APPENDIX 12A. PRELIMINARY ANALYSIS QUESTIONNAIRES

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APPENDIX 12A. PRELIMINARY ANALYSIS QUESTIONNAIRES

12A.1 INTRODUCTION

This appendix contains the questionnaires used during manufacturer interviews during the preliminary analysis. These questionnaires address engineering topics and manufacturer impact topics.

12A.2 PRELIMINARY ANALYSIS ENGINEERING QUESTIONNAIRE

DOE used the preliminary analysis engineering questionnaire as a guide for engineering discussions during manufacturer interviews.

DESIGN FOR ENERGY IMPROVEMENT INFORMATION REQUEST

DOE would like to confirm information on the incremental costs of increasing product efficiency by understanding the design options involved in the efficiency improvement.

Market Share of Products You Sell

To help DOE discover manufacturer subgroups and the relative importance of various product classes to specific manufacturers, please disaggregate your annual unit shipments for each product category as shown below. Please also list the range of Harvest Rate for each product category. Finally, please indicate what percentage of these products are purchased from other manufacturers (*i.e.*, private label), and what percentage of the products are made in the USA. If your products fall under Other Types? of Ice, please indicate the type of ice.

Equipment Type	Harvest Range *lb/day*	Cube	Flake	Nugget	Other Type of Ice
Ice Making Head, Air Cooled					
Ice Making Head, Water Cooled					
Remote Condenser Only					
Remote Condenser and Compressor					
Self-Contained Air-Cooled					
Self-Contained Water-Cooled					

Are there any alternative or hybrid configurations of products (e.g., equipment with dispensing, equipment integrated with soda machines, etc.)? If so, what are the ranges of options and how do they fit into the equipment class structure?

Product Technical Descriptions and Potential for Energy Use Reduction

The following series of exhibits and questions address technical characteristics of key ice maker components for both baseline and improved-efficiency products.

- What is the range of ice quality (as measured by the ASHRAE calorimeter test) typically produced for each type of equipment?
- What design characteristics affect ice quality for a given equipment class? Can ice quality be adjusted for a given machine?

Typical Distribution of Energy Use: Cuber

- What is the typical percent of energy use associated with each key component for energy test conditions?

Component	Typical Percent Energy Use		
	Air-Cooled	Water-Cooled	Remote Condenser
Compressor during icemaking cycle			
Compressor during harvest cycle			
Pump			
Condenser Fan			
Other (Ice Ejection Assist, Controls, etc.)			

Typical Distribution of Energy Use: Flake/Nugget

- What is the typical percent of energy use associated with each key component for energy test conditions?

Component	Typical Percent Energy Use	
	Air-Cooled Flaker	Air-Cooled Nugget Machine
Compressor		
Augur Motor		
Condenser Fan		
Other		

Sequence of Control

- Describe the basic sequence of control for your key product categories.

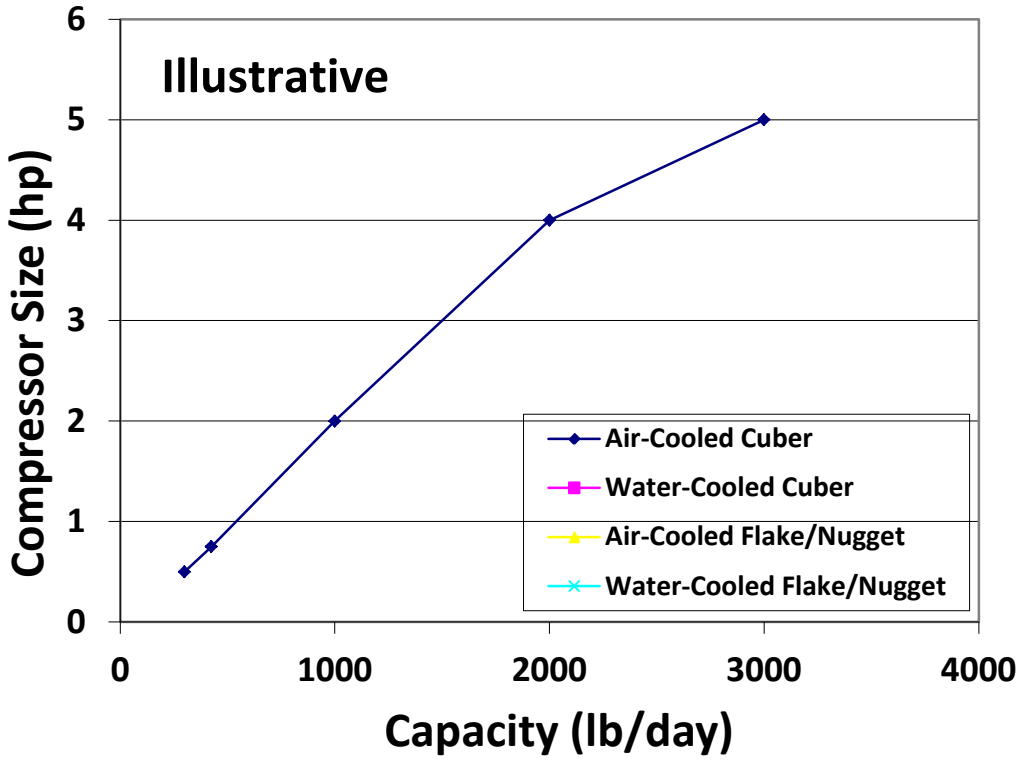
Energy Test vs. Field Use

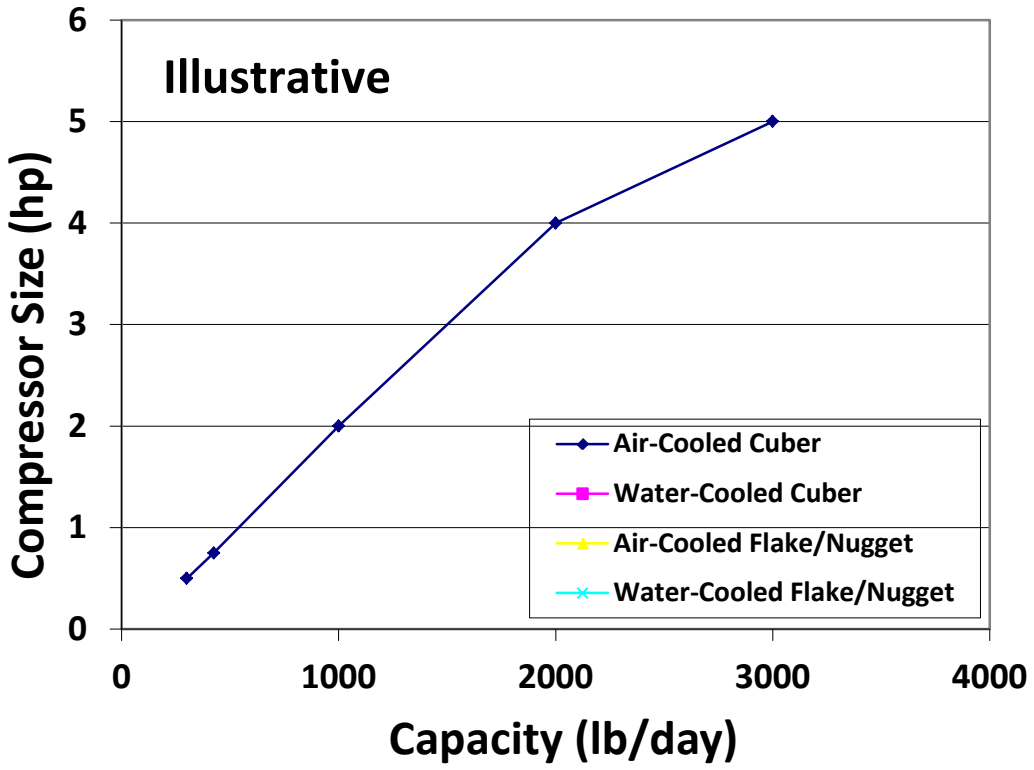
- Are you aware of any data comparing field energy use to energy use for energy test conditions?
- How might adaptive controls impact the energy use in the field compared to the energy use measured in the test procedure?
- What other factors contribute to differences in field energy use as compared to energy use ratings?
- Would there be any simple adjustments in the test procedure that could result in more accurate predictions of field energy use?
- Are there ways to save energy in field use that are not measured by the current energy test?

Compressors

- What types and sizes of compressors are used for different types and capacities of ice makers? Would there be any benefits to using variable speed or dual compressors?
- Generally use medium-back pressure or does this depend on equipment type?
- Generally use hermetic reciprocating compressors? What other types are used?
- Is the compressor hp/ capacity relationship linear? How does it vary with equipment type (cuber vs. flake vs. nugget vs. other type?)
- What is the range of hp representing the transition from single to three-phase designs?
- Are single-phase designs generally medium- or high-starting torque?

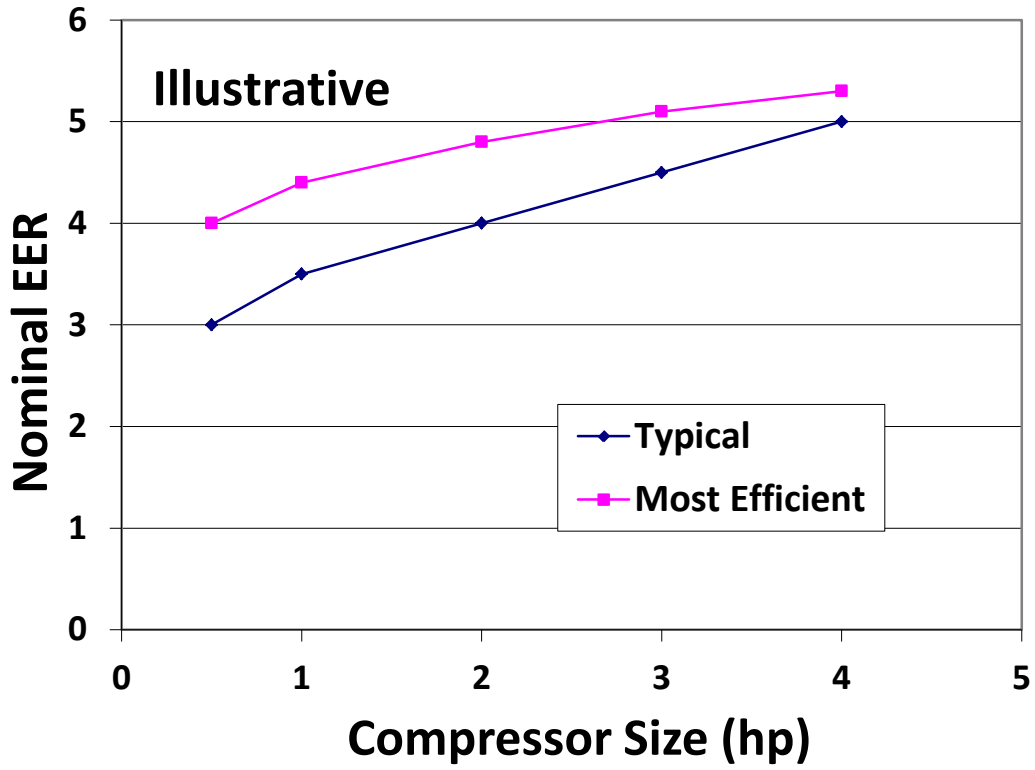
- Are the key compressor vendors Copeland, Tecumseh, and Danfoss? Does your company use any others?
- Are any refrigerants other than R-404A being used in ice makers?





Compressor EER

- What is the basis of nominal EER for the compressors used in icemakers, *i.e.* the evaporating, condensing, superheat, and subcooling temperatures?
- How does the nominal EER of the typical compressors used in ice makers vary with hp?
- How do actual operating conditions differ from the rating conditions?
- Is refrigerant flow control always done using a thermostatic expansion valve? Any use of EEV? What is the typical superheat at the evaporator exit?
- Are suction-line heat exchangers used? If so, how much of the suction gas temperature rise is achieved using such heat exchangers? Do you have rules of thumb for maximum suction temperature to avoid reliability concerns associated with compressor overheating?
- What range of EER is currently being offered by vendors in the relevant hp range? Are the most-efficient compressors generally used in all product sizes?
- What are the costs of typical compressors (as a function of compressor hp), and what are the cost premiums for the highest-available EER?



Cuber Evaporators:

- What are the capacity ranges for the different style ice cubes produced by your company's ice makers?
- Brief description of evaporator designs? Geometry, materials, etc.? Do evaporator tubes use internal enhancement?
- How many distinct evaporator designs does your company produce?
- Regarding the few evaporators/multiple capacities issue (use of a small number of evaporator designs for a wide range of products), what is the typical ratio of maximum capacity to minimum capacity used with the same evaporator design? What is the associated spread of typical operating evaporating temperature during the icemaking cycle as a result of this capacity spread?
- What is the typical range of evaporating temperature at the start and at the end of the icemaking cycle? Do you know what evaporating temperature corresponds to the time that the first ice starts to form on the evaporator surface?
- Do you know how the cooling provided by the refrigeration system breaks out by (a) cooling down water, (b) freezing and subcooling ice that is delivered, (c) freezing and subcooling ice that is subsequently warmed up and/or melted during harvest, (d) evaporator assembly cooldown during icemaking cycle, (e) cooling lost through conduction/infiltration into the evaporator compartment?
- Is there an optimum water circulation rate during the icemaking cycle? Is there a "rule of thumb" for circulation rate as a function of icemaking rate?
- Has your company actively pursued any developments in recent years to improve evaporator performance, to improve heat transfer to the freezing surface during the

icemaking cycle, improve heat transfer and/or focus heat addition to critical locations for harvest, reduce thermal mass, etc.?

Flake/Nugget Evaporators:

- Can you provide a brief description of evaporator designs?
- Is flaker/nugget performance also impacted by the few evaporators/multiple capacities issue? If so, what is the typical ratio of maximum capacity to minimum capacity used with the same evaporator design? What is the associated spread of typical operating evaporating temperature during the icemaking cycle as a result of this capacity spread?
- What is the typical evaporating temperature during operation?
- Has your company actively pursued any developments in recent years to improve evaporator performance?
- Do evaporator tubes use internal enhancement?
- What type of insulation and thickness is used to limit sweating and/or thermal loss?

Condenser Heat Exchanger Characteristics

Air-Cooled

- Does your company use any air-cooled condenser designs other than round copper tube/aluminum fin?
- Please provide descriptions of:
  - Typical fin style, fin thickness, fins per inch?
  - Limitations on fin spacing associated with potential clogging?
  - Internally-enhanced tubes standard? Typical tube OD?
- What consideration is given to the range of ambient conditions? For instance, is optimization for test conditions limited by the need to also be able to operate at much higher or lower ambient conditions?
- How much condenser part sharing vs. optimization by product is done? For example, is there a typical airflow vs. compressor horsepower relationship, or are there a limited number of condenser designs that span the range of ice maker capacities?

Remote Condenser with or without Remote Compressor

- Are remote condensers stock items used for other applications or are they designed specifically for ice makers? If the latter, what makes them different?
- Typical head pressure control? Do any remote condensers engage head pressure control and/or cycle fans in energy test conditions?
- Any possibility of variation in suction line size for remote-compressor units, or are these lines already sized at the limits for safe oil return? Typical pressure drop at the 25-foot line length specified in the test?
- Typical suction line insulation?
- Refrigerant inventory control primarily with liquid receivers at the ice maker? Any potential benefit of locating the receiver at the condenser and using ambient subcooling?

Water-Cooled

- Does your company primarily use coaxial condensers? Primarily steel shell/corrugated copper tube? Any performance limitations associated with available space in ice maker package? Are there possible benefits associated with use of brazed plate condensers?
- What is the typical leaving condenser water temperature at design conditions? Is flexibility in water temperature rise limited by the range of potential cooling water configurations (*i.e.* can't raise temperature more than 10 ˚F because of prevalent use of cooling towers for heat rejection)?
- Head-pressure valve sizing: Typical setting (*i.e.* condensing temperature)? At what entering water temperature would the valve just reach full-open state during the icemaking cycle?
- Any information on prevalence of different cooling water configurations: tap water, well water, cooling tower loop, dry cooler loop, chilled water?
- Rules of thumb for condenser water flow rate? What considerations affect the balance of energy use and condenser water use?

Condenser Fans/Motors

- Typical fan motor hp per compressor hp? Different for air-cooled vs. remote?
- Fan cycles off during harvest for cubers/tube machines?
- Typical motor type: PSC? Typical efficiency level? Open, TEAO, TEFC? Any special requirements for icemaker fan motors?
- Do you use any three-phase motors for condenser fans or are the hp levels too low?
- Is there room for fan blade improvement through use of different blade designs?
- Any room for measurable improvement via improved air flow path design?

Cuber Pumps/Motors

- Typical pump motor hp per compressor hp?
- What types of pumps are used? Centrifugal? What is the pump rpm?
- Are these pumps designed and fabricated specifically for ice makers? What makes them different from other design?
- What is the typical pump efficiency (shaft to water)?
- Typical motor type: PSC? Typical efficiency level? Any special requirements for icemaker pump motors?
- Are these all single-phase motors?

Augur Motors

- Typical augur motor hp per compressor hp? Motor types?
- Typical augur and motor rpm?
- Typical motor type: PSC? Typical efficiency level? Any special requirements for icemaker pump motors?
- Gear drive efficiency?

Cabinet Insulation Characteristics (as applicable)

- What is the typical insulation thickness between the warm and cold portions of the ice maker, and between the cold portion and the exterior? What type of insulation is used?
- Is infiltration an issue?
- Is there any sweating on any external surfaces?
- Are you aware of measurements showing benefits of better insulation performance, *i.e.* by use of thicker insulation?

Refrigerants

- Are there any refrigerants used other than R-404A or R-507?
- Are you aware of any initiatives to move away from HFC refrigerants in ice makers? Are there any alternatives that have been tested in ice makers? What are the efficiency implications?

Electronic Controls and Standby Energy Use

- What is the distribution of ice makers sold with electronic controls?
- What is the range of power consumption for these electronic controls, from standby to peak consumption?

Maintenance

- What are the key maintenance operations recommended and/or actually performed for your key product categories? Recommended frequency? Typically performed by owner/operator or third parties? What is your estimate of the time required by a reasonably well-trained service person to perform such maintenance?
- What maintenance, when performed more frequently, reduces energy use?

Other Technology Options

Reduced Potable Water Use for Cubers

- Have water usage levels been empirically optimized? Based on field data?
- What equipment differences impact the ability to reduce potable water usage?

Drain Water Thermal Recovery

- Do you have any knowledge of testing of systems with drain water thermal recovery?
- Is the key issue in implementation of this option (1) the need to descale heat exchanger surfaces, (2) need for greater product height to accommodate gravity-flow drain water heat exchange, (3) no measurable benefit, (4) not cost-effective, or _____?

Energy Use Reduction

- What do you see as the key opportunities for energy use reduction for the key product categories? Can you share data of products or prototypes that use such technologies?
- What are the achievable max tech levels for key product classes? Are these levels achieved by any commercially available products?

Test Procedures

- What problems do you face in conducting the tests and following the calculations in the DOE test procedure?
- Are there any energy-conserving features of your equipment for which the effects are not appropriately captured by the existing DOE test procedure? If yes, provide details. How might adaptive controls impact energy measurement according to the test procedure?
- Does your company manufacture any equipment which you would have difficulty testing under the current DOE test procedure? If so, please describe the equipment and the aspects of the test procedure that you feel could present difficulties.
- What is the typical or anticipated cost of testing to demonstrate compliance with DOE efficiency standards with the current test procedure? What testing, in addition to testing to show DOE compliance for regulated products, do all or most products typically undergo? How much do these additional tests cost? What is the primary cost associated with testing, i.e. labor, equipment, time? Are the tests conducted in-house or at a third-party lab?
- Are there any concerns with the accuracy or repeatability of the DOE test procedure? Examples of factors that may affect the repeatability of the test procedure results are water hardness, air-cooled condenser inlet temperature, refrigeration line diameter and insulation level, ice quality, or other factors.

12A.3 PRELIMINARY ANALYSIS MANUFACTURING IMPACT QUESTIONNAIRE

DOE used the preliminary analysis manufacturing impact questionnaire to collect preliminary information regarding the potential impact on manufacturers of a new energy standard for automatic commercial ice makers.

PRELIMINARY MANUFACTURER IMPACT ANALYSIS TOPICS FOR AUTOMATIC COMMERCIAL ICE MAKERS

1 Issues

1.1 What are the key issues for your company regarding this product rulemaking?

2 Shipment Projections

2.1 What is your company's approximate market share in each of the product classes?
2.2 Would you expect your market share to change once standards become effective? Does your outlook change with higher efficiency levels?
2.3 How would you expect shipments to change for the industry as a whole as a function of standards, and why?
2.4 Looking at price/cost effects only, how would you expect shipments to change for a 5%, 10%, 25%, or 50% manufacturer price/cost increase?

3 Conversion Costs

3.1 What level of capital expenditure and product conversion costs would you anticipate to make at higher standard levels? Please describe what they are and provide your best estimate of their respective magnitudes.
3.2 How would the imposition of new energy conservation standards affect capacity utilization and manufacturing assets at your domestic production facilities? Would a new standard result in stranded capital assets? Would any facilities be closed or downsized? Added or upgraded?
3.3 How might a new standard impact product innovation?
3.4 At what efficiency levels do you expect to:
- Retire lower-efficiency platforms (and how many)
- Close current manufacturing plants rather than upgrading them to make higher-efficiency automatic commercial ice makers (*e.g.* moving production to new facilities, out-sourcing, or ceasing operations altogether).
- Require the development of a "clean sheet" product platform to meet higher efficiency levels.

3.5 How would manufacturer tax credits for higher efficiency products affect your decisions regarding research and development for highly-efficient automatic commercial ice makers?
3.6 Could manufacturer tax credits influence any of the above manufacturing decisions?

4 Product Mix and Profitability

4.1 How would your company's product mix and marketing strategy change with changes in the efficiency standard?
4.2 Would the current percentage of shipments at the ENERGY STAR level for automatic commercial ice makers be the same under a new standard?
4.3 How would you expect manufacturer tax credits for highly-efficient automatic commercial ice makers to affect your current product mix and profitability?

4.4 What distribution channels are used from the manufacturer to the retail outlet? What is the share of product going through each distribution channel?
4.5 Generally, how would new product standards affect your customer mix, distribution channels, and corresponding profit margins?
4.6 For automatic commercial ice makers, how might a new standard impact the ENERGY STAR program, and consequently your firm?
4.7 What is the approximate percentage of shipments (*i.e.*, market share) for each product, or more specifically, for each product class?

5 Market Shares and Industry Consolidation

5.1 In the absence of new standards, do you expect any industry consolidation?
5.2 How would new standards affect your ability to compete?
5.3 Could new standards disproportionately advance or harm the competitive positions of some firms?
5.4 Do you or any of your competitors own intellectual property that confers a significant cost advantage regarding achieving certain energy efficiency levels?
5.5 Could new standards result in disproportionate economic or performance penalties for particular consumer/user subgroups?
5.6 Beyond price and energy efficiency, could new standards result in products that will be more or less desirable to consumers due to changes in product functionality, utility, or other features?

6 Cumulative Regulatory Burden

6.1 Are there recent or impending regulations on your specific product or other products that impose a cumulative burden on the industry?
6.2 If so, what is the total expected impact of those other regulations in terms of required capital investments, engineering hours spent addressing these issues, and/or product costs?
6.3 Under what circumstances would you be able to coordinate any expenditures related to this and other regulations, thereby lessening the cumulative burden?