

OPTIMIZING US NUCLEAR FLEET OPERATIONS THROUGH DIGITALIZATION



Generating costs of US nuclear reactors have risen 28% over the last 12 years. In a market being increasingly penetrated by natural gas and renewable energy, the digitalization of nuclear operations will play a vital role in making nuclear energy economically viable for the energy mix. The following whitepaper examines the challenges and opportunities ahead for nuclear energy's digital revolution.

Featuring insights from:



Steven Kraft
Senior Technical Advisor
Nuclear Energy Institute



Nick Camilli
Senior Technical Leader
Electric Power Research Institute Inc



Waco Bankston
Chief Information Officer and Director Cyber Security
South Texas Project Nuclear Operating Company



Matt Sacks
Vice President Sales and Business Development
DevonWay



Sean Lawrie
Partner
ScottMadden, Inc.

**Nuclear Plant
Digitalization Conference**

15-16 November, Charlotte, NC

Drive Safety, Reliability and
Economic Performance Through
the Digitalization of Nuclear Power
Programs

Insight from the NEI, EPRI,
STP Nuclear Operating Company,
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Introduction

Vision, innovation, leadership and investment will be pivotal to the digitalization of the nuclear industry, as utilities undergo a culture shift to embrace a technology-driven work environment.

The potential savings in time, money and effort offered by digitalization make a compelling argument for nuclear power plants to adopt digital technology, as the industry addresses the imperative to optimize operational performance and achieve cost-efficient and competitive nuclear power generation.

Business cases that address return-on-investment will be underpinned by extensive investigation into work practices. Total costs of ownership that includes hardware and software, recurring costs such as the IT help desk and associated costs of potential redundancies will also be factors in the strategy.

Industry leadership has embarked on an ambitious initiative supported by research and pilot studies being conducted on-site to set utilities on the digitalization path, helping to mitigate the adoption risk and understand the cost-benefits prior to major investment.

Delivering The Nuclear Promise

Steven Kraft, Senior Technical Advisor, Nuclear Energy Institute

The Nuclear Energy Institute launched the Delivering the Nuclear Promise (DNP) initiative in December 2015 in response to the decline of nuclear power's competitiveness in a marketplace being successfully penetrated by natural gas and wind energy.

Total generating costs of US reactors have risen by 28% over the last 12 years and DNP will identify efficiency measures, as well as adopt best practice and technology solutions to optimize operations and cut generation costs, thereby preventing premature nuclear power plant closures.

The goal is to provide innovative solutions that can be introduced at plant level and enable a 30% reduction in operating costs across the industry by deploying the identified efficiency enhancements to the fleet by 2018. Cost savings are expected to emerge as individual plants implement the innovations.

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The NEI estimates DNP could deliver around \$3 billion in savings by 2020. This figure is based on the average cost per MW generated in 2012, which was \$40/MW, as well as realised cost reductions from 2012 to 2015 combined with further decreases forecast across the next four years.

The DNP Strategic Plan, published in February 2016, identified analyzing technological and operational changes that could enhance safety and improve efficiency, as well as ensuring widespread adoption of innovative tools that could reduce costs, as outcomes that support nuclear energy in being cost effective.

12-Year Trend of Nuclear Plant Costs				
2014 \$ per Megawatt-hour				
YEAR	FUEL	CAPITAL	OPERATING	TOTAL
2002	5.72	3.92	18.59	28.23
2003	5.59	4.93	18.84	29.37
2004	5.28	5.65	18.54	29.47
2005	5.02	5.80	18.95	29.77
2006	5.04	5.56	19.21	29.81
2007	5.13	6.12	19.07	30.31
2008	5.35	6.76	19.51	31.62
2009	5.93	8.91	20.49	35.33
2010	6.76	9.16	20.63	36.55
2011	7.10	10.06	21.88	39.04
2012	7.46	10.76	21.47	39.70
2013	7.73	8.20	20.93	36.86
2014	7.17	8.18	20.92	36.27
2002-14 INCREASE	25%	109%	13%	28%

Source: NEI

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Digitalization Case Studies

Improving the execution and productivity of maintenance with electronic work packages: a mobile work management initiative

Nick Camilli, Senior Technical Leader, Electric Power Research Institute, Inc

The Electric Power Research Institute (EPRI) is an independent, non-profit organization that conducts research and development to find solutions to challenges in the generation, delivery and use of electricity. Work is undertaken in collaboration with scientists and engineers, and academic and industry experts.

The accumulation of checks and balances introduced to enhance safety at nuclear power plants, although necessary, has created complex processes. EPRI identified that work execution had become increasingly cumbersome and started investigating whether carrying out processes electronically and issuing tablets to workers in the field would make processes more efficient without compromising safety.

In November 2015, EPRI published its findings of a three-year project with the objectives of facilitating the design and implementation of e-WPs and demonstrating how their integration into the industry could be used to significantly improve productivity. Participating plant operators undertook a Mobile Work Management (MWM) initiative that used e-WPs to improve maintenance execution and productivity.

Moving from a manual to an electronic-based process with electronic routing has shown processes become more efficient and cost-effective. The report's results tie-in with the industry's DNP initiative to prompt utilities to examine the potential power of the e-WP tool, as well as accepting their future lies in adopting digital platforms.

One area that proved more challenging to utilities looking to adopt electronic technology was the business process exercise, in which a comprehensive picture of existing work flow processes has to be developed in order to design the most appropriate mobile platform.

Utilities need to spend a lot of time on upfront planning to account for real-time decision-making and enable the technology to recognize and adapt to every possible scenario that might be encountered when executing an e-WP. This can involve each utility bringing together cross-discipline teams representing various organizations to sift through all the details and ensure conversion to an electronic system has minimal impact on existing processes.

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Annotated PDFs versus Smart Procedures

Utilities spend considerable time continuously revising and updating procedures. Considering most plants own thousands, if not tens of thousands, of procedures, the decision to move to advanced PDFs or Smart documents comes down to what the utilities want and how each approach, or a combination of the two, fits into their business decision.

PDFs are now more advanced than sometimes realised and they have a lot of functionality. Creating form fields and building in pre-set menus and drop downs are straightforward and allow data entries to be automatically populated in associated forms. All of these features will result in efficiency gains for a work procedure, so there is a lot of power in a PDF.

Smart documents are usually xml-based, which enables greater flexibility and integration with other programs. They are powerful tools and have significant advantages for improving human performance efficiency. Although more resource-intensive and expensive, smart procedures have a lot of potential when carrying out high risk, infrequent procedures in which there is no room for human error.

Few utilities across the US nuclear fleet have, so far, implemented MWM platforms. Feedback on the application and use of technology from operators involved in this project has been varied, with some operators reporting PDFs are working well in their system and others preferring to have smart procedures integrated into the digitalization of their plant.

Summary

Feedback about the entire project has been largely positive and nuclear operators have recognized that, given the current economic situation, they need to move towards digitalization to survive.

Successfully introducing MWM requires obtaining universal agreement across the organization on its place within a three-to-five year vision. Operators looking to digitalize work processes should benchmark against utilities already leading the field and identify key learning points, while spending time upfront to make sure everyone in the company is on onboard with an agreed digitalization program.

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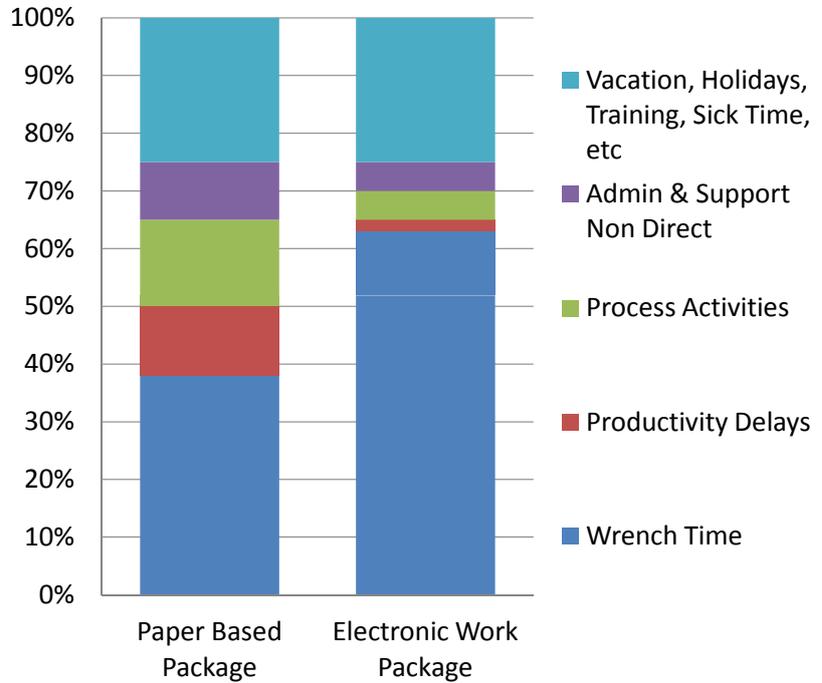
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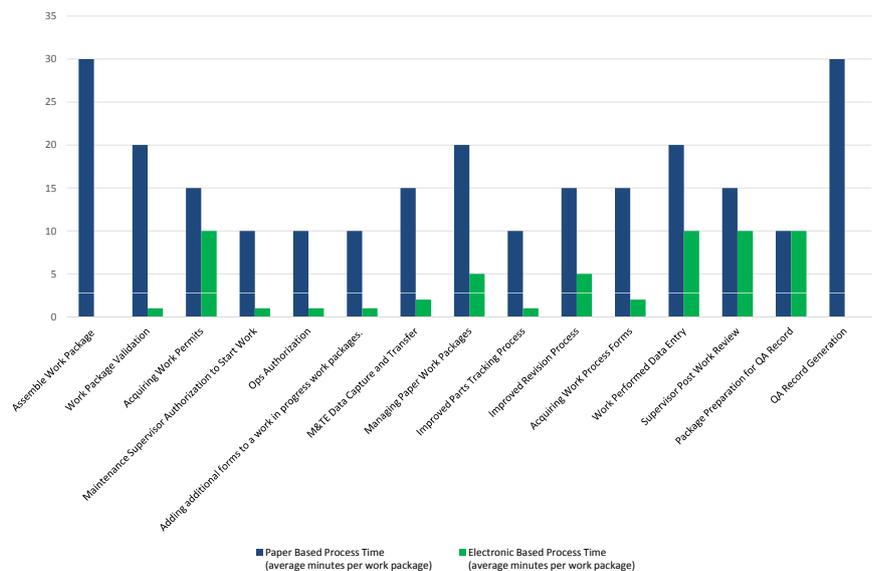
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Comparison of Wrench Time and Associated Job Delays for Work Packages



Source: EPRI

Workflow Comparison of Paper to Electronic Activity Duration for Each Task



Source: EPRI

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Mobile Work Management System

Waco Bankston, Chief Information Officer and Director of Cyber Security at South Texas Project Nuclear Operating Company

South Texas Project's (STP) Electric Generating Station has two Westinghouse PWRs that produce 2,700 MW every year. The plant is located on the outskirts of Bay City and has three owners: NRG Energy (44%), CPS Energy (40%) and Austin Energy (16%). STP employs around 1,200 people.

STP evaluated implementation trials of an MWM system. Inefficiencies in the execution of paper-based work packages by multiple personnel were identified as major contributory factors to poor operating performance. Time-consuming activities and duplication of effort hampered the progress of work by employees, while the vast volumes of paper-based consumables were attached to high expenditure.

The benefits of digitalization were projected to extend beyond baseline budgets and include improved efficiency of workloads, both of which would contribute to optimizing operational performance. STP looked to replacing costly paper-based materials with electronic documents and databases, as well as streamlining the process of problem identification followed by preparatory work scheduling that is necessary prior to physically walking to the site under scrutiny to work on and close out a work package.

The company had already been testing the proof-of-concept by giving craft employees robust Motion Computing and iPad tablets. The tablets were installed with operating system Windows Surface Pro and allowed staff to execute minor work packages while working in the field. Bespoke software had been developed from the Oracle database system and a wifi network comprising 440 wireless access points was installed across the plant.

Oracle's custom-built software opened the opportunity for STP to develop a MWM solution that fully integrated aligned reporting and administration processes, which allowed the system to amalgamate separate areas such as purchasing with work maintenance. In addition, reporting audited by the Nuclear Regulatory Commission (NRC) including the Corrective Action Program (CAP) was fully integrated into the MWM system. A bespoke solution also offered autonomy over design, ownership and associated license fees.

This approach of expanding the program beyond e-WPs to encompass the entire process beginning with the identification of an issue through to closing out all aspects of the work has proved a major benefit. Issued with the tablet, field workers can instantly access information necessary to continue executing the work package, circumventing time-consuming actions that require the worker to interact with different areas and allied co-workers to reference material and obtain sign-offs.

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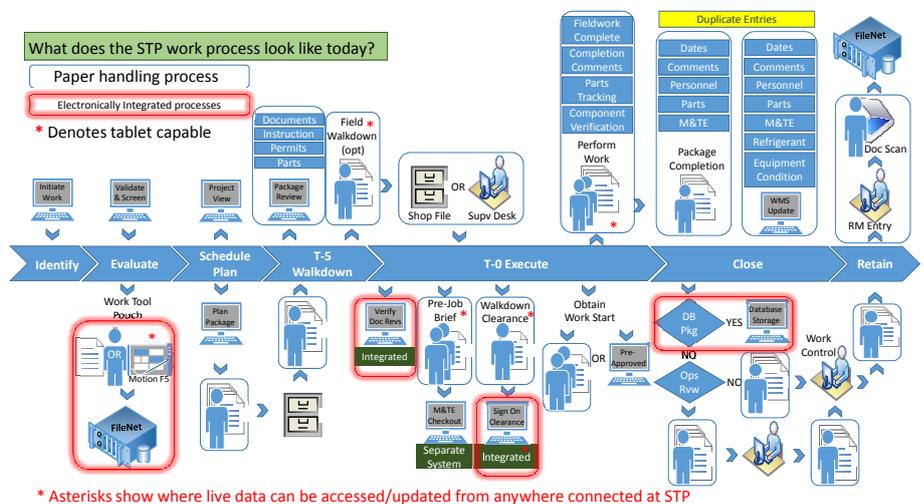
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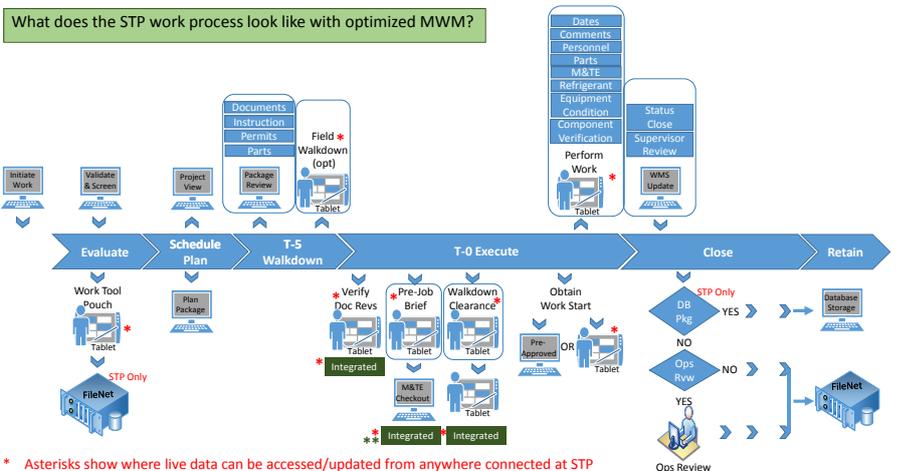
The trials have so far demonstrated that digitalization enables staff to work more fluidly and work to be more coordinated, as the ability for one person to identify, open, execute, add CAP and close an e-WP in a timely manner eliminates many duplicate steps in the process. Expenditure on paper and paper-related costs is also significantly cut and, together with optimizing workload efficiency, has positive implications across the plant.

STP is currently evaluating the MWM trials and gathering craft workers' feedback on using the tablets in the field. The company is assessing whether there are other work areas that would benefit from the application of e-WPs and a formal roll-out project is expected to be developed in mid-2016.



* Asterisks show where live data can be accessed/updated from anywhere connected at STP

Source: STP Nuclear Operating Company



* Asterisks show where live data can be accessed/updated from anywhere connected at STP
 ** M&TE/WMS enhancements required to automate barcode for better integration

Source: STP Nuclear Operating Company

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Smart Work Packages

Matt Sacks, Vice President Sales and Business Development at DevonWay

DevonWay is a business software and mobile application supplier, with expertise in cloud-based continuous improvement and asset management apps. Within the nuclear industry, the firm provides digital tools to enable utilities to improve their efficiency in achieving regulatory compliance.

As a supplier to the nuclear fleet, DevonWay focuses on implementing technology at plant level that directly impacts on costs and headcount. The Smart Work Package (sWP) is a digital tool that advances annotated PDFs and extends the application of technology further into work processes, which enables utilities to achieve cost-effective excellence in plant generation.

The business case for e-WPs as a solution to removing paper-based consumables from the plant remains relevant to sWPs, which work planners can manage online and workers in the field can process on mobile devices. The sWPs function in conjunction with annotated PDFs, with workers using a simple application to collect more structured data entries.

Data storage is a key advantage of sWPs, as it offers the opportunity to analyze disparate datasets for patterns after the work package is completed. For example, the automatic tracking and recording of the exact time taken to begin and end each step of a procedure means the data can be analyzed over long periods to identify any corresponding changes in productivity.

Information capture and storage can also highlight potential issues. Continued updates to an asset's database allow intelligent alerts that prompt field workers and teams beyond the field crew if tolerance thresholds for that asset are being exceeded. Decisions on what, if any, interventions need to be performed on that asset can then be actioned based on real-time data.

Databases can also be integrated, as sWPs collect information throughout the execution process that can be pushed directly into health and CAP applications. Collecting and documenting equipment readings automatically feed equipment health reports, removing the duplication of data entry and reducing potential errors when re-entering data into other applications.

Advantages to craft professionals are three-fold: they are enabled to perform field work accurately and efficiently; their time is better used; and their improved performance contributes to the overall performance of the plant.

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Field Work

- Multimedia functionality allows workers to use video to record work package procedures, which can be archived for future use by new and inexperienced recruits.
- Equipment and parts are fitted with bar codes that are scanned prior to starting a task, which not only verifies the correct location and tools, but also that the person is qualified for the work.
- Should problems arise workers can request and receive advice and assistance in real time by visualizing the issue in a photograph, which is instantly transmitted to experts.
- Deviating from the correct task sequence due to flipping between pages in a file is less likely, as the sWP automatically displays the next step on the tablet.
- Records of the entire work package process are stored in one location, including work steps, equipment and visuals, which are then available for review by supervisors.

Time

- The sWP tracks each step, task and work order and anticipates interdependencies so, if there is a delay to completing a task, the worker can be redirected and is not left waiting around.
- Scheduled work can be reviewed days or weeks in advance, allowing workers to revisit hazards and familiarize themselves with the upcoming procedure or work activity.

Operations

- Multimedia functionality allows audio, video and photographic records to be taken during and after completing tasks, yielding a more comprehensive and accessible log for the plant.
- Work status, data recording and situation assessment automatically and instantly update plant configuration, without the need for transcription or paper scanning.

The sWP eliminates paper, while coordinating, facilitating and streamlining work procedures. Two-way, real time communication channels promote more effective collaboration between the field, schedulers and supervisors and more advanced analytics notify appropriate personnel of report progress, variations and anomalies that impact on optimizing maintenance and operations.

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Source: Devonway

A Business Case For Advanced Outage Management

Sean Lawrie, Partner at ScottMadden, Inc., a Management Consulting Firm

ScottMadden's nuclear generation practice expertise focuses on business and cost management, peer-to-peer benchmarking, organization structure and staffing, plant turnaround and improvement. Although pilot studies of new technology provide robust evidence of their significant contribution to enhancing nuclear power plant performance, there are still barriers to justifying the high-value investment needed to install, implement and maintain these innovations on site. Utilities need to clearly identify demonstrable and documented cost savings, in addition to the non-cost performance benefits such as more streamlined and efficient working practices.

In recognition of these challenges, ScottMadden, along with an industry research organization, developed a Business Case Methodology (BCM) as a guide for utilities drawing up a business case to adopt emerging digital technology. The BCM identifies direct benefits to targeted work processes, as well as improved efficiency in related work processes and how costs are minimized by improving the quality of work. It allows operators to assess the combined impact of multiple technologies and summarizes the total organizational benefits.

Building on a 2015 pilot that showed substantial advantages obtained from applying the BCM to evaluate Mobile Work Package (MWP) technology, ScottMadden participated in a pilot to assess the impact of adding a suite of technology that enables Advanced Outage Management (AOM).

The results showed the addition of AOM technologies to the MWP business case more than doubled the estimated annual cost savings. The combined business case points to a typical two-unit plant saving more than \$7 million annually.

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Fundamental to digitalization are the commonalities that exist between different work activities. Pre-job briefs, use of procedures and correctly identifying components are tasks undertaken across the plant regardless of whether the work activities are in Radiation Protection or Operations. Since digitalization occurs at this level, the technology could be rolled out to work activities across the site.

The BCM study identified how savings could be realised through digitizing processes at a two-unit nuclear plant with a recognized exemplary operational profile. Data were gathered on actual outage management reports, work activity schedules and related performance, as well as from management and coordination personnel interviews.

A comprehensive analysis of improved capabilities during an outage evaluated the impact of technology on nine task areas and its significance in optimizing AOM. One of these areas, automated status updates, was considered a solution to reducing time spent in the field on monitoring, gathering data, preparing work plans and re-organizing workloads.

The most significant advantage of AOM technologies combined with MWP over current practices is the ability for outage managers to oversee the progress of jobs previously untracked in real time. Replacing traditional communications with digital channels was shown to maximize work time and maintain an uninterrupted flow of work.

The primary benefits of automated status updates were the decreased need for full-time equivalents working elsewhere in the plant that saved time, as well as MWP status transmitted and acted upon in real time enabling greater accuracy in planning schedules.

Secondary benefits were also identified. Work steps in procedural or instruction documents were signed off in a timely and objective manner, enabling real-time monitoring of work progress. Reporting the work status did not interrupt the work flow and, overall, less effort was required to achieve a more effectively managed work scheduling process.

In terms of combined annual labour savings in operations, maintenance, outage management, radiation protection, chemistry and engineering, the BCM in this particular case calculated that using automated status updates yielded an estimated cost reduction of \$1 million. The workload associated with information gathering was estimated to be reduced by 80%.

Overall, the BCM study showed that by attaching AOM technology to the MWP business case, there was a reduced necessity for costly manual handoffs and it facilitated real-time communications and analysis. Digital communication, networking and analytical technology opens the way for plants to manage outages with fewer resources in management roles and support more effective and productive output from the remaining team.

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Summary Results

Key Findings

The overall results provided by the BCM are substantial. The addition of AOM technologies to the MWP Business Case more than doubled the estimated annual savings. The study demonstrates the scale of savings that can be achieved when digital technologies are applied to work processes to the benefit the NPP. Costly manual handoffs of information are reduced, communications are in real time, analysis is supported in real time by analytical tools, and the risk of a costly outage extension is reduced through better management of the bulk work and improved situational awareness. A summary of the annual savings is presented the figure below:

Business Case Annual Benefits (\$000s)

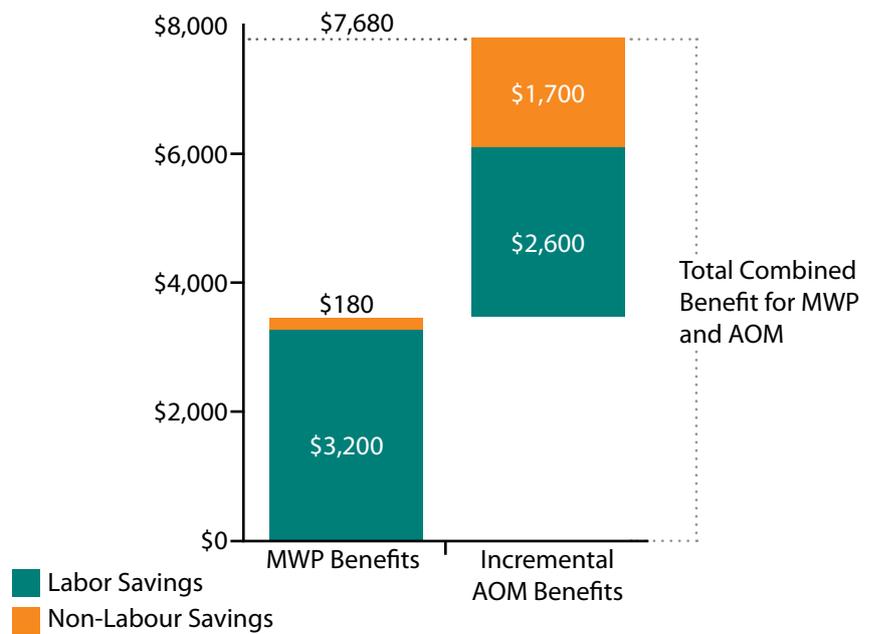


Figure 5: Business Case Annual Benefits

The combined business case indicates that a typical two-unit plant can save in excess of \$7.7 million annually. The figure above provides a breakup of labor and non-labor savings developed in the BCMW.

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List Of Acronyms

AOM	Outage Operations and Management
CAP	Corrective Action program
CBP	Computer Based Procedures
DNP	Delivering the Nuclear Promise
EPRI	Electric Power Research Institute
e-WP	electronic Work Package
IT	Information Technology
MWM	Mobile Work Management
MWP	Mobile Work Package
NEI	Nuclear Energy Industry
NRC	Nuclear Regulatory Commission
STP	South Texas Project
sWP	Smart Work Packages

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