Paper Title: **Refrigerator Ice Making Modules Utilizing VE Methods Reducing 27.4% of Cost and Energy Savings of 50% Creating Life Cycle Value of 116 Times of Cost Savings**

Authors: **Won Jin Sunu, CVS (SKVE); email: johnsunu@hanmail.net**
Hyeon-Cheol Woo, AVS (DaeChang); email: yunitech@unitel.co.kr
Joon-Dong Ji, AVS (DaeChang); email:jdji@edaechang.co.kr
Kui-Yong Choi, CVS-Life (SKVE); email: choikuiyong@naver.com

Abstract

The Korea's best ice maker manufacturer utilizing VE/VM methods is leading the global refrigerator ice making with energy saving of 50% compared with the competitors coupled with creating cost savings over life cycle period of 116 times over the first year's cost savings. Low-end technology ice makers are trying to survive in the low margin refrigerator market as OEM suppliers. However, this company exceeds the global requirements by reducing costs over 27.4% and also reducing energy consumptions by 50% using their state-of-the-technology acquiring more than 50 patents per year. Not only this company provides quality ice makers to the premier customers, but also it fulfills the future needs and demands of the consumers offering very critical differentiation competitive edge in the global market.

Refrigerator market can be attractive with its $20 billion market size and an average annual growth rate of 2~4%, but only the companies with the competitiveness and differentiating offerings can enjoy in this market. The U.S. market is environmentally friendly oriented by establishing very stringent energy consumption requirements. The Department of Energy (DOE) mandates with its DOE standards along with the State agencies by conducting elaborate assessment and analysis as described in DOE Refrigerators Final Ruling executing the requirements of the flow diagram of analyses for the energy conservation standards rulemaking analysis process, including market & technology assessment, screening analysis, engineering analysis, energy use, markups for equipment price determination, shipment analysis, life-cycle cost and payback period analysis, national impact analysis, preliminary manufacturing impact analysis, life-cycle cost sub-group analysis, utility impact analysis, environmental assessment, and regulatory impact analysis. While the pricing has been discounted from $2,000 to $500 for an average size refrigerator since 1972, the power or energy saving is moving at a much faster rate, which offers significant benefits to the consumers and will be the most important product attributes. The impact of the energy savings will be even greater as the life cycle period is equated in the value modeling.

To produce the world class results, the VE/VM methods are utilized extensively. The Enhanced FAST with Sensitivity Matrix is used for enterprise level planning during the implementation phase. After defining the functions, the FAST, Function Analysis and Value Indexing using Paired Comparison Analysis are used in streamlining the functions and processes resulting in cost reduction of 27.4%. Also, for the new technology development, innovative ideas and concepts are developed using TRIZ Technical Contradictions with Inventive Principles and Lotus Blossom Technique, which contributed significantly in reducing the energy consumption by 50% or a total of 42.1 kWh per year. In appreciating the environmentally friendly society, the invaluable assets of the society must be sustained and consequently developing life cycle valuation practices is very critical in pursuing the value creation.

The most important performance of VE/VM is to institute an entire organization with innovative minds and capability focusing on the human aspects pursuing the excellence of VE/VM producing VE/VM specialists who contribute for the best of the company as well as in the society by increasing the intellectual capabilities tremendously. In order to prepare for the long-term sustaining growth, instituting VE/VM is the necessity, and the scope must expand from research to sales and services.

I. Background

Refrigerators market appears to be attractive with a projected global market size of $20 billion by 2018 with an average annual growth rate of 2~4%; however, refrigerator manufacturers nowadays must equip with diverse requirements to compete in the global fierce competitions. Price only differentiation does not hold for the long-term competition in the global arena. The number one ice maker in Korea with annual sales revenue of $100 million must fulfill the global corporate B2B (business to business) customers with premier quality and global competitive pricing. In addition, this company must identify the consumer's needs and must satisfy them along with the corporate customers. Differentiating factors are not obvious to be identified in the midst of the fierce and very competitive global market.

Utilizing VE/VM methods, this company developed the state-of-the-art technology offering the cost competitiveness as well as the industry's first and best premier differentiation that none of the competitors are able to compete. The appliance manufacturers in Korea confront serious competition issues and obstacles to overcome in order to survive or to sustain the growth. Global suppliers particularly in China and Vietnam capture significant portion of the low-end market with price only differentiation.

In order to determine the most critical differentiating factor, the refrigerator's external factors must be carefully analyzed through intense market analysis. According to ASAP (Appliance Standards Awareness Project), since 1972 the refrigerator's sizes in cubic feet have increased while the price has been discounted from $2,000 to $500 for an average size refrigerator as shown in the Attachment 1. [(1)] In order to make products environmentally friendly on a society level, the U.S. government agencies mandated very stringent power consumption requirements. The power reduction program has been driven by the DOE and other agencies in efforts to reduce CO_2, NOx, and other environmental pollution factors. By reducing one watt of power consumption, all the relevant environmental pollution factors can be reduced and the reduction amount in dollars can be calculated in accordance with the DOE standards. DOE Refrigerators Final Ruling shows the requirements of the flow diagram of analyses for the energy conservation standards rulemaking analysis process, including market & technology assessment, screening analysis, engineering analysis, energy use, markups for equipment price determination, shipment analysis, life-cycle cost and payback period analysis, national impact analysis, preliminary manufacturing impact analysis, life-cycle cost sub-group analysis, utility impact analysis, environmental assessment, and regulatory impact analysis as shown in the Attachment 2. [(2)]

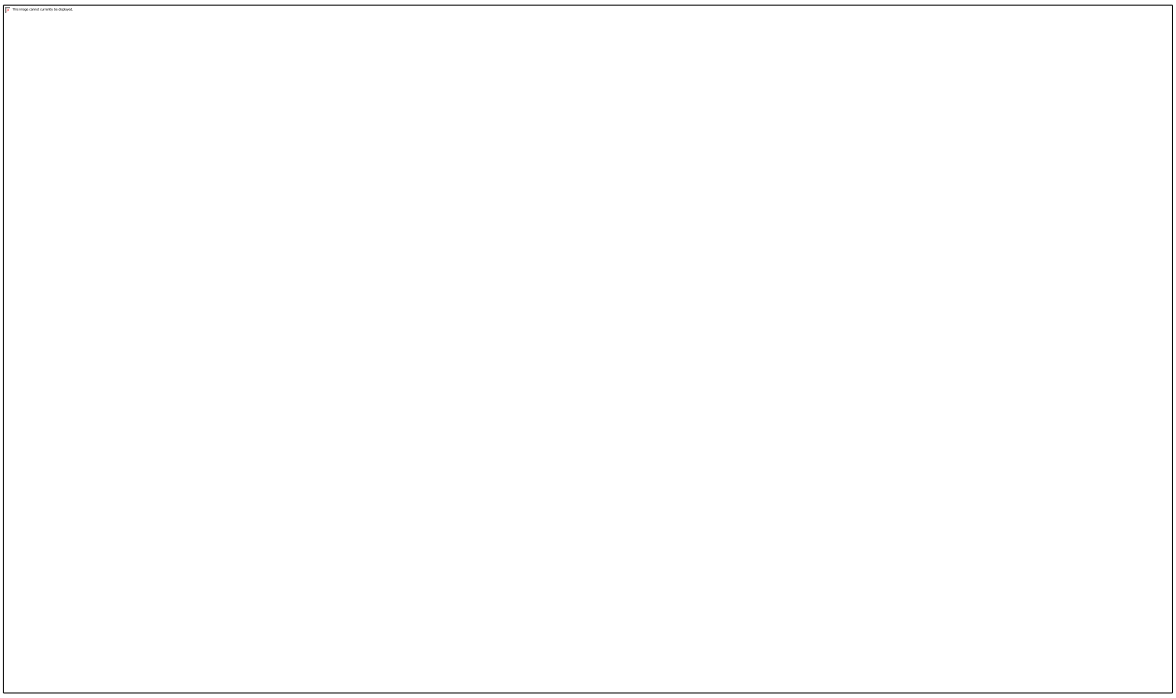
As the importance of power consumption for the refrigerators are described in the above, NIST (National Institute of Standards and Technology) in its Tech Beat Report on April 12, 2011, in the article "The Heat Is On: NIST Zeroes In On Energy Consumption of Ice Makers" highlighting the importance of controlling the power consumption of the ice makers in the refrigerators. It describes that an ice maker consumes approximately 25% of the refrigerator, and 75% of the ice maker's energy consumption is used for heating the ice maker, demonstrating the importance of the ice maker in the future. Starting in 2014, DOE mandated a minimum efficiency standard by 25% over the previous year's level. [(3)] It is very clear that minimizing the power consumption will benefit the B2B corporate customer with the most demanding differentiator and the consumers with an annual savings of the power usage that can be calculated for a life cycle period. Based on the procedures defined by DOE in its standard, the first year's consumer's energy savings can be determined, and this saving can be equated for a life cycle of 12 years as per DOE's life cycle term for a refrigerator. Then, with the total energy savings in Watts, the CO_2, NOx, and other pollution savings can be calculated according to this DOE standard, which would give us a total saving for a term of the life cycle. It is obvious here that VE/VM methods are already implemented and embedded in the DOE standard. Thus, in this VE study, DOE life cycle modeling as shown in the Attachment 3 is utilized to determine the full benefits of the power consumption reduction. [(3)]

II. VE/VM Projects Organization & Enhanced FAST with Sensitivity Matrix

The CEO's commitment and his leadership throughout the company turns out the most critical factor driving the departments to go forward as a team for the targeted objectives. The VE Projects Organization is shown in Figure 1. Participating members are from the Production, Customers, Vendors, Costing, and System & Infrastructure coordinated by the Innovation Team and VE specialists with core activities of value creation, strategic planning and performance management.

To achieve VE projects successfully in a medium size company, VE practices must be implemented throughout the organization in order to maximize the results of improving the functional values while reducing the costs. The level of organizational participation can be quite extensive; however, this can be effectively achieved with an enterprise-level planning utilizing Enhanced FAST with Sensitivity Matrix [(4)]. VE Project must be carefully designed with the right specialists and responsible people to improve the current functional values and to reduce costs. Optimizing the overall project processes and activities must be coordinated and facilitated throughout the project. With the company's production process-oriented FAST, planning activities are integrated for the enterprise-level VE. This Enhanced FAST is used to control the VE project and activities in the company. To have a dedicated and committed organizational participation, the VE enterprise-level planning can be very useful in communicating with the top as well as to the other parts of the company determining who is responsible for what and to manage effective VE projects. Also, this planning tool assigns the teams to be committed for the objectives of the VE projects.

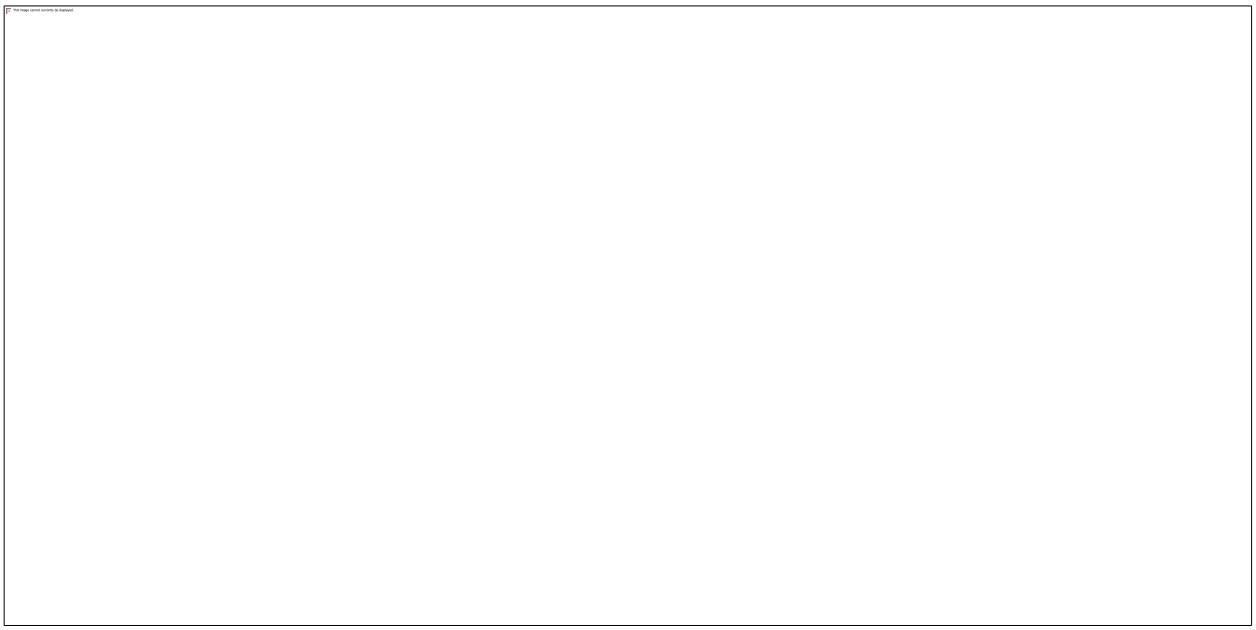
<Figure 1. Value Engineering Projects Organization>



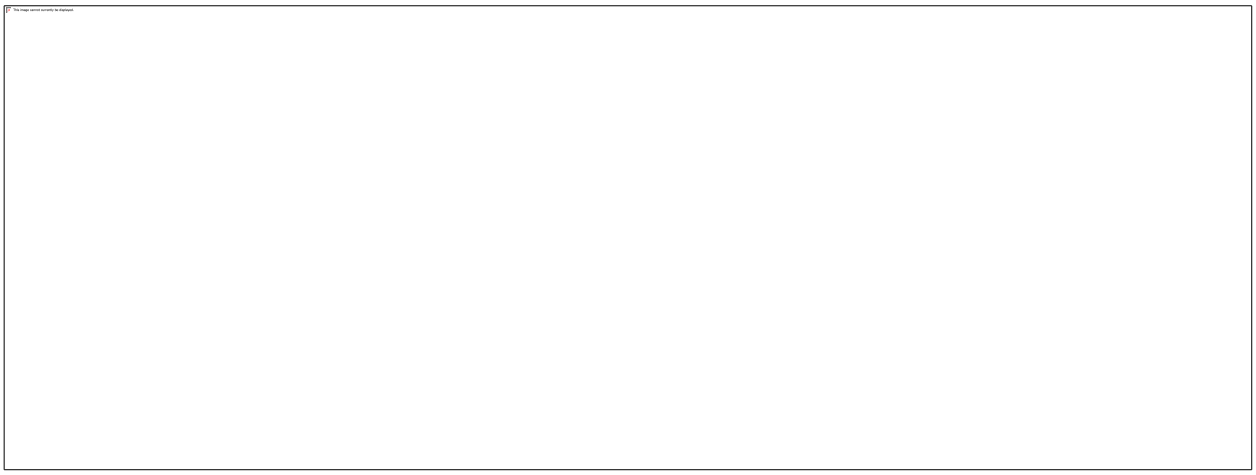
III. Function Analysis and Value Index

First, the functions of the ice making module are defined, and the FAST is drafted in accordance with the procedures and methods defined by Charles W. Bytheway in his book, FAST *Creativity & Innovation*. [5] After the functions and the FAST are defined, the functions are evaluated on the relative importance using Paired Comparison Analysis [7] as shown in Figure 2. Using this PCA scoring or Functional Importance Weight is determined. With the costing of the functions are determined, Worth (or Cost Distribution based on the Functional Importance Weight), and Value Index is determined as shown in Figure 3.[6] One can see from this Figure that VI's above 1.5 is clearly the items to be targeted as the potential cost reduction items. These 4 parts are selected for a potential cost reduction of 27.4%.

< Figure 2. Paired Comparison Analysis >



< Figure 3. Function Analysis & Value Index >



IV. VE Ideation Methods “LBT” [8] to Reduce Energy Consumption by 50%

In order to reduce the heater energy consumption by 50%, broad level of ideation is conducted using LBT (Lotus Blossom Technique) introduced by Anita Lukose during the SAVE International Conference in 2015 [8] in addition to typical brainstorming using “Post-It” and a whiteboard and KJ Mapping. This VE method was effective in brainstorming with the researchers together in expanding ideas as many as layers that could be expanded. Also, none of the ideas were deleted for future usage. Since this is a technology oriented, LBT seems to fulfill the first level ideation. As a result, possible ideas and concepts were introduced for this challenging objective of reducing energy by50%.

< Figure 4. Enhanced “Lotus Blossom Technique” [8] for Idea/Concept Generation >

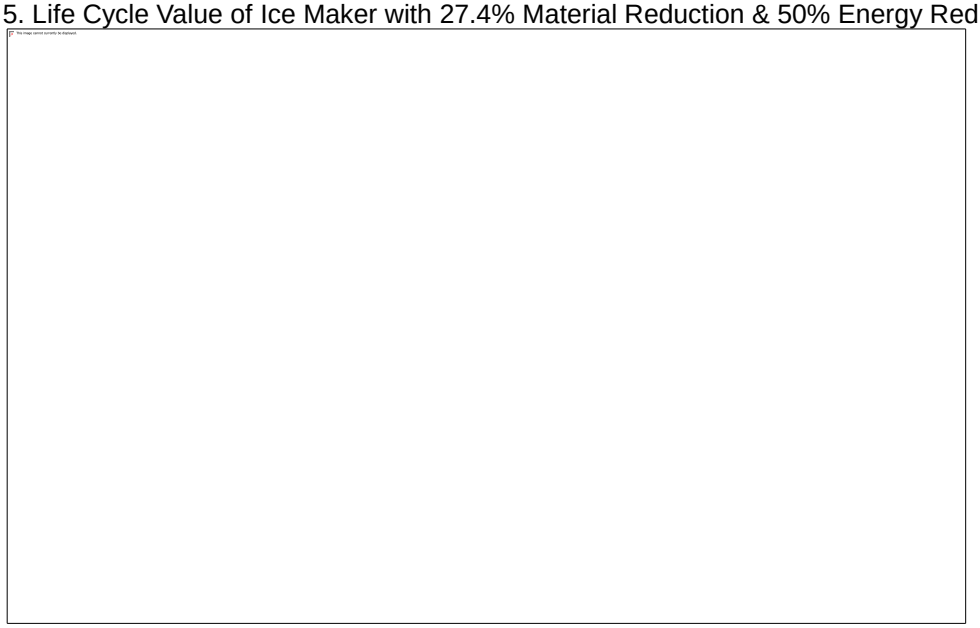
V. TRIZ Resolving Technical Contradictions [9]

From the previously identified ideas and concepts to reduce energy consumption by 50%, 6 Technical Contradictions were identified. To resolve these 6 Technical Contradictions, there were 5 Improving Features (#2 Weight of stationery object, #4 Length of stationery object, #8 Volume of stationery object, #32 Ease of manufacturing, #39 Extent of automation) and 10 Worsening Features (#10 Force, #11 Stress or pressure, #13 Stability of object’s composition, #14 Strength, #16 Duration of action of stationery object, #29 Manufacturing precision, #32 Ease of manufacturing, #36 Device complexity, #37 Difficulty of detecting and measuring, #39 Extent of automation. Utilizing Technical Contradiction Matrix, a total of 25 boxes are identified for Inventive Principles. A total of 29 out of the 40 Inventive Principles, including #1, #2, #3, #6, #8, #9, #10, #11, #12, #13, #14, #15, #17, #18, #19, #22, #24, #26, #27, #28, #29, #32, #34, #35, #36, #37, #38, #39, #40 were determined. These Inventive Principles were then developed to apply the specific technology oriented solutions. One example of the 29 Inventive Principles that produced an outstanding result was the surface treatment of the tray case. Instead of water dropping with size of 3~5μL, it is preferred to be rolled before they are freezed. To accomplish this, there are three parameters to control (1) Surface treatment quality to make the water droplets to be superhydrophobic, (2) Water Contact Angle to be more than 150˚, (3) Water Sliding Angle of approximately 10˚. With sufficient experiments, the company was able to perform the anticipated results.

VI. VE Projects Producing Successful Results

Out of the targeted cost reduction opportunities, a total of 27.4% material cost reduction is realized. Next, a total of 50% of the energy reduction is achieved on the ice makers in the current production level of over half million units per year. The annual energy savings for the life cycle period of 12 years, the Present Value of these annual energy savings is 10.5 times of the price. In accordance with DOE standards, the first year's energy reduction amount in dollars has a direct impact on the following year's price of the product either using 1/3 rule or an empirical formulation. Here, a total of 42.1 kWh/Year of energy saving by the ice maker, the price increase is estimated to be around 1.76 times of the ice maker's price. Then, CO_2 and NOx reduction values are determined as 3.6 times of the price and 5% of the price. The total lifecycle value of this company's ice maker is 116.4 times of the material savings, which is very significant in creating value for the company and their customers. The total value of material and energy reduction cost savings during the life cycle period is millions of dollars.

< Figure 5. Life Cycle Value of Ice Maker with 27.4% Material Reduction & 50% Energy Reduction >



Assumptions:

- In accordance with DOE standard, 12 years of life cycle period is assumed.
- NPV = FV $\{1/(1+i)^N\}$ where i is assumed to be 3~5%

In addition to the monetary tangible benefits, intangible benefits are also very significant. VE/VM methods instituted to develop new technologies in leading the industry. Functional analysis with Value Index analysis were very effective instrumental in making clear directions with priorities and strategic decisions coordinating the upper level executives and lower level managers throughout the company. As a enterprise level VE innovation project, this has a very significant meaning in directing the company with vision and hope for the employees. Any of the employees can challenge to be the VE specialist contributing superior results for the performance of the company. Also, providing the demanding values to the potential customers is the core in establishing the VE capabilities and enterprise level intellectual property driven human infrastructures, which will be the main driver of the company's long-term sustaining growth. Also, in appreciating the environmentally friendly society, the invaluable assets of the society must be sustained and consequently developing life cycle valuation practices along with lifecycle costing is very critical in assessing the value creation as well as the costing elements. The company also utilizing VE TRIZ, ingenious ideas and solutions were adopted resulting in numerous patents that gave tremendous capabilities of intellectual properties increasing the gap against the competitors. Along the way, over 40% of this company's R&D experts are value specialists recognized by SAVE International®.

VIII. Conclusion

The Korea's best ice maker manufacturer utilizing VE/VM methods exceeds the global requirements by reducing costs over 27.4% and leads the global refrigerator ice making with energy saving of 50% compared with the competitors using the state-of-the-technology by acquiring more than 50 patents per year coupled with creating cost savings over life cycle period of 116 times over the first year's cost savings. Not only this company provides premier quality to the global customers, but also it fulfills the future needs and demands of the consumers offering very critical differentiation competitive edges in the global market. In aligning with the global demands by both consumers and governments to fulfill the environmentally friendly society, appliance manufacturers must consider the life cycle valuation along with the life cycle costing as demonstrated by DOE for the appliances in their DOE Refrigerators Final Ruling executing the requirements of the flow diagram of analyses for the energy conservation standards rulemaking analysis process, including market & technology assessment, screening analysis, engineering analysis, energy use, markups for equipment price determination, shipment analysis, life-cycle cost and payback period analysis, national impact analysis, preliminary manufacturing impact analysis, life-cycle cost sub-group analysis, utility impact analysis, environmental assessment, and regulatory impact analysis. In short, the total value of the savings for the life cycle is worth millions of dollars.

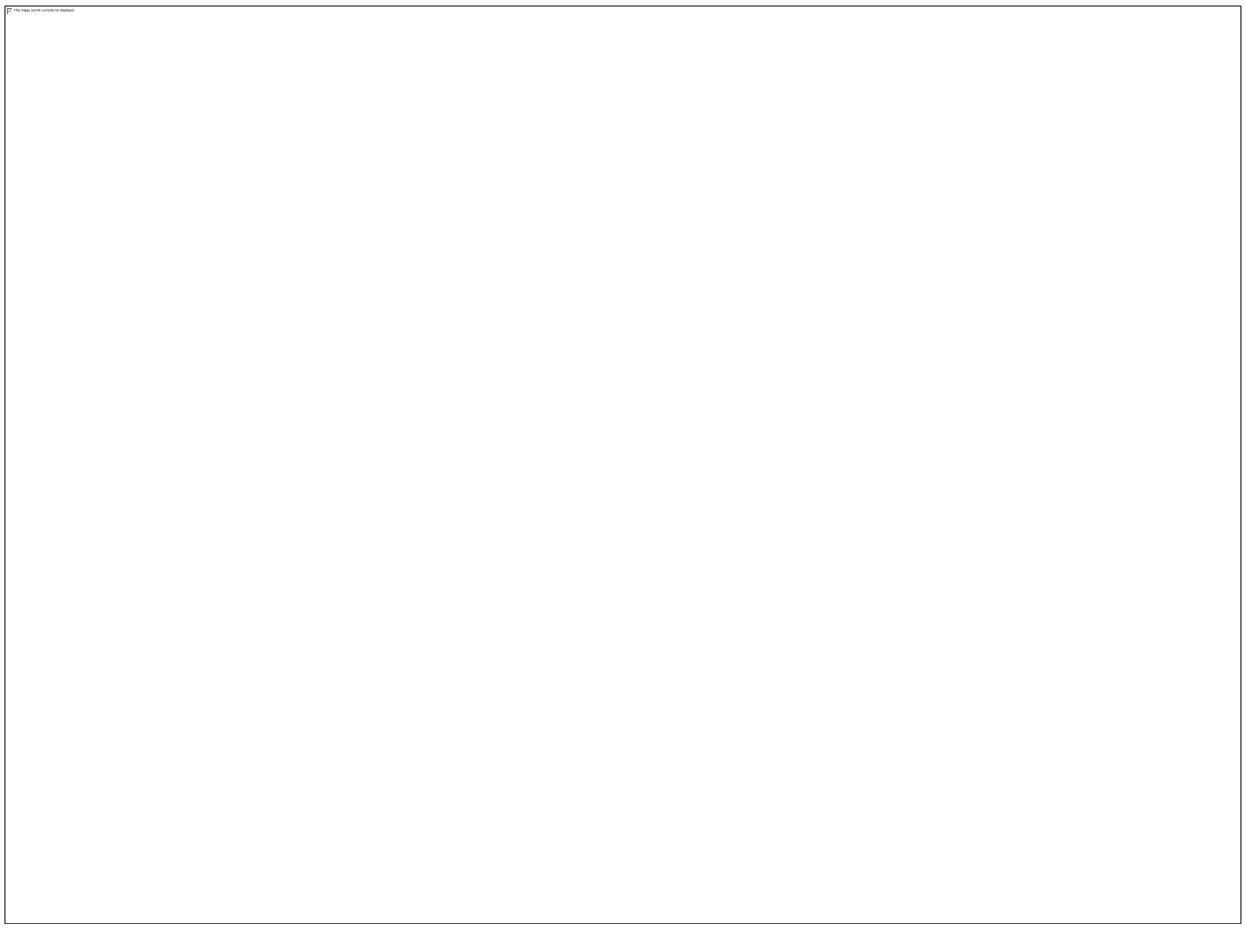
To produce the world class results, the VE/VM methods are utilized extensively. The Enhanced FAST with Sensitivity Matrix is used for enterprise level planning during the implementation phase. After defining the functions, the FAST, Function Analysis and Value Indexing using Paired Comparison Analysis are used in streamlining the functions and processes resulting in cost reduction of 27.4%. Also, for the new technology development, innovative ideas and concepts are developed using TRIZ Technical Contradictions with Inventive Principles and Lotus Blossom Technique, which contributed significantly in reducing the energy consumption by 50% or a total of 42.1 kWh per year. In addition, VE/VM is instituted in human resource management by stimulating innovative minds and VE capability pursuing the excellence of VE/VM specialists who contribute for the best of the company as well as in the society. In order to prepare for the long-term sustaining growth, instituting VE/VM is a necessity, not an option.

Request for Joint Study or Joint Project:
For the VE/VM specialists and companies who would like to perform a VE/VM Joint Study or a VE/VM Joint Project, please contact to : Won J. Sunu, CVS email: johnsunu@hanmail.net

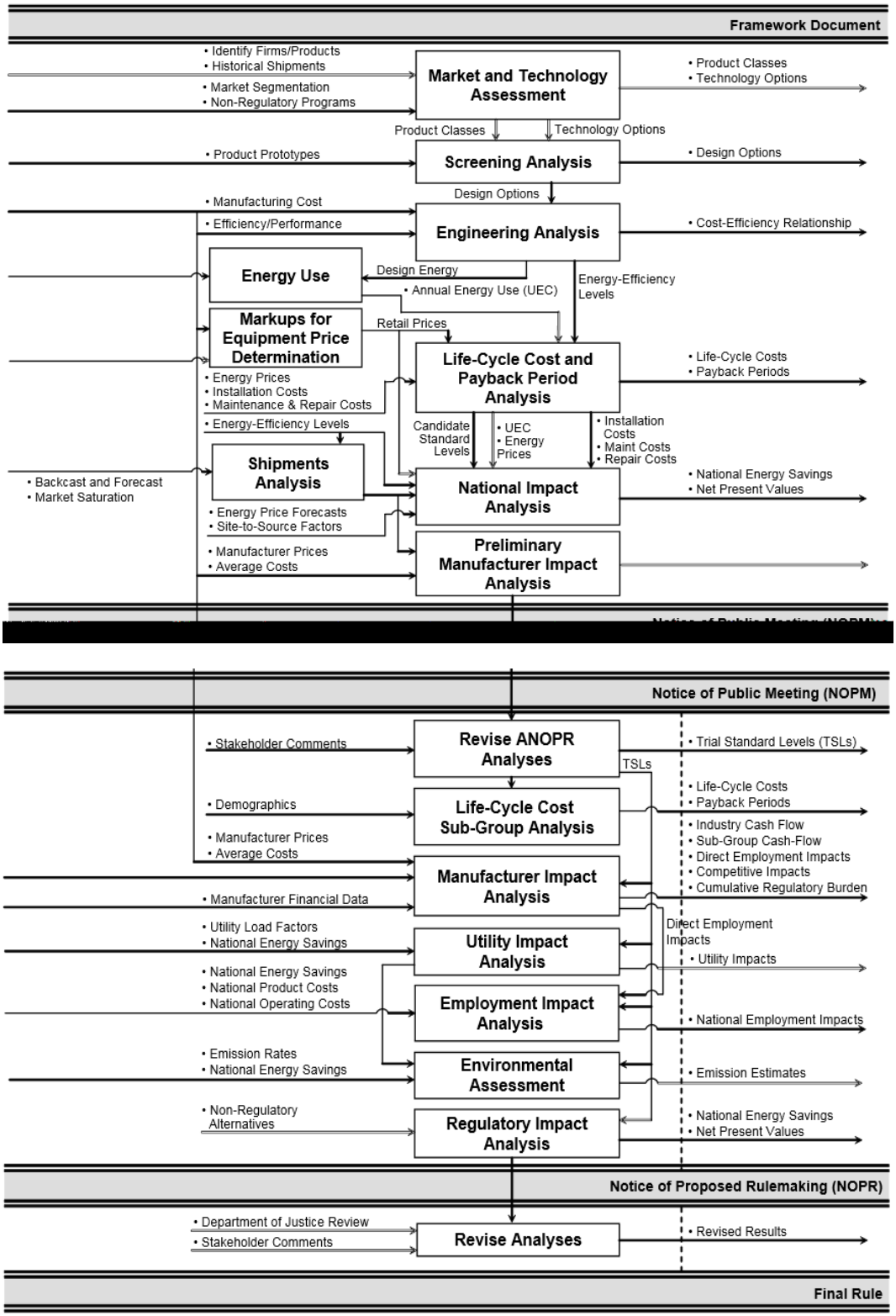
References:

1. Association of Home Appliance Manufacturers (AHAM) for energy consumption and volume: U.S. Census Bureau for price
2. Energy Conservation Program: Energy Conservation Standards for Residential Refrigerators, Refrigerator-Freezers, and Freezers, Department of Energy, 10 CFR Part 430, Docket Number EE-2008-BT-STD-0012.
3. NIST (National Institute of Standards and Technology), The Heat Is On: NIST Zeroes In On Energy Consumption of Ice Makers, Tech Beat Report, April 12, 2011.
4. J. Jerry Kaufman, Roy Woodhead (2006), Stimulating Innovation in Products and Services with Function Analysis and Mapping, A John Wiley & Sons, Inc.
5. Charles W. Bytheway (2007), FAST Creativity & Innovation, J. Ross Publishing, Inc.
6. SAVE International® CVS® Module II Training material (2014), Function Analysis and Value Index, Society of Korean Value Engineers.
7. J. Jerry Kaufman (1990), Value Engineering for the Practitioner, North Carolina State University.
8. Anita Lukose (2015), Enhancing Creative Phase of the VM Job Plan, SAVE International Value Summit Conference proceedings, 2015.
9. TRIZ Training (2003) by John Terninko, Technical Contradictions & Inventive Principles, Samsung Advanced Institute of Technology

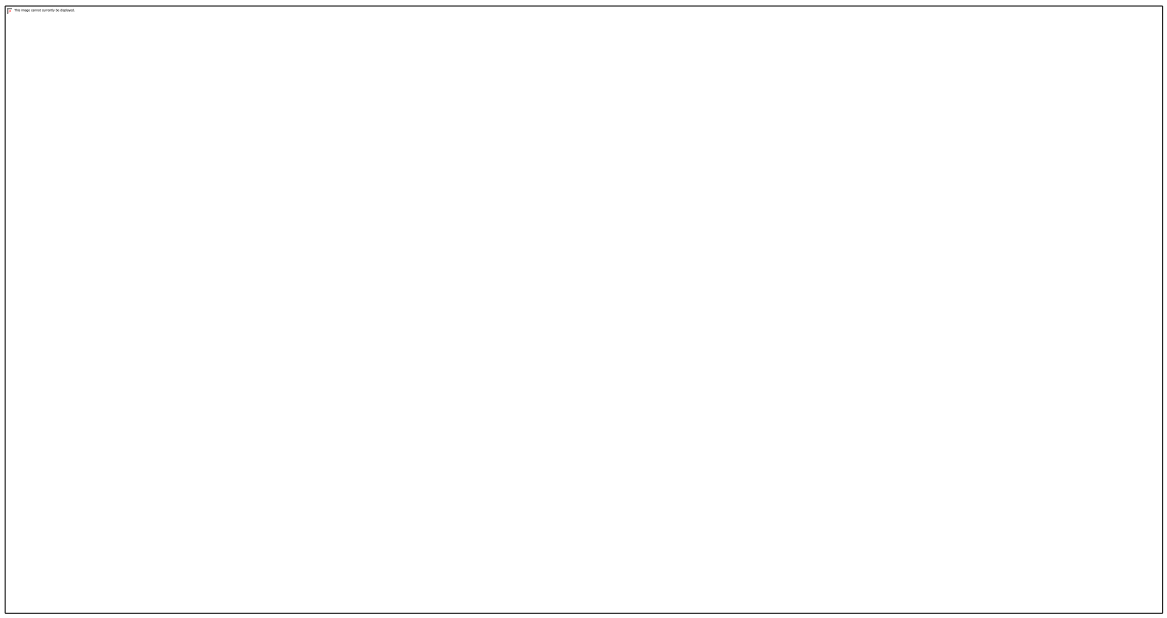
< Attachment 1. Refrigerator Price, Size, and Energy Savings Trends by ASAP [(1)] >



< Attach't 2. Flow Diagram of Analysis for the Energy Conservation Standards Rulemaking Analysis [(2)] >



< Attachment 3. The Heat is On: NIST Zeroes In On Energy Consumption of Ice Makers [3] >



< Attachment 4. Flow Diagram of Inputs for Life-Cycle Cost and Payback Analyses [2] >