Northwest Power and Conservation Council

System Optimization Measures Guide

6th Power Plan

Prepared For
Charlie Grist

Prepared By
Les Tumidaj
Martin Lott

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STRATEGIC ENERGY GROUP

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Introduction

The Northwest Power and Conservation Council commissioned the development of an Industrial Conservation Supply Curve (ISC) for its Sixth Power Plan. To improve on traditional methods and benefit from regional experience to-date, the ISC was developed using a bottom-up method to construct the supply curve employing as much regional and local load, program tracking, and case study data as possible. In addition, the development of the ISC relied on updated program information, technical sources, market information, and case studies on industrial energy efficiency measures, best practices, and emerging trends.

An earlier assessment of industrial efficiency opportunities sponsored by the Council found that the major opportunities for industrial energy efficiency were to be found in the optimization of whole systems rather than primarily discrete equipment upgrades. Such optimization practices usually entail: demand-side assessment; proper design, sizing, and/or reconfigurations to match supply to demand; system "commissioning;" sustainable O&M; and supporting management practices. As a result, the ISC for the Sixth Power Plan notably includes measures that characterize system optimization opportunities, ranging from single systems to whole plant upgrades described in this guide.

This document, and the accompanying System Optimization Workbook, is intended to provide a synopsis of these system optimization and whole plant measure bundles, the input assumptions, and supporting sources**.**

Overview

This document is a guide to the system optimization component of the Industrial Supply Curve. It provides a discussion of modeling techniques, assumptions and corroborating documentation in support of the accompanying Systems Optimization Workbook. The System Optimization Workbook is an Excel workbook which synopsizes the input measures values and characteristics for three primary end-use technologies[1] – pumps, compressed air, and fans & blowers – and a section characterizing their potential when applied in concert for an entire plant. This guide discusses the methodology, assumptions, and corroborating sources behind each of these building blocks.

The System Optimization Workbook has four basic parts:

1. Compressed Air
2. Pumps
3. Fans & Blowers
4. Whole Plant

[1] Refrigeration was modeled separately, based on proprietary data provided by an engineering firm specializing in industrial refrigeration in the Pacific Northwest.

The Systems/Plant Optimization Workbook synopsizes the characteristics of progressively comprehensive system optimization measure bundles. The primary systems compressed air, pumping, fans & blowers, and refrigeration are each broken into three tiers – Good, Better, and Best. Each tier defines the types of measures contained, the energy savings potential of those measures and the industry subsectors which the measures apply. Within each tier are conservation and econometric values derived from historic conservation program data; technical papers & case studies; and the engineering, the program planning and implementation experience of Strategic Energy Group, and consultations with regional/national industrial systems experts.

The tiers are then rolled up into multi-system plant-wide savings and cost bundles using end-use load weighted averages and correction factors for double counting. In this way, the measure bundles are amenable to transparent treatment in the supply curve model, logically relevant to practical applications in plants, and amenable to potential programmatic treatment. Although rooted in actual technologies, case studies and practices, the measure bundles act as proxies for the various real-world measures – depending on the specific system, plant or industry.

The three progressive tiers of measure bundles are defined below:

Good – Energy Management
The Good tier consists of structured Energy Management practices that include system assessment and diagnosis, structured protocols for energy management, operator training, and possible certification of practices. These practices are sometimes regarded as "enhanced O&M". They are based on established and documented industry practices such as Compressed Air Challenge (CAC), Pump Systems Matter (PSM), etc., which are noted in the System Optimization Workbook.

Better – Equipment Optimization
The Better tier is based on system equipment retrofits and replacements utilizing system assessments and optimization strategies based on established industry protocols identified in the System Optimization Workbook sources. This measure bundle also includes the measures, practices and savings from the first tier bundle (Good), with the resulting savings and costs being a meld of the Good and Better measures.

Best – System Optimization
The Best tier contains best practices (based on national and international industry sources). These are applied to the targeted system during major system upgrades or reconfiguration. Savings from these measures are enabled and supported by systematic systems management practices. "Best" also incorporates the measures and practices and savings from the previous two tiers.

None of these bundled measures presume that any of the referenced protocol, training program, standard, and/or certification will necessarily be part of a resulting program; rather, these sources are referenced to demonstrate the market-readiness of the measure.

The savings associated with the system/plant optimization bundles are provided by the effective application and use of energy efficient technologies. The "management" aspect of energy management seeks to improve the persistence of savings, increase the penetration rate of efficient technologies, and to instill a more comprehensive use of energy efficiency in operations. Efficient technology measure costs and savings are established incrementally for each tier and are documented in the worksheets. Estimates are based on actual program tracking/evaluation data and case studies, and were corroborated through reference to other program data sources (e.g., utility, regional and national energy efficiency programs/initiatives).

The Workbook also has the following four supporting sections:

- Introduction Notes
- Compressed Air-Sample Cases
- Pumps-Sample Cases
- Fans-Sample Cases

The sample case studies illustrate real world examples of systems optimization that encompass a broad array of energy management activities. While they were used in calculating the econometrics of the system characterizations, they are not the only sources used.

Table 1 - Key Definitions

Measure	An action including equipment upgrade or operational method to improve the energy efficiency of a system or component.
Energy Management	A structured system/plant operations and management program that relies on well-defined protocols for O&M, demand-side assessments, properly trained system operators, and, where appropriate, adherence to industry standards or certification.
System Optimization	The coordinated application of technology-based measures and system design so as to most effectively match system service to production needs in the most efficient manner possible.
Measure Bundle	A combination of energy efficiency measures that include energy efficient technologies, systems optimization, and effective energy management practices. The bundles are designed to best simulate practical applications in plants while being amenable to treatment in a supply curve
Optimization Tier	A relative grade of measure bundles that represent a combination of market-ready technologies, design and management practices.

Industrial Systems

The systems included in the System Optimization Workbook were chosen for their amenability to established optimization measures, high relative loads, energy intensiveness, and ubiquity among most industrial sectors.

The following systems are modeled in the System Optimization Workbook:

Compressed Air
Compressed air optimization is a combination of energy management (as defined above) and equipment improvements. Nearly all industries employ compressed air systems. However, the greatest opportunity for energy savings and market acceptance reside with the medium or large industries utilizing relatively high horsepower, multi-compressor systems.

The first tier - Energy Management (Good) - defines low/no cost Energy Management as it relates to compressed air specifically. Note that this measure includes lower cost equipment replacement/improvements done in conjunction with comprehensive demand side management and retro-commissioning.

The second tier – Equipment Optimization (Better) - builds upon the previous tier by including additional retrofits and replacements such as VSD controls, and the application of recognized compressed operations standards such as ASME EA-4-2008.

The third tier – System Optimization (Best) - builds upon the previous tiers by rolling the Good and Better tiers' equipment improvements, retro-commissioning, and operational improvements into a sustaining energy program. A plant in this tier treats its energy program in a similar manner to safety or quality control programs: an individual or team is tasked with developing and enforcing standards, goals are set, regular reports are generated and reported to management, and all plant employees are engaged and held accountable.

Pumps
Much like compressed air, Pumping System Optimization includes technology-based capital improvements and energy management. However, the industries targeted by the Supply Curve are the pulp & paper, refinery, chemical, and large food processing industries given the size, complexity and energy-intensiveness of these systems in these industries.

The first tier - Energy Management (Good) - quantifies low/no cost Energy Management as it relates to pumping systems specifically. Measures include coupling alignment, lubrication, seal maintenance, vibration analysis, motor conditioning, and others based on a comprehensive demand side assessment.

The second tier – Equipment Optimization (Better) - builds upon the previous tier by including equipment replacement during times of major repair or shutdown such as proper pump sizing, impeller trimming, control valve replacement, and VSD control. Moreover, these improved systems would be assessed and managed in accordance with recognized standards such as ASME EA-2-2008.

The third tier – System Optimization (Best) - builds upon the previous tiers by rolling the Good and Better tiers' system analysis, equipment improvements, and operational improvements into a sustaining energy program. A plant in this tier treats its energy program in a similar manner to safety or quality control programs: an individual or team is tasked with developing and enforcing standards, goals are set, regular reports are generated and reported to management, and all plant employees are engaged and held accountable. Plants will have a system for identifying, screening, and tracking capital projects in conjunction with procurement policies, system redesigning, and demand side management.

Fans & Blowers

Fan & Blower optimization is a combination of energy management, and equipment improvements. Based on discussions with fan & blower system optimization professionals in the Pacific Northwest, significant cost effective energy savings opportunities exist in all industries employing such systems. For this reason all industry are included in this section.

The first tier - Energy Management (Good) - quantifies low/no cost Energy Management as it relates to fans & blowers specifically. Measures include basic system maintenance including changing filters, tensioning belts, repairing duct leaks, and confirming damper actuation.

The second tier – Equipment Optimization (Better) - builds upon the previous tier by including control measures such as VSD controls.

The third tier – System Optimization (Best) - builds upon the previous tiers by rolling the Good and Better tiers' equipment maintenance and control measures into a sustaining energy program with improved system design. A plant in this tier treats its energy program in a similar manner to safety or quality control programs; an individual or team is tasked with developing and enforcing standards, goals are set, regular reports are generated and reported to management, and all plant employees are engaged and held accountable.

Note on Refrigeration Systems

Energy savings potential for refrigeration system optimization and energy management for food storage sectors were modeled separately. These measures are specific to the food processing/storage sectors and were not treated as cross-cutting measures.

Whole Plant

The Whole Plant measure bundles capture the synergistic savings opportunities of plant-wide energy management and equipment improvements for multiple systems; such as, compressed air, pumping, and fans & blowers systems. Only the larger plants of pulp & paper, refining, and food processing were used in the Industrial Supply Curve to estimate Whole Plant savings. Larger plants in these sectors are more likely to have the management resources to adopt whole plant management programs and related technologies. Although small-to-medium sized plants, and plants in non-targeted sectors may also be amenable to Whole Plant treatment, these were not estimated in this analysis. However, cross-cutting, industry specific and system optimization measures are addressed for these plants and sectors.

Measure Attributes

Conservative applicability and penetration rates were applied to the whole plant measures for the targeted sectors. Unlike cross-cutting measures that may have high achievability rates in response to the maximum application of cost-effective program incentives, the Whole Plant measures use more conservative rates to account for those industrial management and business cycle barriers that are not as responsive to program incentives. As a result, the Whole Plant measures, despite their significant savings fractions, only apply to a smaller proportion of the total industrial load and any given sector.

Whole Plant measure bundles costs and savings are derived from the system optimization measures and are rooted in these high efficiency technologies. These bundles are meant to also serve as proxy for other combinations of systems and technologies that would yield equivalent savings at equivalent costs (i.e. actual measure bundle may include a different mix of refrigeration, motor systems, pumps, etc. for a given plant).

Whole Plant Measure Tiers

The first tier – Plant Energy Management (Good) - includes low/no cost energy efficiency projects for multiple systems that are supported with comprehensive demand-side assessments and good preventative maintenance practices. Maintenance and operations are based on system-specific guidelines and supported by system operator training as noted in the system optimization measure descriptions. This measure also includes low/no cost equipment upgrades for some of the systems.

The second tier – Energy Project Management (Better) – is based on a package of optimized equipment improvements, but also includes the assignment of an energy engineer (or equivalent capability), tracking energy costs, identification and prioritization of capital projects, application of systems optimization tools and practices on the key systems in the facility. Energy waste is readily identified and mitigated by the energy engineer and his/her team, and the equipment installed under this measure is optimized. From a program perspective, the energy engineer function could be accomplished through other approaches including external support.

The third tier – Integrated Plant Energy Management (Best) - is based on the combination of best practices equipment improvements and a comprehensive plant management program including development and implementation of an energy management plan (policy, accountabilities, goals, department/system level targets and measurements, etc.) to support sustainable improvement of energy intensity and productivity, and independent verification of energy savings. The American National Standard for energy management, or equivalent standards, provides a point of reference for the level of management activity assumed by this measure bundle. This measure bundle could entail plant modernization in order to approximate the performance of higher performing plants currently competing in the international markets. In addition, the management practices increase the likelihood of best practices-based plant upgrades and the persistence of these savings over time. Therefore, the savings are derived from the effective application and operation of the high efficiency technologies, and this is enabled by the management practices.

Several additional points should be highlighted concerning the Systems Optimization/Whole Plant bundled measures:

- The Whole Plant measures are designed to be applied over a 20 year period. Ramp rates reflect this and assume a minimum of 15 years activity to reach the targeted savings. In addition, conservative estimates for measure applicability and penetration are used to target only a portion of the largest, most energy-intensive plants.

- The Whole Plant section is based on the weighted amalgam of compressed air, pumping, and fans & blowers tiers. Weighting is based on the end-use load shares identified in the Industrial Supply Curve model. However, these measure bundles also serve as proxies for other system mixes that would provide equivalent savings at equivalent cost-effectiveness levels.

- The System Optimization Workbook itself does not control for double counting between the systems-level measures and the Whole Plant measures. Rather, the Industrial Supply Curve model corrects for this.

- Over 90% of the savings estimates associated with the whole plant measures are based on equipment improvements and, therefore, would be subject to monitoring and verification equivalent to that used by current programs for custom and process measures.

- The measure descriptions make reference to various protocols, guidelines, standards, staffing requirements and so on to illustrate the functional system/plant management requirements for the measures. However, the Industrial Supply Curve does not mandate any specific measure; the actual tools and practices used by programs will be based on subsequent program design in the region.

Supporting Information

Supporting information for savings, costs and other measure attributes for Systems Optimization are based on the following:

- Reviews of program tracking/evaluation data);
- Case studies (sample of which are provided in the Workbook);
- Other technical studies/resource assessments (e.g., BC Hydro, LBNL, ACEEE, etc.); and
- SEG technical analysis and consultations with regional/national industry experts for motors, pumping, compressed air, fans and blowers, refrigeration, and industrial process systems.[2]

Supporting /corroborating information for energy efficient management practices for Whole Plants measure bundles include the above sources and the following:

- Individual plant case studies for each major sector of plants engage in Whole Plant energy management and multi-system improvements. These case studies provide "snapshots" of plants on the integrated plant energy management trajectory and not necessarily at the end point.
- Case studies of corporate initiatives that document the incremental improvements in energy management and technology utilization over a multi-year period.
- Public/educational agency information on plant-wide assessments, especially the US DOE-EERE and the Industrial Assessment Center data bases
- International industrial initiatives and benchmarks of high performance industries which are part of the international competitive environment challenging PNW industries.
- Research and reports on national and international industrial best practices for energy efficiency in key industrial systems and sectors.

The supporting documentation is listed in the Industrial Supply Curve Document Catalogue which is posted on the Council's web site (note, the catalogue is being updated so check periodically).

The ISC analysis also relied on confidential sources which are not available for public review, including: utility/agency energy efficiency program tracking and evaluation data bases; load and energy flow data for individual industrial plants; confidential energy project reports/studies/memos for individual industrial plants; consultations with industrial equipment/service/system vendors on specific industry practices; and personal interviews and plant-visits that entailed the discussion of confidential information on plant operations and capital investments.

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[2] Note: although these industry experts provided invaluable insights and comments on the Industrial Supply Curve analysis; the resulting application of this information is solely the responsibility of the Council and its contractors.