:

[1] Nuclear Energy Institute (NEI) webpage, nei.org

[2] Ventyx Velocity Suite, Energy Information Administration

[3] Public Information from the NRC webpage, nrc.gov