Thinking Forward: Leadership in a Global Marketplace

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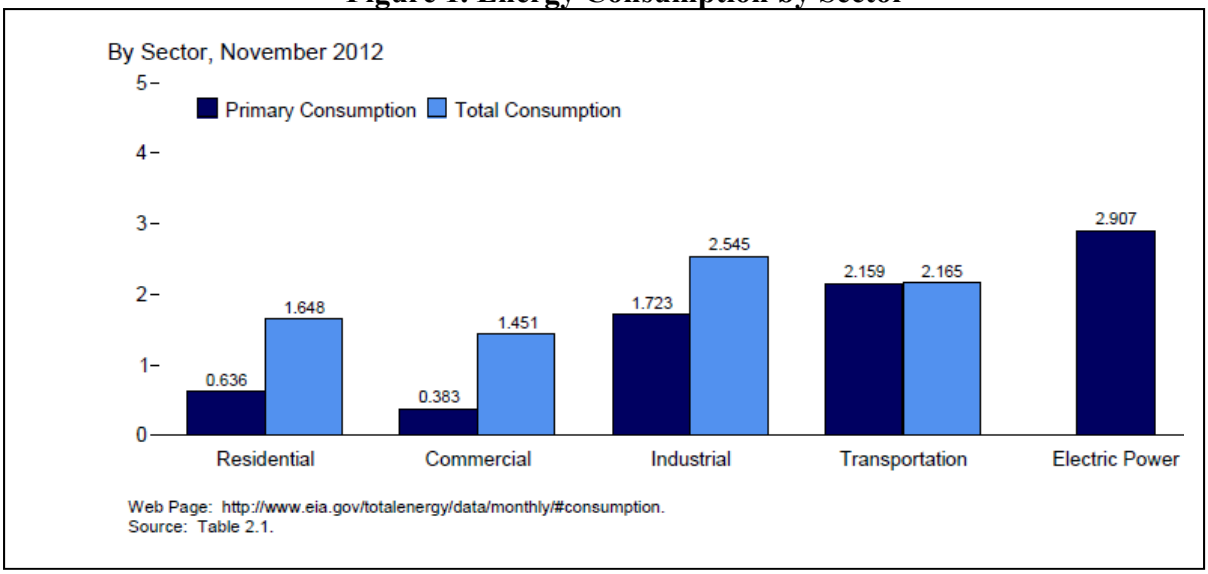
ABSTRACT

The International Energy Agency (IEA) reported nearly a third of the world's energy consumption and 36% of carbon dioxide (CO2) emissions are attributable to manufacturing industries. Figure1 Shows the U.S. industrial sector, according the U.S. Energy Information Administration (EIA), was responsible for more than 2.545 (Quadrillion Btu) Energy Consumption by Sector of total domestic energy consumption in November 2012.

Figure 1. Energy Consumption by Sector



Source: http://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf

In order to reduce energy consumption and related greenhouse gases, various government entities, green building rating systems, and energy codes are targeting Net Zero Energy as the ultimate energy performance goal.

Kingspan's vision is to be a global leader in sustainable business and establish a leading position in the supply of ethical, renewable, and affordable best-practice solutions for the construction sector. As a thought leader in sustainable design innovation, with over 50 years of experience and operating in over 40 countries, it's a natural progression that Kingspan enact a corporate-wide "NetZero Energy by 2020" mandate within its own facilities. The Kingspan Net Zero Energy mandate is a top down leadership supported effort.

This case study will walk you through Kingspan North America's Net Zero Energy Manufacturing business case for their Insulated Metal Panels manufacturing division, development process, various technology scenarios, and solutions being explored.

United States Federal Net Zero Energy Market Drivers

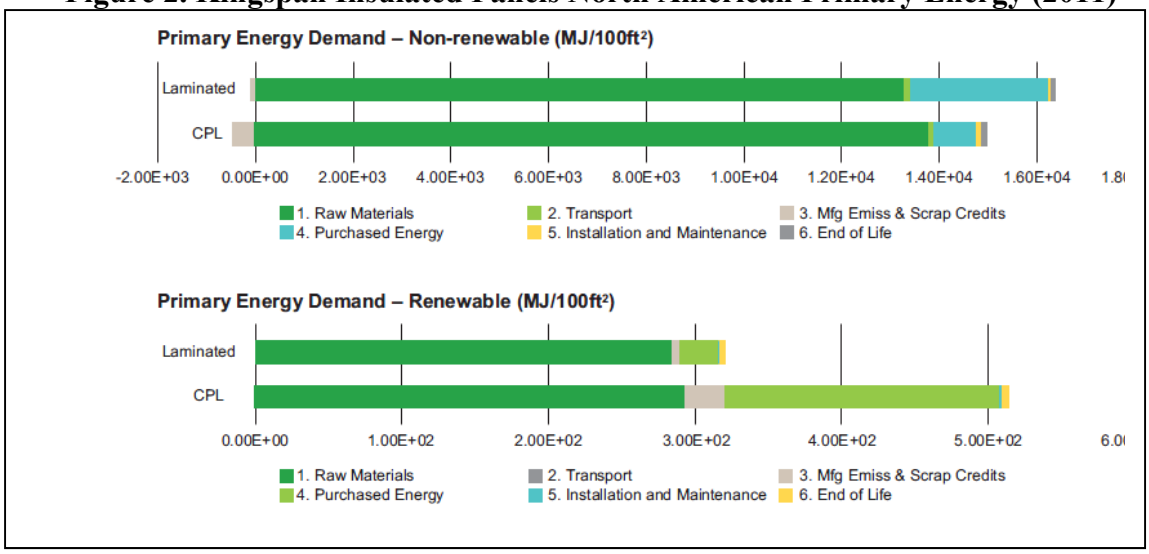
Executive Order 13514 of October 2009 directed US federal agencies, beginning in 2020, to achieve net-zero energy use in new construction and renovations by 2030. The Energy Independence and Security Act (EISA) of 2007 set a goal of net-zero energy use for commercial buildings by 2030. EISA 2007 further specified a net-zero energy target of 50% of U.S. commercial buildings by 2040 and a net-zero standard for 100% of new and existing commercial buildings by 2050. States like California have the goal of achieving Net Zero Energy status for commercial facilities by 2030.

Net Zero Energy Efficiency Business Case

Businesses, as reported by the Deloitte reSources 2012 Study, have become increasingly focused on energy consumption and its impact on their operational costs and bottom-lines. 90 percent of surveyed companies reported increased formalization of energy goals, with greater linkage between energy costs and financial competitiveness, and a higher level of sophistication of energy related programs being implemented. The report concluded that U.S. businesses view energy management programs as essential to profitability and an important part of their corporate image and brand.

Kingspan's Net Zero Energy mandate contributes to the bottom line and to improving products' environmental Life Cycle Assessment impacts including: ozone depletion, eutrophication, global warming associated with green-house gas emissions, smog creation, and acidification. These environmental impacts are reported in Kingspan's certified Cradle-to-Grave, Environmental Product Declaration (EPD) which includes assessments of primary energy use (renewable and non-renewable), as shown in Figure 2.

Figure 2. Kingspan Insulated Panels North American Primary Energy (2011)



Source: 2011 Kingspan Environmental Product Declaration - http://www.kingspanpanels.us/media/3070/epd_2012.pdf

The Kingspan Insulated Panels: North American Strategy for Meeting the Corporate Net Zero Energy Mandate

Kingspan Insulated Panels (North America) operates five manufacturing locations in significantly different climatic regions, each with different manufacturing capabilities production requirements as shown in Table 1:

Table 1. Kingspan Insulated Panels North American Manufacturing Locations

Location	ASHRAE Climate Zone	Total Area	Conditioned Space	
		sq ft	sq ft	%
Deland, Florida, USA	2A	243,600	22,980	9.43%
Modesto, California, USA	3B	96,250	6,100	6.34%
Columbus, Ohio, USA	5A	113,000	5,790	5.12%
Caledon, Ontario, Canada	6A	209,132	12,000	5.74%
Langley, British Columbia, Canada	5A	68,500	5,000	7.30%
Totals		**730,482**	**51,870**	**7.10%**

Due to the varying processes, climatic conditions, and available alternatives for renewable energy, the challenges of meeting the corporate Net Zero Energy mandate are unique for each location.

Formation of the Net Zero Energy Project Team

Establishing a project team is critical for a successful outcome for a Net Zero Energy mandate. Ideal knowledge areas include: Certified Energy Manager/Engineer, Specialized functions e.g. environmental & sustainability focus, Plant managers, Operations Director, Net Zero Energy Program Manager, Finance, Marketing, Suppliers, Contractors providing energy equipment or resources, Internal and external stakeholders.

Social and environmental indicators combined with financial considerations ultimately decide the feasibility of a Net Zero Energy project. An initial return-on-investment (ROI) evaluation provides the framework for project scheduling and budgetary constraints on implementation.

Energy costs are a significant portion of the operating expenses for a manufacturer. Investment evaluations are based on the capital cost impact verses the potential for future savings, particularly since energy cost volatility is a primary concern motivating a Net Zero Energy project. Kingspan's Deland, FL, facility may spend more than $450,000 per year in electrical and natural gas energy costs, providing significant commercial and financial justification for energy reduction/grid elimination projects. Establishing the potential annual cost savings (considering forecasted cost increases) provides the gross budgetary target for investment, where potential profitability is realized with any savings.

The renewable energy and related technology typically required to meet energy use neutrality will likely be more expensive than traditional alternatives. The replacement of existing, (i.e. paid for), systems with more efficient alternatives results in capital investments

with payback periods wholly dependent on the efficiency difference. Acceptable payback periods will depend on the availability of capital financing and potential long-term savings. Financial management is critical to ensure that the project meets the financial as well as environmental goals.

The process can be summarized by:

- **Step 1:** Collect energy cost data to establish a baseline energy savings "budget". Adjust the budget for desired financial gains and set target dates for achieving financial goals.
- **Step 2:** Identify and quantify energy cost consumers.
- **Step 3:** Identify potential cost savings opportunities (per consumer) and perform return-on-investment (ROI) analyses for each opportunity.

By comparing the results to the established baseline, management has the decision making tools necessary to determine the feasibility of each opportunity.

The identification and optimization of energy cost consumers is further refined by a series of common, organizational tasks, including: Project definition, Benchmarking, Energy Reduction/Conservation Measures, Energy Budgeting, Final Implementation.

Project Definition

There are many definitions of Net Zero Energy for buildings, and the National Renewable Energy Laboratories (NREL) guide document on Net Zero Energy and related classifications is useful for developing a Net Zero Energy Manufacturing definition:

Defining Net Zero Energy

- **Net Zero Site Energy:** produces at least as much renewable energy as it uses in a year, when accounted for at the site.
- **Net Zero Source Energy:** produces (or purchases) at least as much renewable energy as it uses in a year, when accounted for at the source.
- **Net Zero Energy Costs:** the amount of money the utility pays the building owner for the renewable energy the building exports to the grid is at least equal to the amount the owner pays the utility for the energy services and energy used over the year
- **Net Zero Emissions:** net-zero emissions building produces (or purchases) enough emissions-free renewable energy to offset emissions from all energy used in the building annually.

Applying a Classification System to Net-Zero Energy Buildings

NREL has suggested that NZEBs (Net Zero Energy Buildings) may be classified based on the renewable energy supply options used and definitions met:

- **Buildings Classified as NZEB: A**
  - NZEB:A buildings generate and use energy through a combination of energy efficiency and renewable energy collected within the building footprint.

- **Buildings Classified as NZEB:B**
  - NZEB:B buildings generate and use energy through a combination of energy efficiency, renewable energy generated within the footprint, and renewable energy generated within the site.
- **Buildings Classified as NZEB:C**
  - NZEB:C buildings use the renewable energy strategies as described for NZEB:A and/or NZEB:B buildings to the maximum extent feasible.
- **Buildings Classified as NZEB:D**
  - NZEB:D buildings use the energy strategies as described for NZEB:A, NZEB:B, and/or NZEB:C buildings.

Kingspan's Definition

Kingspan is currently working on a global definition, with review of the NREL definitions and classifications and proposing a global "Aggregated" Net Zero Energy approach.

Benchmarking

Benchmarking cannot be stressed enough when establishing a Net Zero Energy Manufacturing (NZEM) project. The Kingspan North American Net Zero Energy initiative involves multiple locations that require benchmarking to define the project's scope and create a format for tracking subsequent improvements and final implementation. Energy cost consumers need to be identified and tracked closely to evaluate if applied measures meet individual and overall project performance expectations or if the strategy needs to be adjusted accordingly. All benchmarking exercises include auditing:

- Type 1 Audit(ASHRAE 2011): An initial macro-assessment of the current energy usage of a facility.
- Type 2 Audit (ASHRAE 2011): A more detailed assessment of the building's energy usage, including quantification of individual energy consumption systems.

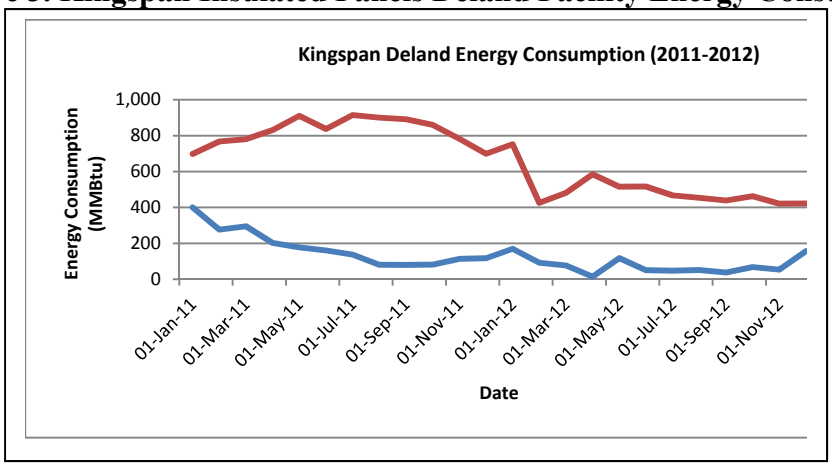
Type 1 auditing establishes overall usage values typically used for progress reporting and final evaluation of performance. Programs like the US Department of Energy's "Better Buildings, Better Plants" track the progress of energy reduction projects based on overall performance results. Additionally, the results of Type 1 audits provide initial direction when setting priorities for multiple-facility organizations like Kingspan.

Type 2 auditing provides the detailed breakdown of energy usage data necessary to identify specific remediation opportunities, to be used for higher-level strategic decisions. Type 2 auditing is synonymous with "sub-metering", the detail of which is highly dependent on the processes and systems present in a facility. While the costs associated with Type 2 auditing can be significant, it is a critical strategic element necessary to establish, track, and validate the performance of the various components that make up a complex system like a manufacturing facility.

Energy planning involves a review of activities that can affect energy performance. Kingspan Insulated Panels North American energy review began by collating measurement data and other energy use information that had an influence on overall operational energy

performance. Gross energy consumption and emission data for each plant is tracked based on fuel type and unit production.

Figure 3. Kingspan Insulated Panels Deland Facility Energy Consumption



Additionally, Kingspan's US sites participate in the US Department of Energy's "Better Plants" program, that requires energy consumption data be reported (based on fuel type) and normalized considering unit production and specific site HDD/CDD (heating and cooling degree days) data. Kingspan North America agreed to participate in this program in 2012, by signing a corporate-wide voluntary pledge to reduce energy intensity by 25% over ten years. The initiative is led by the Advanced Manufacturing Office (AMO) within the U.S. Department of Energy's (DOE's) Office of Energy Efficiency and Renewable Energy (EERE).

Participants in the Better Plants program learn about and move toward more rigorous energy management with the support with an assigned technical engineer account manager (TAM) who assists in analyzing key energy use data and metrics. In return, DOE requires Kingspan to be an active Program Partner, which means providing staff to work with DOE to identify and implement energy savings projects, making energy intensity reductions a priority throughout their organizations, and championing continuous improvement in energy management. Requirements include completing the following within 12 months: Establish energy use and energy intensity baselines, Develop an energy management plan, Designate an energy manager,

Take steps to reduce energy intensity, thereby lowering related carbon emissions, Report energy intensity and energy use data and achievements to D.O.E.(U.S. Department of Energy)

Sachin U. Nimbalkar, PhD of the R&D Staff at Oak Ridge National Laboratory (ORNL) Commercial Buildings and Industrial Energy Efficiency states that "As a Better Plants Technical Account Manager (TAM), I work with program partners to establish energy intensity baselines, develop energy management plans, organize and coordinate services to identify and implement energy savings projects, prioritize energy intensity reductions throughout an organization, and champion continuous energy intensity improvement results."

Although the Better Plants program applies directly to Kingspan's United States operations, Canadian operations are recording energy consumption using the same process.

Kingspan has also signed onto the *Architecture 2030 – 2030 Challenge for Products*, an initiative targeting the reduction of carbon footprint for product manufacturing by 2030.

Another planning and reporting tool supported by The Department of Energy (DOE) and Energy Star for Buildings and Plants is the ISO 50001 Energy Management System Standard. It is a proven approach for U.S. industrial and commercial facilities to plan, manage, measure, and continually improve energy performance. Kingspan North America is currently reviewing this standard.

Though participation in these programs, Kingspan has been able to identify several obvious savings opportunities which have been realized through scheduling adjustments and equipment upgrades (as seen in Figure 3.).

Benchmarking provides the detailed information necessary to separate the overall project into individual tasks, allowing each energy consumer to be evaluated for its impact to the overall energy reduction of the location. This exercise allows each subproject to be given a project "value" to guide decision makers with prioritization of capital investment and other resources.

Energy Reduction/Conservation Measures (ECMs)

Energy consumption in buildings is commonly broken down into six major categories (ASHRAE 90.1) which can help organize projects within the Net Zero strategy: Building Envelope, Heating, Ventilation, and Air Conditioning, Service Hot Water Heating, Power Distribution, Lighting and Other Equipment.

By considering each category individually, the analysis can be tailored to each building's unique energy footprint and individual savings opportunities can be identified, quantified, and prioritized. Identifying the major components in each category can also be used to determine sub-metering and monitoring requirements for initial and subsequent performance auditing.

Energy Conservation Measures (ECM): Building Envelope

The building envelope has a significant effect on other building energy systems, especially those related to maintaining the interior environment (HVAC) - Heating, Ventilation & Air Conditioning and Lighting. Optimization of the building envelope should be considered as a means of improving energy performance of an existing building where feasible. An energy model of the specific building can indicate performance improvements potentially realized by the improved thermal resistance, reduced infiltration, and reduced solar heat gain made possible by building envelope improvements.

93% of Kingspan's North American plant square footage is dedicated to manufacturing and is largely unconditioned space. Given the range of climate zones represented, energy models for each building are being developed to determine the value of upgraded envelope components toward overall energy performance.

Energy Conservation Measures (ECM): Heating, Ventilation, and Air Conditioning

The impacts of HVAC costs are highly dependent on building use. In typical commercial buildings, environmental conditioning (heating, cooling, and lighting) may account for over 50% of the building's energy use (Department of Energy - DOE 2010). For industrial applications, this value may be significantly different, depending on the varying space conditioning requirements. Again, results of Kingspan building modeling will aid in cost/benefit decisions regarding upgrades to existing HVAC systems.

Energy Conservation Measures (ECM: Service Hot Water Heating

Once again, application will dictate savings opportunities. Kingspan's manufacturing processes use very little heated water therefore the impact of improvements in this category would likely be very limited.

Energy Conservation Measures (ECM): Power Distribution

Power distribution may be organized in two groups: Power efficiency and power controls. Supply-side KVAR (Kilo-volt amp reduction) studies have been done on each of Kingspan's North American facilities and power quality analysis will be performed to ensure that energy is distributed as efficiently as possible. Additionally, demand load studies should be performed, in the interest of reducing costs and evaluating opportunities for schedule optimization and controls.

Energy Conservation Measures (ECM): Lighting

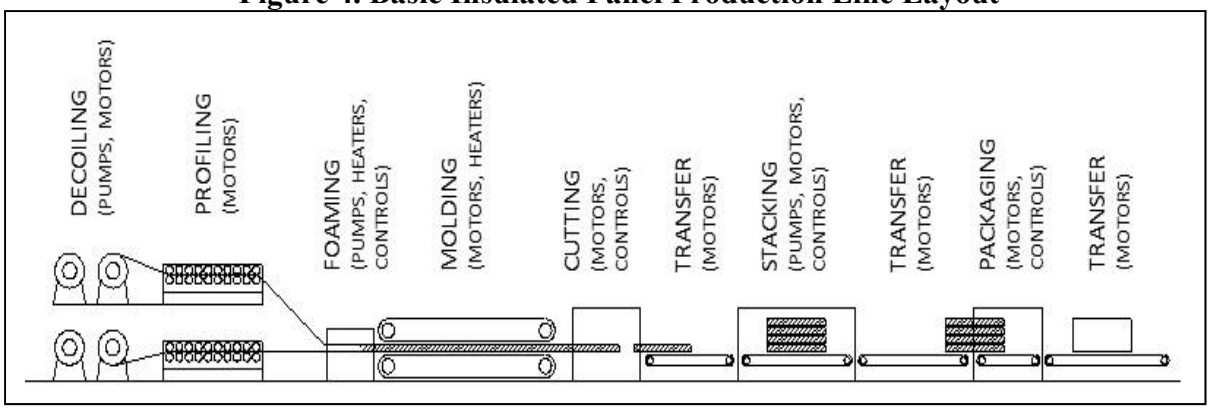
In industrial applications like Kingspan's, lighting can be a very significant energy consumer. Industrial lighting costs can be estimated (based on fixture types, number, and shop schedule) and improvements evaluated based on alternative equipment and shop scheduling adjustments. For these reasons, Energy Star identifies lighting as the second step in their *Staged Approach to Building Upgrades* (EPA 2007). A key consideration when developing Lighting strategies includes evaluation of process lighting requirements, which can identify additional potential savings by use of system timers, motion sensors, light sensors, and daylighting.

Kingspan commissioned an audit of its existing lighting scheme to evaluate replacement of high-bay lighting in the various plants. In the Deland location, a final decision was made to replace the existing metal-halide lighting with higher efficiency fluorescent fixtures, with the addition of light level sensors and motions detectors to take advantage of existing daylighting and reducing lighting requirements in areas with little traffic.

Energy Conservation Measures (ECM): Other Equipment

Processing equipment typically accounts for the majority of the energy consumed in dedicated manufacturing facilities like those operated by Kingspan. While the actual details of the equipment used may differ from plant to plant based on the products being produced at each location, a simplified diagram for the system, such as Figure 4. can illustrate the various energy consumers (and optimization opportunities):

Figure 4. Basic Insulated Panel Production Line Layout



Kingspan North America has been able to identify several opportunities for energy conservation within their processes. As an example, by realizing that the majority of natural gas usage at each site is dedicated to process molding equipment, older, low-efficiency heating systems have been replaced with new technology furnaces and improved delivery design to provide more efficient operation. Sub-metering is being installed to improve the accuracy of analyses on primary energy users.

Energy Budgeting

Since energy reduction is the first focus of a Net Zero Energy Manufacturing project, it's important to consider the often higher comparative cost of efficiency when evaluating alternative energy reduction solutions. The individual return-on-investment (R.O.I.) analysis for each subproject and comparison to its project "value" (established during benchmarking) ensures that solution choices fit into the overall project requirements

A Net Zero Energy Manufacturing (NZEM) project must not only meet its initial zero net energy usage and production requirements, but also demonstrate the capability to continue that performance into the future. To meet that capability, the strategy for implementation must deal with projected energy usage as the building's demands change. There is a level of speculation and uncertainty in this process that can be mitigated by applying a combination of commercial planning, expert opinion, and historical data. The strategy must include a process that addresses future changes in energy demand and a procedure for maintaining energy neutrality (either by equal energy reduction or increased renewable energy production/procurement).

Final Implementation

Implementation of Energy Reduction Measures typically takes two forms:

- Procedural: Including changes to current procedures and schedules that create energy savings opportunities. Costs of procedural changes should not be underestimated, even considering the low (or no) capital investment requirement. Impacts on productivity should be quantified if possible.
- Capital: Including technology upgrades (new equipment, higher efficiency replacements, etc.).

The importance of continued benchmarking and monitoring becomes evident, since implementation is typically performed in a staged process. All changes are evaluated periodically to ensure effectiveness and compatibility with required operational processes. Any subsequent adjustments to initial implementation need to be tracked, so that impacts on overall and detailed energy consumption may be properly accounted for.

The transition to Net Zero Energy status for an existing facility may be reduced to a series of financial and energy consumption accounting exercises that include optimizations and improved building energy usage to establish targets. The remaining energy consumption must be offset by an energy source compatible with the Net Zero Energy definition. Considering the higher cost of renewable energy (either through installation or purchase), the design of the offset program needs to be considered during the process of evaluating energy reduction measures to ensure that they fit within the project's budgetary constraints.

Capital costs and return on investment (R.O.I.) are critical to any energy conservation project, since investment results are seldom immediate. Today, a key component of any such financial evaluation must include proper research into available incentives.

US Energy Efficiency Incentive Programs

US energy financial opportunities include the federal Energy Policy Act of 2005 established as a tax deduction for energy-efficient commercial buildings applicable to qualifying systems and buildings placed in service from January 1, 2006, through December 31, 2007. This deduction was subsequently extended through 2008, and then again through 2013 by Section 303 of the federal [http://thomas.loc.gov/cgi-bin/query/z?c110:H.R.1424.enr: Energy Improvement and Extension Act of 2008] (H.R. 1424, Division B), enacted in October 2008. A tax deduction of $1.80 per square foot is available to owners of new or existing buildings who install (1) interior lighting; (2) building envelope, or (3) heating, cooling, ventilation, or hot water systems that reduce the building's total energy and power cost by 50% or more in comparison to a building meeting minimum requirements set by ASHRAE Standard 90.1-2001

A valuable tool for researching available energy related incentive programs is found at the DSIRE website which is a comprehensive source of information on state, federal, local, and utility incentives and policies that support renewable energy and energy efficiency.

"Offset" Energy Production and Procurement

Concurrent with each facility's energy reduction programs is the development of energy offset alternatives, since the specific cost of offset energy for each location may influence capital outlay for additional energy reduction measures (depending on which is found to be more cost effective). Considering that the ultimate goal is to completely offset energy use, it's useful to determine a "unit offset energy cost" based on kWh (kilowatt-hour), MMBtu (mega Btu), or other metric, for each location.

Because of the varied locations Kingspan operates in North America, choices (and limitations) of potential offset energy sources are very specific to each facility. Sites that are favorable to one form of energy production are unlikely to be suitable for others, resulting in different unit energy costs for each location. States and provinces like California or Ontario may have incentive programs for solar photovoltaics that reduce the initial capital costs and payback

periods while other locations may take advantage of green power purchasing from off-site sources as the most feasible supply solution.

Addressing this key issue, Kingspan Insulated Panels in North America is considering an "Aggregated Net Zero Energy Manufacturing" approach within their definition, which allows excess renewable energy generated at one facility to be allocated as an offset for facilities that either cannot benefit from current renewable technologies or are limited by utility or governmental restrictions.

Unit offset energy cost is a valuable financial tool when evaluating energy reduction measures, since their anticipated energy savings need to be compared not only to current energy costs, but to the ultimate cost of supplying offset energy to a net zero facility.

Kingspan's Global Net Zero Energy Manufacturing Mandate

In August of 2010, during a global senior management strategy meeting, Kingspan's "Road to Net Zero Energy" was introduced as a mandate to be completed by 2020.

Net Zero Energy Manufacturing Recommendations

Defining Industrial/Manufacturing Net Zero Energy is the critical first step, to determine required measurement standards. Each operation is unique to the scope and boundaries of the definition and should be carefully considered and sufficiently detailed to ensure that individual circumstances are addressed while maintaining the ultimate goal of zero net energy use.

Project accounting plays an equally critical role, with energy usage accounting balanced with investment and future financial benefits. Initial return-on-investment (R.O.I.) benchmarks and continues calculations throughout the process guides management with implementation decisions and establishes schedules.

Energy use is fundamental to nearly every business function. Establishing a diverse project team will help provide a balanced approach to decisions that will affect operational and commercial processes.

Determining the cost of renewable energy production systems or renewable energy procurement based on initial benchmarking provides a "unit offset energy cost" that can be used to evaluate the value of energy reduction measures. This evaluation should be performed for each facility, since unit offset energy costs will differ depending on location and available incentives.

Programs like the U.S. Department of Energy's – Advanced Manufacturing Office – Better Plants program are a great resource to begin energy efficiency improvements towards a Net Zero Energy goal.

Net Zero Energy programs are ultimately a long-term investment that require understanding return on investment (R.O.I.). Financial considerations will dictate prioritization of the various sub-projects associated with the project. The Department of Energy's - Advanced Manufacturing Office offers the *State Incentives and Resource Database* which aids commercial and industrial managers seeking to make energy efficiency upgrades in their facilities find the financial and technical incentives, tools, and resources they need. It is critical that available financial resources from National, State/Provincial, and local levels be fully researched.

Conclusions

Participation in the Department of Energy's Better plants program is advantageous because of their technical support and network of energy focused specialists.

Defining Net Zero Energy Manufacturing (NZEM) scope and boundaries is challenging, especially with a portfolio approach. Net Zero Energy Manufacturing (NZEM) is a logical extension of net-zero energy buildings (NZEB) according to the ACEEE paper -The Path to Net-Zero Energy Manufacturing.

Kingspan's North American aggregated approach to Industrial Net Zero Energy is considering allowance of excess renewable energy production from one facility to be allocated as an offset for facilities that can't benefit from current renewable technologies. However the ultimate goal is to have each plant producing as much energy as consumed. The business case for Kingspan favors a Net Zero Energy Cost Balance approach that includes capital expense improvement investment considerations. Energy risk assessment is also part of an Industrial Net Zero Energy business case regarding potential impact of changing weather patterns to manufacturing and related energy sources.

Life Cycle Assessment is relative to Net Zero Energy efforts by measurement and reporting all aspects of the manufacturing processes including primary energy (non-renewable and renewable) along with impacts such as ozone depletion, eutrophication, global warming associated with Green-house gas emissions, smog creation, and acidification. Carbon reduction strategies will also take into account related Green House Gases (GHG) impacts of natural gas verses non fossil fuel alternatives.

Green Power purchasing will be critical to achieving Kingspan's Industrial Net Zero Energy goals. In North America, renewable technologies such as solar photovoltaics will need a stronger business case for near term investment in renewable technologies.

In the short-term there are "Net Zero Energy Ready", "Near Net Zero" "Zero Energy Capable" and "Low Energy" strategies that can move industrial operations towards Net Zero Energy goals at a pace that is in alignment with corresponding levels of return on investment.

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