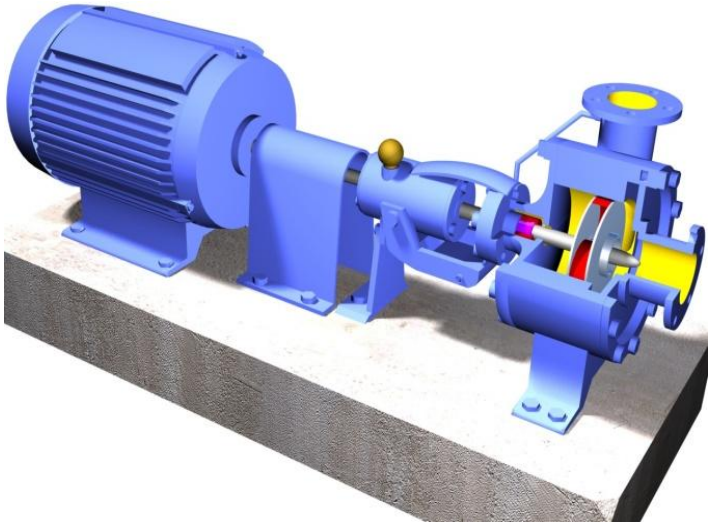
Energy Conservation Standards for Commercial & Industrial Pumps: Framework Public Meeting



U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Charles Llenza
BUILDING TECHNOLOGIES PROGRAM

February 20, 2013

Welcome and Introduction

- Introductions
- Role of the Facilitator
- Ground Rules (Norms)
  - Listen as an ally
  - Use short, succinct statements/keep to the point
  - Hold sidebar conversations outside the room
  - Focus on issues, not personalities
  - One person speak at a time (raise hand to be recognized; state your name for the record)
  - Set cell phones to silent/vibrate
- Housekeeping Items
- Agenda Review
- Opening Remarks

Agenda: Morning

9:00 – 9:05 am	**Welcome**
9:05 – 9:30 am	Opening Remarks, Introductions, and Agenda Review
9:30 – 9:45 am	Rulemaking and Analytical Methodology Overview
9:45 – 10:30 am	Legislative History and Coverage
10:30 – 10:45 am	**Break**
10:45 – 11:45 am	Regulatory Regimes and Metrics
11:45 – 12:00 pm	Test Procedure
12:00 – 1:00 pm	**Break for Lunch**

Agenda: Afternoon

1:00 – 1:30 pm	Market and Technology Assessment, Screening Analysis
1:30 – 2:15 pm	Engineering Analysis, Manufacturer Impact Analysis
2:15 – 2:45 pm	Markups and Energy Use Determination
2:45 – 3:00 pm	**Break**
3:00 – 3:30 pm	Life-Cycle Cost and Payback Period Analysis, Shipments Analysis, National Impact Analysis
3:30 – 3:45 pm	NOPR Analyses
3:45 – 4:00 pm	Other Issues and Comments
4:00 pm	**Closing Remarks**

Opening Remarks

Interested parties who contacted DOE to request an opportunity to issue an opening statement should speak now.

Public Meeting Agenda

1	Introduction
2	Rulemaking Process Overview
3	Legislative History & Coverage
4	Regulatory Regimes & Metrics
5	Test Procedure
6	Rulemaking Analyses
7	Closing Remarks

Introduction

Purpose of the Framework Document Public Meeting

- Present the analytical approaches to be used to evaluate energy conservation standards for commercial and industrial pumps
- Inform interested parties of and facilitate the rulemaking process
- Provide a forum for public discussion of rulemaking issues
- Encourage interested parties to submit data, information, and written comments

Introduction

Request for Comment

<u>Item #-#:</u> DOE solicits comment on a range of specific issues throughout the Framework Document.

- Throughout this presentation, these issues will be highlighted for discussion in comment boxes such as this.
- Item numbers correspond to those in the Framework Document.
- DOE welcomes comments concerning these specific issues and any other issues related to this rulemaking.

Introduction

Instructions for Submitting Comments

- **In all correspondence, please refer to this Commercial and Industrial Pumps Rulemaking by:**
  - Docket # EERE-2011-BT-STD-0031, and/or RIN 1904-AC54
- **Electronic:** Pumps2011STD0031@ee.doe.gov OR www.regulations.gov
- **Postal Mail:** Ms. Brenda Edwards
  U.S. Department of Energy
  Building Technologies Program, Mailstop EE-2J
  1000 Independence Avenue, SW.
  Washington, D.C. 20585-0121
- **Courier:** Ms. Brenda Edwards, 950 L'Enfant Plaza, SW., 6th Floor
- **Phone:** (202) 586-2945

Comment period closes May 2, 2013

Public Meeting Agenda

1. Introduction
2. **Rulemaking Process Overview**
3. Legislative History & Coverage
4. Regulatory Regimes & Metrics
5. Test Procedure
6. Rulemaking Analyses
7. Closing Remarks

Rulemaking Process Overview

Standards Development

- The Energy Policy and Conservation Act (EPCA) of 1975 (Public Law 94-163) established an energy conservation program for certain commercial and industrial equipment.
- This program, set forth in Part C of Title III of EPCA, includes pumps as covered equipment and authorizes DOE to issue standards, test procedures and labeling requirements for them. 42 U.S.C. 6311(1)(A)
- DOE is directed to develop new or amended standards designed to achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified for which DOE's rulemaking process provides the schedule and analyses to do so.

Rulemaking Process Overview

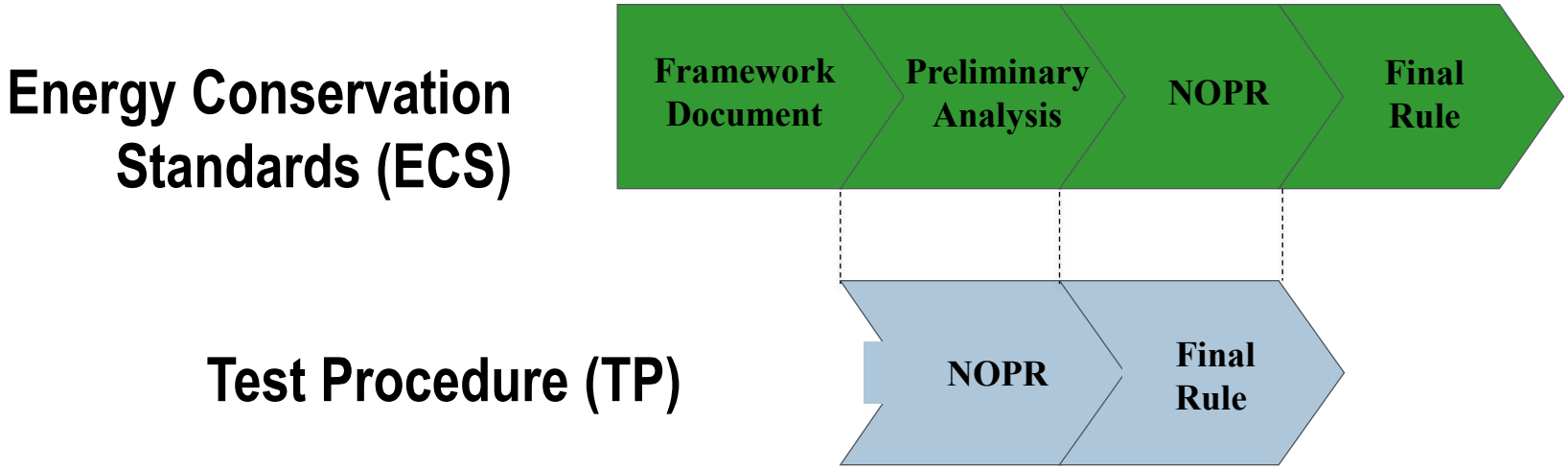
- **EPCA directs DOE to consider seven factors for analysis when setting technologically feasible and economically justifiable standards:**

EPCA Requirement	Corresponding DOE Analyses
1. Economic impact on consumers and manufacturers	• Life-Cycle Cost Analysis • Manufacturer Impact Analysis
2. Lifetime operating cost savings compared to increased equipment cost	• Life-Cycle Cost Analysis
3. Total projected energy savings	• National Impact Analysis
4. Impact on utility or performance	• Engineering Analysis • Screening Analysis
5. Impact of any lessening of competition	• Manufacturer Impact Analysis
6. Need for national energy conservation	• National Impact Analysis
7. Other factors the Secretary considers relevant	• Emissions Analysis • Utility Impact Analysis • Employment Impact Analysis

Source: (42 U.S.C. § 6295(o)(2)(B)(i) and 42 U.S.C. § 6316(a))

Rulemaking Process Overview

Test Procedure and Standard Rulemakings Timelines



- TP and ECS rulemakings are separate processes but have integrated timelines.
- The TP rulemaking timeline duration is about 1.5 years from cradle to grave.
- The ECS rulemaking timeline duration is about 3 years from cradle to grave.
- For additional information on the rulemaking process go to:

http://www1.eere.energy.gov/buildings/appliance_standards/standards_dev_and_revision.html

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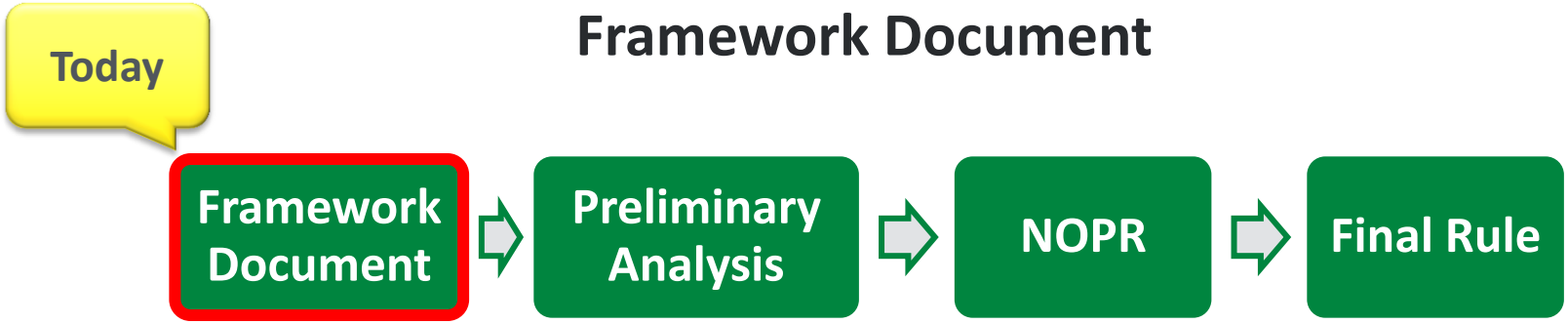
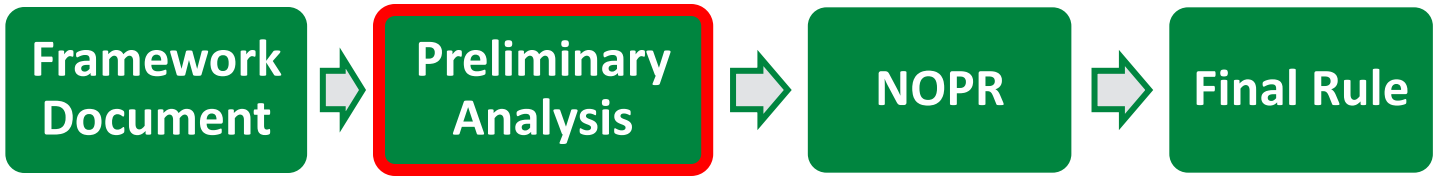
Rulemaking Process Overview



- **Provides an overview of the rulemaking process and encourages early participation from interested parties**
- **Invites comments on proposed approach and issues**
- **Accompanying *Federal Register* Notice of Public Meeting (NOPM) – 78 FR 7304, February 1, 2013**
  - Gives notice of the public meeting and availability of the Framework Document being discussed today
  - Encourages interested parties to submit comments

Rulemaking Process Overview

Preliminary Analysis Document



- **Planned Federal Register Notice and Public Meeting (NOPM) –Summer 2014:**
  - Gives notice of public meeting and availability of the Technical Support Document (TSD)
  - Encourages interested parties to submit comments
- **Analysis:**
  - Design options to increase efficiency (engineering analysis)
  - Manufacturer-to-user markups
  - Energy use
  - Consumer life-cycle cost (LCC) and payback period (PBP)
  - Shipments
  - National impacts (including national energy savings (NES) and consumer net present value (NPV)
  - Preliminary analysis of manufacturer impacts
  - Discussion of comments received in response to the framework document

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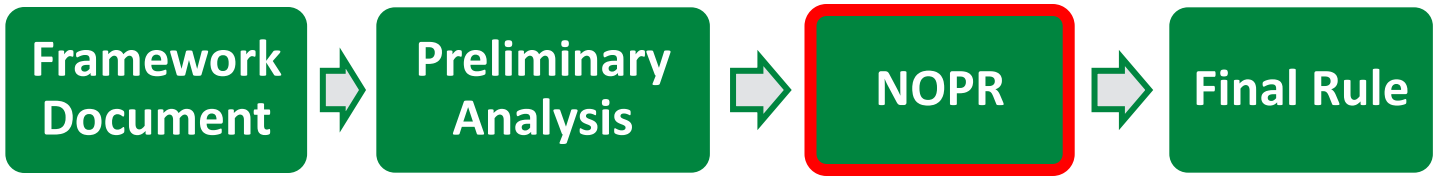
Rulemaking Process Overview

NOPR Document



- **Discussion of comments received in response to Preliminary Analysis TSD**
- **Analysis of the impacts of potential standards on consumers, manufacturers, and the Nation and weighting of these impacts**
- **Proposed standard levels for public comment**
- **Accompanying *Federal Register* Notice of Public Meeting (NOPM) – Planned Summer 2015**
  - Gives notice of the public meeting and availability of the revised Technical Support Document (TSD)
  - Encourages interested parties to submit comments

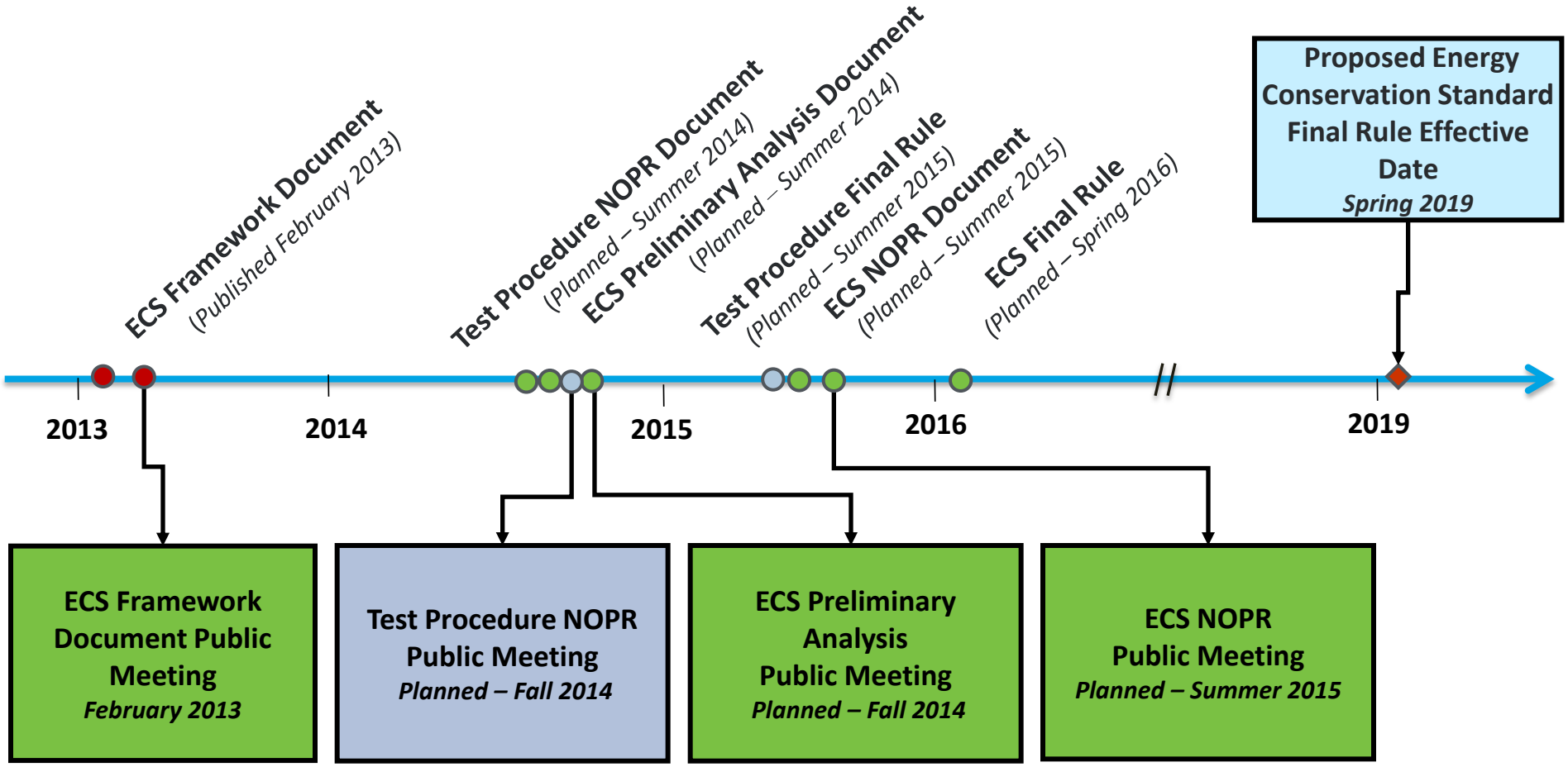
Rulemaking Process Overview

Final Rule Publication

- **Discuss comments received in response to the NOPR**
  - DOE will consider all written & verbal input in preparing the final rule.
- **Revise analysis of the impacts of standards & weighting of these impacts of the final rule**
- **Determine the standard levels DOE will adopt**
- **Establish the compliance date for the adopted standards**
- **Accompanying *Federal Register Notice* – Planned Spring 2016**

Rulemaking Process Overview

Commercial & Industrial Pumps Rulemaking Schedule



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Public Meeting Agenda

1. Introduction
2. Rulemaking Process Overview
3. Legislative History & Coverage
4. Regulatory Regimes & Metrics
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6. Rulemaking Analyses
7. Closing Remarks

Legislative History and Coverage

Authority and Background

- **Currently no energy conservation standards for commercial and industrial pumps**
- **The Energy Policy and Conservation Act (EPCA) of 1975 (Public Law 94-163) established an energy conservation program for certain commercial and industrial equipment.**
  - This program, set forth in Part C of Title III of EPCA, includes pumps as covered equipment and authorizes DOE to issue standards, test procedures and labeling requirements for them. (42 U.S.C. 6311(1)(A)).
- **DOE issued a Request for Information (RFI) on June 13, 2011 (76 FR 34192) and received comments from stakeholders.**

Legislative History and Coverage

Authority and Background (cont.)

- **In December 2011, the Appliance Standards Awareness Project and the Hydraulic Institute notified DOE that efficiency advocates and pump manufacturers had initiated discussions regarding potential energy conservation standards for commercial and industrial pumps.**
- **Letters to DOE and an Ex Parte Meeting Memo are available in the docket at www.regulations.gov.**
- **DOE published a Federal Register Notice and Public Meeting (NOPM) – 78 FR 7304, February 1, 2013 -**
  - Some aspects of the stakeholder proposals are referenced in the Framework Document and this presentation.

Legislative History and Coverage

Pumps for Which DOE is Considering Standards

- **Clean Water Pumps**
  - Consistent with the EU regulation and stakeholder agreement
  - DOE may define "clean water" as in the EU or "pumps designed for clean water."
    - The latter might be based on metallurgy, sealing/sealless technology, impeller type, replaceable wear plates, barrel casing, and center-line support.

Not Considering Covering	Possibly Considering Covering
Wastewater, Sump, Slurry, Solids Handling	ANSI Chemical Pumps
API 610 Pumps	Pumps for other liquids with no solids that behave similarly to water

- **Rotodynamic (Clean Water) Pumps**
  - Consistent with the EU regulation and stakeholder agreement
  - Represent 70% of sales by value and 90% of pump energy use
  - Not considering positive displacement pumps at this time

Legislative History and Coverage

Pumps for Which DOE is Considering Standards

Request for Comment

<u>Item 1-1:</u> DOE seeks comment on its proposal to cover only clean water pumps in this rulemaking.

<u>Item 1-2:</u> DOE requests comment on whether it should rely on a definition of 'clean water' to determine coverage of pumps, as in the EU, or if, instead, the definition of 'clean water pumps' should include physical characteristics that distinguish pumps designed for clean water or exclude pumps designed for other purposes.

<u>Item 1-3</u>: DOE seeks comment on the list of physical differences that may exist between pumps designed for clean water and pumps designed for other substances. Specifically, (1) is the list accurate and exhaustive, (2) do the differences impact efficiency, and (3) do the differences have increased cost?

Legislative History and Coverage

Pumps for Which DOE is Considering Standards

Request for Comment
<u>Item 1-4:</u> DOE seeks comment on whether it should consider standards for pumps designed for non-water liquids that contain limited solids in this rulemaking. DOE is specifically interested in ANSI chemical process pumps, API 610 pumps, sealless (magnetic drive, canned, or cantilever) pumps, sanitary pumps, refrigerant pumps , and general industrial pumps. When suggesting pump types for which standards should not be considered, please be specific as to the reason why. **<u>Item 1-5:</u> DOE requests comment on whether any design changes made to standard clean water pumps would carry through to pumps designed for other applications.**

Legislative History and Coverage

Pumps for Which DOE is Considering Standards

Request for Comment
<u>Item 1-6:</u> DOE seeks comment on its proposal to consider standards for rotodynamic pumps and not positive displacement pumps. In particular, DOE requests comment on the extent of the overlap between rotodynamic and positive displacement pumps and whether there are certain categories of rotodynamic pumps (pump types and ranges of flow and specific speed) for which positive displacement pumps could be a direct replacement.

Legislative History and Coverage

Pumps for Which DOE is Considering Standards

Pump Type	Sub-Type	Stages	DOE Coverage Proposal and Terminology	EU Coverage/ Stakeholder Proposal
End Suction	Close Coupled	Single	**End Suction Close Coupled (ESCC)**	Covered
		Two		
	Own Bearings/ Frame Mounted	Single	**End Suction Frame Mounted (ESFM)**	Covered
		Two		
In-Line		Single	**In-Line (IL)**	Covered
		Two		
Axial Split		Single	**Double Suction (DS)**	Not Covered
		Multi	**Axially Split Multi-Stage (AS)**	Not Covered
Radial Split		Single		
		Multi	**Radially Split Multi-Stage (RS)**	Partial (vertical in-line)
Vertical Turbine	Non-Submersible	Any	**Vertical Turbine (VT)**	Not Covered
	Submersible	Any	**Submersible (VT-S)**	Partial (> 1 stage)
Axial/Propeller and Mixed Flow		Any	**Axial/Propeller and Mixed (A-M)**	Not Covered
Regenerative Turbine		Any		
Pitot		Any		

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Legislative History and Coverage

Pumps for Which DOE is Considering Standards

Request for Comment
Item 1-7: DOE seeks comment on its proposal to consider standards for pumps not covered in the EU. **Item 1-8**: DOE seeks comment on its development of pump equipment categories and whether these categories provide an appropriate basis for developing equipment classes. (See section 3.2.) **Item 1-9**: DOE seeks comment on whether standards for any additional pump categories should be considered. In particular, DOE is interested in pump categories that may have significant potential for energy savings.

Legislative History and Coverage

Pumps for Which DOE is Considering Standards

Request for Comment

<u>Item 1-10</u>: DOE seeks comment on the pump types as described by ANSI/HI nomenclature that fall into the equipment categories set forth in Table 1.1 (Slide 28). For example, pump type OH1 would be classified as an end suction frame mounted pump. For ANSI/HI pump types that would not fall into the categories in Table 1.1, please provide a specific reason, such as "solids-handling only."

<u>Item 1-11</u>: DOE seeks comment on whether wet-running circulator-type pumps should be covered in this rulemaking.

<u>Item 1-12</u>: DOE seeks comment on the market size for wet-running circulators in the United States, including the split between commercial and residential applications in terms of physical size or other features, as well as the potential for growth of the market for circulators in commercial applications.

Legislative History and Coverage

Parameters for Potential Energy Conservation Standards

- **DOE is considering excluding self-priming pumps and pumps designed for fire-fighting applications.**
  - DOE does not consider vertical turbine pumps to be self-priming.

Request for Comment
<u>Item 1-15</u>: DOE requests comment on the technical features and applications for fire-fighting pumps and self-priming pumps that would allow it to determine whether these pumps should be covered.

- **DOE is not considering adopting other coverage parameters except to exempt certain pumps from standards for specific reasons.**

Legislative History and Coverage

Parameters for Potential Energy Conservation Standards

- **Stakeholder Coverage Parameter Proposal*:**
  - 25 gpm and greater
  - 295 feet of head maximum
  - 1-200 horsepower
  - Temperature range from -10 to 120 degrees C
  - Meant to generally align with EU scope (although it is different)
- **DOE estimates of pumps excluded by these parameters:**

Pump Category	Percent Excluded	
	Model Availability	Shipments (Units)
End Suction Close Coupled (ESCC)	43%	71%
End Suction Frame Mounted (ESFM)	41%	34%
In-Line (IL)	43%	47%
Double Suction (DS)	58%	32%
Axially Split Multi-Stage (AS)	80%	86%
Radially Split Multi-Stage (RS)	87%	49%
Vertical Turbine (VT)	49%	43%
Submersible (VT-S)	54%	42%
Axial/Propeller and Mixed (A-M)	36%	40%
Total	**48%**	**68%**

*Material available in docket from DOE meeting 5/1/12.

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Legislative History and Coverage

Parameters for Potential Standards

Request for Comment

Item 1-13: DOE requests comment on which parameters, if any, should be added to this rulemaking. For each parameter proposed, please include the rationale and the type of pump that the parameter is designed to exclude from standards. Comments may address those translated from the EU or those proposed by stakeholders, but do not have to be limited to those proposals. DOE especially seeks comments on parameters that should be added to exclude pumps used primarily in residential applications. DOE also seeks comment on whether, if using power as a coverage parameter, hydraulic power would be more appropriate than shaft power.

Item 1-14: DOE requests comments on the estimates of pumps that would be excluded based on the stakeholders' proposed parameters.

Legislative History and Coverage

Proposed Pump Definitions

- **Currently there are no statutory definitions for pumps.**
  - Definitions have been discussed in the Framework Document.
- ***DOE Proposed Definitions –***
  - ***Pump:*** A device that moves liquid by physical or mechanical action.
  - ***Rotodynamic water pump*:** A pump that moves clean water by means of hydrodynamic forces, excluding regenerative turbine pumps.
  - ***End suction water pump*:** A single-stage rotodynamic water pump in which the liquid enters from the end, opposite the pump's shaft-end and parallel with the shaft, and the discharge is at a right angle from the shaft.
  - ***End suction frame mounted water pump:*** An end suction rotodynamic water pump with its own bearings; such a pump does not rely on the motor bearings to support the impeller.
  - ***End suction close coupled water pump:*** An end suction rotodynamic water pump in which the motor shaft is extended to become also the pump shaft.

Proposed Pump Definitions

- ***DOE Proposed Definitions (cont.) –***
  - ***In-line water pump:*** A single-stage rotodynamic water pump in which the water inlet of the pump is on the same axis as the water outlet of the pump; such pumps are generally installed with the shaft oriented vertically and the motor on top.
  - ***Radially split multi-stage water pump***: A rotodynamic water pump with two or more stages in a radially split case. Flow proceeds from the inlet through the stages in series, with each stage increasing the total head. The flow rate is the same through each stage.
  - ***Submersible water pump:*** A rotodynamic water pump with one or more stages designed to be operated in a borehole with the motor fully submerged in the pumped water; such pumps are generally vertical turbine pumps with submersible motors mounted to the bottom.
  - ***Double suction water pump:*** An axially split single-stage rotodynamic water pump with two inlets.

Proposed Pump Definitions

- ***DOE Proposed Definitions (cont.) –***
  - ***Axially split multi-stage water pump:*** A rotodynamic water pump with two or more stages in an axially split case that is generally oriented horizontally.
  - ***Vertical turbine water pump (non-submersible):*** A rotodynamic water pump in which liquid enters the lower end through the suction bell and then passes through one or more stages with impellers and diffuser cases called bowls; these pumps are narrow in diameter as a result of their origin as deep-well pumps, and the diffuser bowls are in-line with the impellers rather than outside them; above the column section, the pump supports a vertical motor located above the pumped water.
  - ***Axial/propeller and mixed flow water pump:*** A rotodynamic water pump with an impeller(s) that develops head (pressure) through axial or close to axial forces or a mix of axial and radial forces, with the characteristic of relatively high rotational speed and flow relative to head or intermediate flow and head.

Legislative History and Coverage

Proposed Pump Definitions

Request for Comment
<u>Item 1-23:</u> DOE requests comment on the suggested definitions for pumps. **<u>Item 1-24:</u> DOE requests input on whether the definitions proposed by DOE are sufficient to allow manufacturers to determine whether their pumps are covered, and in which pump category their equipment falls.** **<u>Item 1-25:</u> DOE requests comment on what minimum specific speed should demarcate the axial/propeller and mixed flow water pump.**

Legislative History and Coverage

Proposed Pump Definitions

Request for Comment

<u>Item 1-26:</u> DOE requests comment on the definition of 'clean water'. DOE specifically requests input on the translation of wording and units to those typically used in the United States, such as parts per million limits for suspended and dissolved solids. DOE also seeks comment on the appropriateness of the proposed limits. DOE requests clarification on whether mixtures including water with freezing points above -10°C should be considered clean water for the purposes of this definition and rulemaking.

<u>Item 1-27:</u> DOE requests comment on whether maximum solids diameter, which is a parameter provided with many pump curves, could be used in the definition of 'clean water'.

Public Meeting Agenda

1	Introduction
2	Rulemaking Process Overview
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5	Test Procedure
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7	Closing Remarks

Regulatory Regimes and Metrics

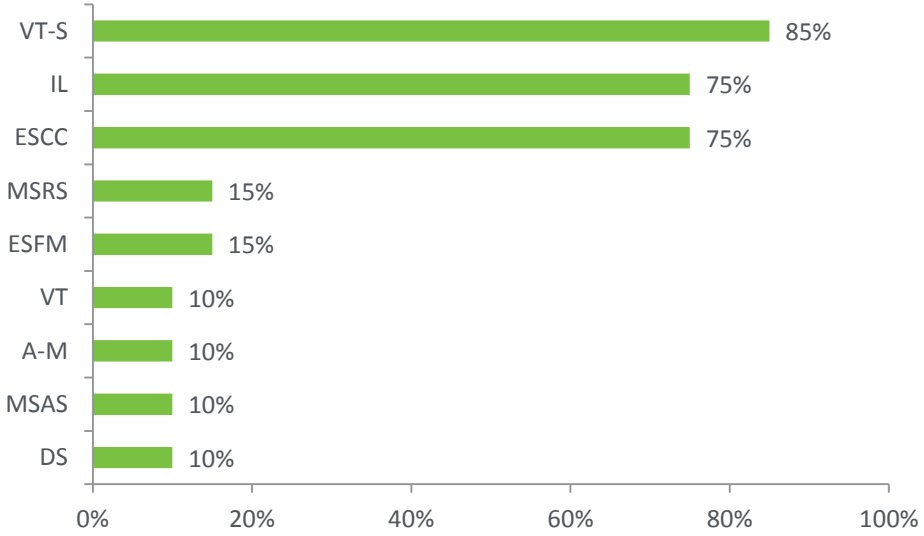
Pumping System

- **The EU has been exploring an approach to address the pump, inclusive of the motor and controls.**
  - The stakeholders have expressed an interest in this approach.
- **Variable Speed Drives (VSDs) are control devices that can address some system inefficiencies.**
  - Savings are found primarily in variable load applications.
    - Dependent on time spent at various operating conditions
    - VSDs under constant load operation may degrade efficiency.
  - The same pumps can be used in both constant and variable load applications.
    - DOE is not aware of any specific pump type that is always used in an application that would benefit from a VSD.
- **Manufacturers cannot control if or how a VSD is used.**
  - DOE will conduct analyses across the full spectrum of pump applications and baseline conditions to determine in which cases VSDs save energy in the field.

Regulatory Regimes and Metrics

Pumping System

- **Most pump types are generally sold without motors:**



  - However, ESCC pumps (generally sold with motors) have the highest shipments

- **DOE estimates that only 2% of clean water pumps are sold with VSDs by pump manufacturers**
  - The percentage may be higher in some application categories such as circulators or city water pressure booster pumps.

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Regulatory Regimes and Metrics

Pumping System

Request for Comment

<u>Item 1-16:</u> DOE requests data on how pumps are sold by pump manufacturers. Specifically DOE requests data on market share of pumps 1) sold by themselves, 2) sold attached to or integrated with motors only, 3) sold attached to or integrated with both motors and VSDs, 4) sold physically separate from but priced together with a motor only, or 5) sold physically separate from but priced together with both a motor and VSD. DOE seeks these data by size, equipment category (see section 3.2), and application.

<u>Item 1-17:</u> DOE requests data and information on whether pumps are more often combined with motors, VSDs, or both by the pump manufacturer or by distributors.

Regulatory Regimes and Metrics

Pumping System

Request for Comment

<u>Item 1-18:</u> DOE requests information on how often and in what circumstances the intended application of the pump is known when the pump is sold.

<u>Item 1-19:</u> DOE understands that VSDs are not very effective without system feedback. DOE seeks comment on the need for considering feedback in any definition for pumps that includes motors and/or controls.

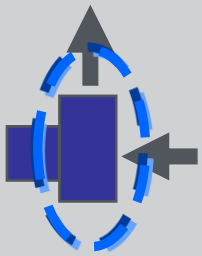
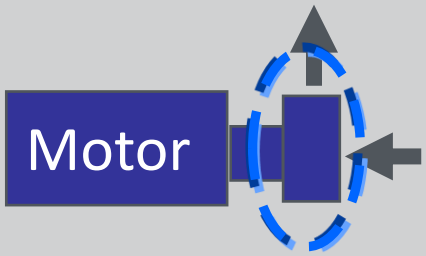
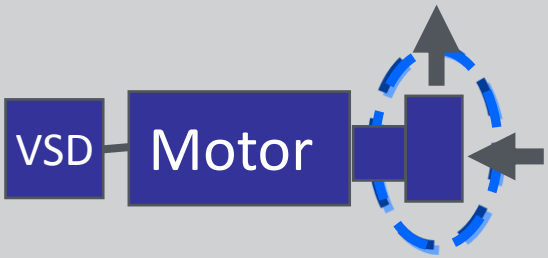
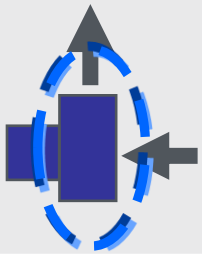
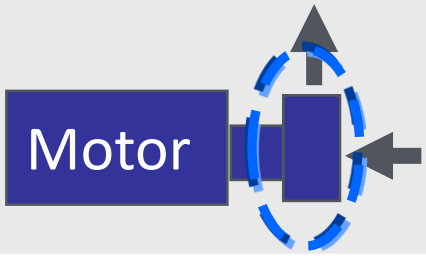
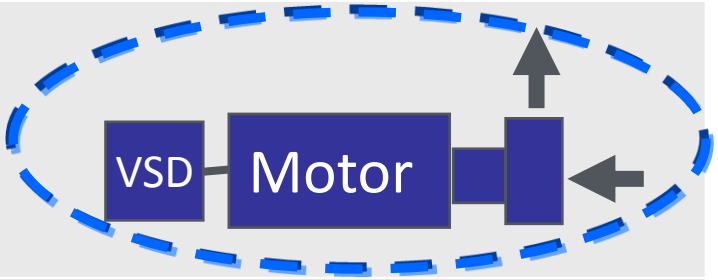
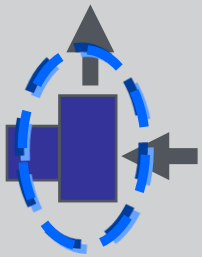
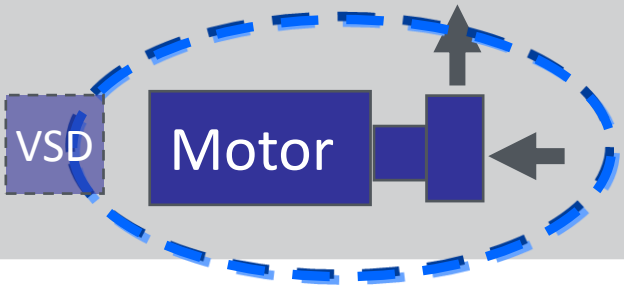
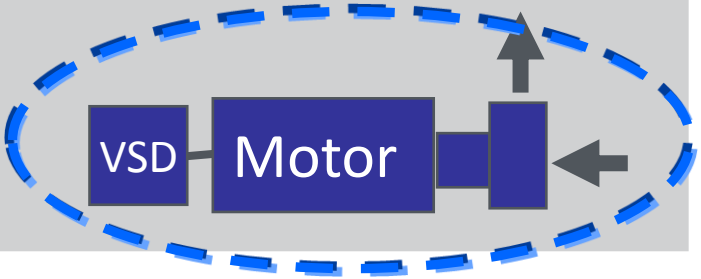
Regulatory Regimes and Metrics

Pumping System – Regulatory Regimes Under Consideration by DOE

- **Pumps Alone**
  - ***Regulatory Regime #1:*** one equipment class set
    - DOE is considering standards for all pump types exclusive of the motor regardless of how they are sold
  - Consistent with current EU approach for clean water pumps
- **Combined Pump Equipment**
  - ***Regulatory Regime #2:*** two equipment class sets
    - Pump without VSD (with or without motor)
    - Pump with VSD
  - ***Regulatory Regime #3:*** two equipment class sets
    - Pump without motor
    - Pump with motor (with or without VSD); VSD is a design option to increase efficiency
- **DOE notes that in regimes 2 and 3, the same pump model may be placed in two equipment classes if it is sold both alone and with a motor (or motor and VSD).**

Regulatory Regimes and Metrics

Pumping System - Regulatory Regimes

	Pump Sold Alone	Pump Sold with Motor	Pump Sold with VSD
1			
2			
3			

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Regulatory Regimes and Metrics

Pumping System

Request for Comment

<u>Item 1-20:</u> DOE requests comment on the benefits and drawbacks of the regimes presented above. For regimes 2 and 3, DOE seeks comment on whether these regimes could increase the beneficial use of VSDs in the field, and whether these regimes could result in the use of a VSD in an application for which it is not suited.

<u>Item 1-21:</u> DOE seeks comment on the market share of pumps by category that would be used in applications that would benefit from VSDs, as well as those where use of a VSD could result in increased energy use.

Regulatory Regimes and Metrics

Pumping System

- **Approximately 10% of pumps DOE is considering may be driven by natural gas or diesel engines or steam turbines.**
- **For pumps sold with an engine or for use with an engine, DOE is considering regulating pumps as sold alone regardless of the regulatory regime chosen.**

Request for Comment

<u>Item 1-22</u>: DOE seeks comment on the market share and applications of pumps by category driven by equipment other than an electric motor.

Regulatory Regimes and Metrics

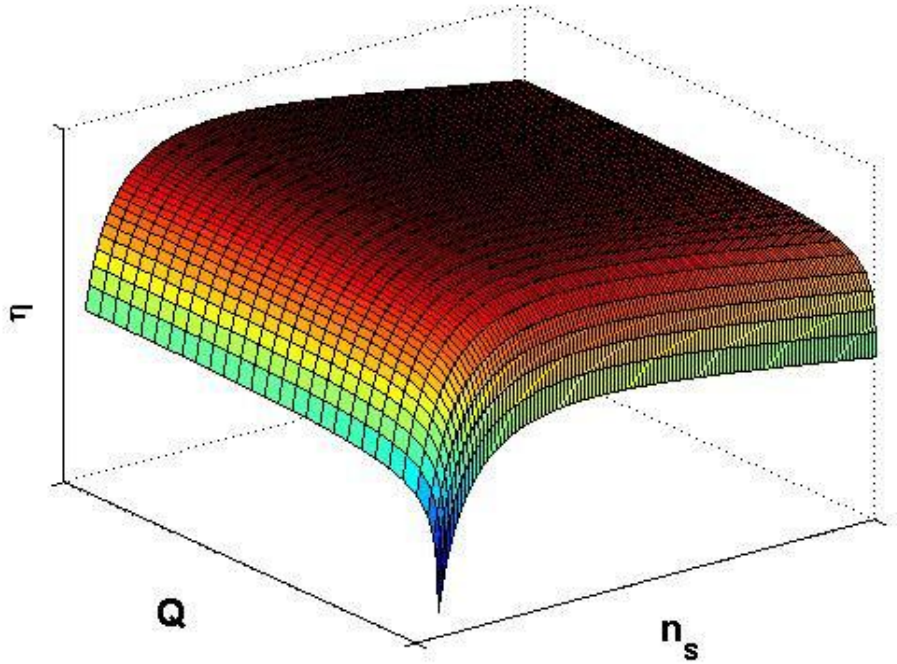
Efficiency Metrics - Existing

- **Pump Efficiency:** The ratio of hydraulic power to shaft input power
  - EU clean water pump regulation and clean water pump selection guide
  - HI 20.3-2010 Rotodynamic Pump Efficiency Prediction
  - Mexico (vertical turbine pumps), South Korea, China
- **Overall (Wire to Water) Efficiency:** The ratio of hydraulic power to the electric power input at the motor and/or the VSD
  - Used in Mexico for submersible pumps
- **EEI:** Energy efficiency index based on average hydraulic power and a reference power
  - Used in EU circulator regulation
- **Bowl Efficiency:** The ratio of hydraulic power output from the bowl to the power input to the bowl
  - Considered in HI 14.6-2011 for vertically suspended pumps

Regulatory Regimes and Metrics

Efficiency Metric – EU Approach

- **Minimum pump efficiency is based on an equation taking into account flow (Q), specific speed (Ns), pump type, and rotating speed (N).**
  - Ns also incorporates head.
- **Result is a 3D surface, described as a function of Q and Ns.**
  - The EU raises or lowers the surface to cut-off a certain percentage of the market for a given pump equipment class and design speed.



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Regulatory Regimes and Metrics

Efficiency Metric – EU Approach

- **Pump efficiency at BEP, 75% BEP flow (part-load), and 110% BEP flow (over-load)**
  - Standard at 75% is 0.947 of standard at BEP
  - Standard at 110% is 0.985 of standard at BEP
  - Must pass all three points to meet standard
- **Standard and testing based on pumps with a full impeller**
- **For vertical multi-stage water pumps, standard and testing based on 3 stage version; For submersible multi-stage water pumps, based on 9 stage version**

Regulatory Regimes and Metrics

Efficiency Metric – DOE Considerations

- **<u>Pumps sold alone (or all pumps if not considering motor and controls):</u> DOE is considering following the EU approach with pump efficiency at BEP, 75% BEP, and 110% BEP**
  - DOE may consider overall (wire-to-water) efficiency for submersible pumps or bowl efficiency for vertical turbine and submersible pumps

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Regulatory Regimes and Metrics

Efficiency Metric – DOE Considerations

- **<u>Pumps inclusive of motor and/or controls</u>: The metric needs to reflect energy efficiency increases not captured in pump efficiency.**
  - <u>For pumps sold with motors and VSDs (regime 2)</u>, DOE is considering a metric that can be used to account for the use of more efficient VSDs.
    - Possibly overall (wire-to-water) efficiency at the same three points
  - <u>For pumps sold with motors (regime 3)</u>, DOE must identify a metric that can capture the impacts on energy efficiency associated with the use of a VSD in comparison to a pump with a motor but without a VSD.
    - Possibly based on motor/control input power ,such as input power per unit flow or ratio of input power at part-load to input-power at full load in a non-VSD condition, also using multiple load points

Regulatory Regimes and Metrics

Efficiency Metric – DOE Considerations

- **If DOE pursues regime 2 or regime 3, two sets of equipment classes will be developed.**

- **DOE is considering the following three efficiency metric options:**
  - Different metrics, one for each set of equipment classes [Separate]
  - Single, uniform metric for all equipment classes [Same]
  - Single efficiency metric for pump-only equipment and multiple metrics for pump-motor or pump-motor-VSD equipment [Multiple]

Regulatory Regimes and Metrics

Efficiency Metric – DOE Considerations

Regulatory Regime		Equipment Class Set	Metric Options		
			Separate	**Same**	**Multiple**
2	Pumps inclusive of motor and VSD	Pumps Without VSD (with or without motor)	Pump Efficiency	Overall Efficiency (standardized motor)	Pump Efficiency
		Pumps With VSD	Overall Efficiency	Overall Efficiency	Pump Efficiency and Overall Efficiency
3	Pumps inclusive of motor	Pumps Without Motor	Pump Efficiency	Electric Input Power Based (standardized motor)	Pump Efficiency
		Pumps With Motor (with or without VSD)	Electric Input Power Based	Electric Input Power Based	Pump Efficiency and Electric Input Power Based Metric

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Regulatory Regimes and Metrics

Efficiency Metric – DOE Considerations

- **The metric options may impact manufacturer burden.**

- **A pump sold both with and without a motor (or VSD) could placed into two equipment classes.**

- **DOE believes that the same test stand could be used, but some metrics or metric alignment options may require additional measurements or calculations such as:**
  - Shaft input power and electric input power
  - Multiply pump efficiency by standard motor and VSD efficiency

Regulatory Regimes and Metrics

Efficiency Metric – DOE Considerations

Request for Comment

<u>Item 1-28:</u> DOE requests comment on its proposal to follow the EU approach using pump efficiency if pumps are defined without the motor or controls. DOE is especially interested in whether a pump should have to meet a standard at multiple load points, or if a weighted average metric should be developed.

<u>Item 1-29:</u> DOE requests comment on the selection of 75% BEP flow as the part-load point and 110% as the overload point and whether these are the most appropriate points to encourage broad pump efficiency curves.

<u>Item 1-30:</u> DOE requests comment on whether the use of an overall efficiency metric for submersible pumps would cause problems for manufacturers, as the EU metric is pump efficiency.

<u>Item 1-31:</u> DOE requests comment on whether the metric for vertically suspended pumps should be bowl efficiency rather than pump efficiency.

Efficiency Metric – DOE Considerations

Request for Comment

<u>Item 1-32:</u> DOE requests comment on its proposal to adapt the EU standard metric to overall efficiency for pumps sold with both motors and VSDs. DOE is also interested in whether additional test points should be added below 75% of BEP flow to address more of the operating range of pumps with VSDs.

<u>Item 1-33:</u> DOE requests comment on the appropriate metric to capture the energy efficiency impacts of VSDs. DOE is interested in whether test points at BEP, 75% BEP flow, and 110% BEP flow are appropriate for this metric and whether additional test points should be added below 75% BEP flow to address more of the operating range of pumps with VSDs. DOE is also interested in whether pumps should be required to meet minimum levels at multiple points or if a weighted average metric should be developed.

Regulatory Regimes and Metrics

Efficiency Metric – DOE Considerations

Request for Comment
<u>Item 1-35:</u> DOE recognizes that the same pump may in some cases be sold alone or may be sold in conjunction with a motor or motor/control package. DOE seeks comment on any issues that may result from having different metrics for pumps sold alone and pumps sold with motors or VSDs.

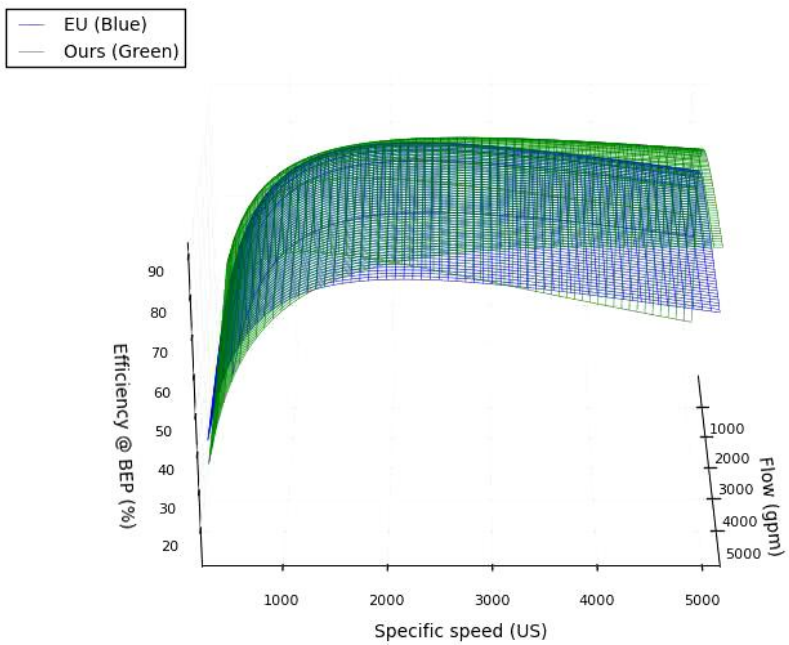
Efficiency Metric - Potential Implementation Method

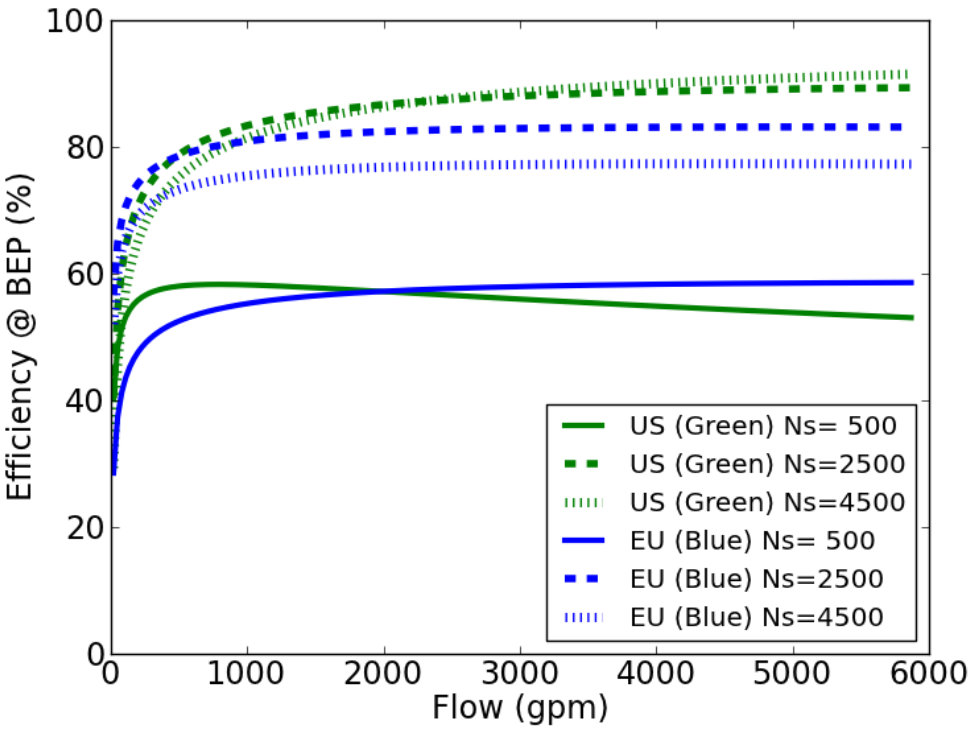
- **Efficiency Surfaces**
  - DOE is considering whether any standard would be a function of specific speed and flow, as in the EU water pumps regulation.
  - DOE expects to adapt the EU approach to the US market.
    - Initial analysis indicates that the distribution of efficiency in the US pump market is different from that in the EU.
  - DOE could use the EU equation but change the C value (same surface at a different vertical position).
  - DOE could use the EU equation form but change coefficients (different surface).
    - Unique to individual equipment classes
    - Change surface shape from bottom- to top-of-market
- **The data presented are based on clean water ESCC pump models extracted from PUMP-FLO™ Desktop.**

Regulatory Regimes and Metrics

Efficiency Metric - Potential Implementation Method

- **Comparison of EU MEI 50 surface to US average surface**





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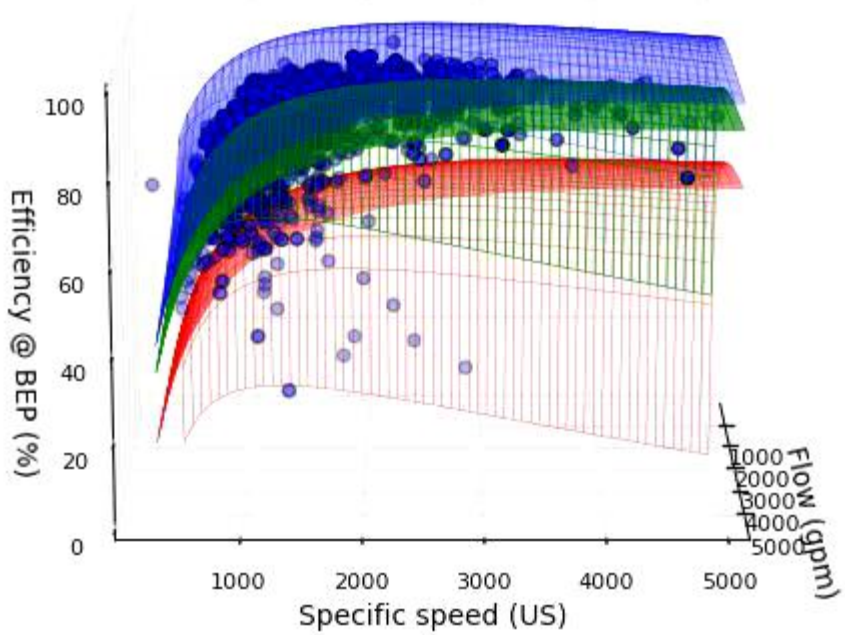
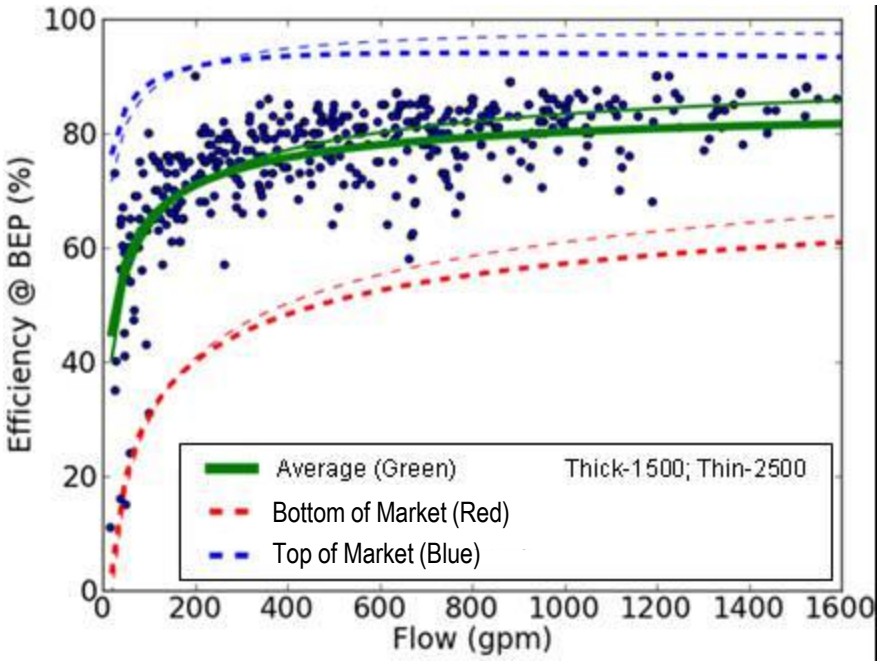
Regulatory Regimes and Metrics

Efficiency Metric - Potential Implementation Method

- **Average, top-of-market, and bottom-of-market surfaces for US ESCC pumps (demonstrating range of efficiencies)**





Average (Green) Bottom of Market (Red) Top of Market (Blue)

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Efficiency Metric - Potential Implementation Method

Request for Comment

<u>Item 1-36:</u> DOE seeks comment regarding the implementation methodology described in this section, including whether basing efficiency on flow and specific speed is appropriate and, if so, whether the EU surface should be used as is, with adjusted Cs, or with modified shapes (adjustment of all coefficients). The last option would allow type- and efficiency level-specific surfaces. DOE also seeks comment on whether other parameters or combinations of parameters would be more appropriate or easier to implement, such as flow and head (instead of specific speed).

Regulatory Regimes and Metrics

Efficiency Metric - Potential Implementation Method

Request for Comment

<u>Item 1-37:</u> DOE requests data that would help it improve its database, specifically performance data (i.e., head, flow, power, and efficiency at BEP and multiple additional points) for clean water pumps from catalogs not available on PUMP-FLO.

<u>Item 1-38:</u> DOE seeks comment on how to calculate specific speed (with regard to flow) for double suction axial split pumps and axially split multi-stage pumps with a double-suction first stage (i.e., whether to use total flow ore one-half the flow).

<u>Item 1-39:</u> DOE seeks test data for pumps at 75% and 110% BEP flow points that would allow it to better analyze potential efficiency levels for these points.

Regulatory Regimes and Metrics

Efficiency Metric - Potential Implementation Method

- **Testing based on three stages for radially split multi-stage pumps and nine stages for submersible pumps**
  - Axially split multi-stage pumps may have to be tested as sold (not cellular).
- **Standard based on full impeller**

Request for Comment

<u>Item 1-40:</u> DOE requests comment on the appropriateness of setting a standard based on a full impeller.

<u>Item 1-41:</u> DOE requests comment on standards based on certain numbers of stages for radially split multi-stage and submersible pumps. DOE also seeks comment on whether the same approach could be taken for axially split multi-stage pumps.

<u>Item 1-42:</u> DOE requests data on the percent of pumps sold with a full impeller, as well as the distribution of pump sales with reduced impellers (as a percentage of full impeller).

Public Meeting Agenda

1	Introduction
2	Rulemaking Process Overview
3	Legislative History & Coverage
4	Regulatory Regimes & Metrics
5	Test Procedure
6	Rulemaking Analyses
7	Closing Remarks

Test Procedure

Approach

- **DOE is conducting a test procedure rulemaking.**

- **When establishing test procedures, DOE reviews existing industry test procedures to measure the energy use or energy efficiency of the covered equipment.**

- **Once adopted, manufacturers must use a DOE prescribed test procedure to establish compliance with any standards and make representation of the basic model's efficiency.**
  - DOE develops test procedures to ensure test repeatability and fair comparison of equipment .

Test Procedure

Review of Industry Test Procedures

- **ANSI/HI 14.6-2011: *"Rotodynamic Pumps for Hydraulic Performance Acceptance Tests"***
  - Applies to any size centrifugal, mixed, and axial flow rotodynamic pump without fittings using any pumped liquid behaving as clear water
  - Based on measuring the flow of the pumped liquid
  - Allows for the use of alternative homogenous liquids when water is not appropriate for the application

- **ISO 9906-2012 *"Rotodynamic pumps – Hydraulic performance acceptance tests – Grades 1, 2 and 3"***
  - Mirrors ANSI/HI 14.6-2011

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Test Procedure

Review of Industry Test Procedures

- **ANSI/HI 11.6-2012: *"Submersible Pump Tests"***
  - Similar metrics, test conditions, and protocols to ANSI/HI 14.6-2011 and ISO 9906-2012
  - Applies only to centrifugal submersible pumps
  - Test must be performed on clean water

- **ISO 5198-1999: *"Centrifugal, mixed flow, and axial pumps. Code for hydraulic performance tests. Precision class"***
  - Test procedure based on thermodynamic principles rather than flow
  - Temperature and pressure measurements are used to determine pump efficiency

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Test Procedure

Request for Comment

<u>Item 1-43:</u> DOE requests comment on the use of the ANSI/HI 14.6-2011, ANSI/HI 11.6-2012, ISO 9906-2012, and ISO 5198-1999 test procedures, as well as any other test procedures that DOE should consider, as a basis for the development of a DOE test procedure, including any modifications or additions that may be necessary.

<u>Item 1-44:</u> DOE requests comment on the scope of each test procedure with respect to the equipment for which DOE is considering in the scope of this rulemaking, as well as any limitations of these test procedures.

<u>Item 1-45:</u> DOE is also interested in the pros and cons of using a thermodynamic approach instead of a flow-based approach to determining pump or pumping system efficiency, as in ISO 5198-1999.

Test Procedure

Pump+Motor+VSD

- DOE may define commercial and industrial pumps inclusive of motors and VSDs.
- ANSI/HI 14.6-2011 provides a potential basis for testing overall system efficiency (wire-to-water) with motors and VSDs, using a wattmeter to measure the input power to the motor or VSD.
- ANSI/HI 14.6-2011 also describes a “string” test that relies on rated efficiencies of the motor or VSD, or both, to determine the pump efficiency.

Test Procedure Accuracy and Repeatability

- **Test accuracy and repeatability can vary based on the sensitivity and calibration of the selected measurement equipment.**

- **DOE will consider establishing tolerances on test conditions and test results and defining the number of units that should be tested.**

Test Procedure

Request for Comment

<u>Item 1-47:</u> DOE requests comment on the applicable test procedures for complete pump, motor, and VSD system packages.

<u>Item 1-48:</u> DOE requests comment on the accuracy of different measurement equipment used to measure pump power, input power to a motor or VSD, pump flow, head, or other parameters and their impact on the accuracy of the measured pump efficiency. DOE also requests comment on the calibration frequency required to maintain sufficient equipment accuracy.

Test Procedure

Request for Comment

<u>Item 1-49:</u> DOE requests comment on the applicability of calculation methods to determine rated pump efficiencies from similar, tested pump efficiencies.

<u>Item 1-50:</u> DOE requests comment on the number of unique pump models manufacturers would have to test, as well as the ability for a calculation method to reduce testing burden. DOE also requests comment on the reduction in test accuracy when using a calculation method to determine rated efficiency of a unit.

Public Meeting Agenda

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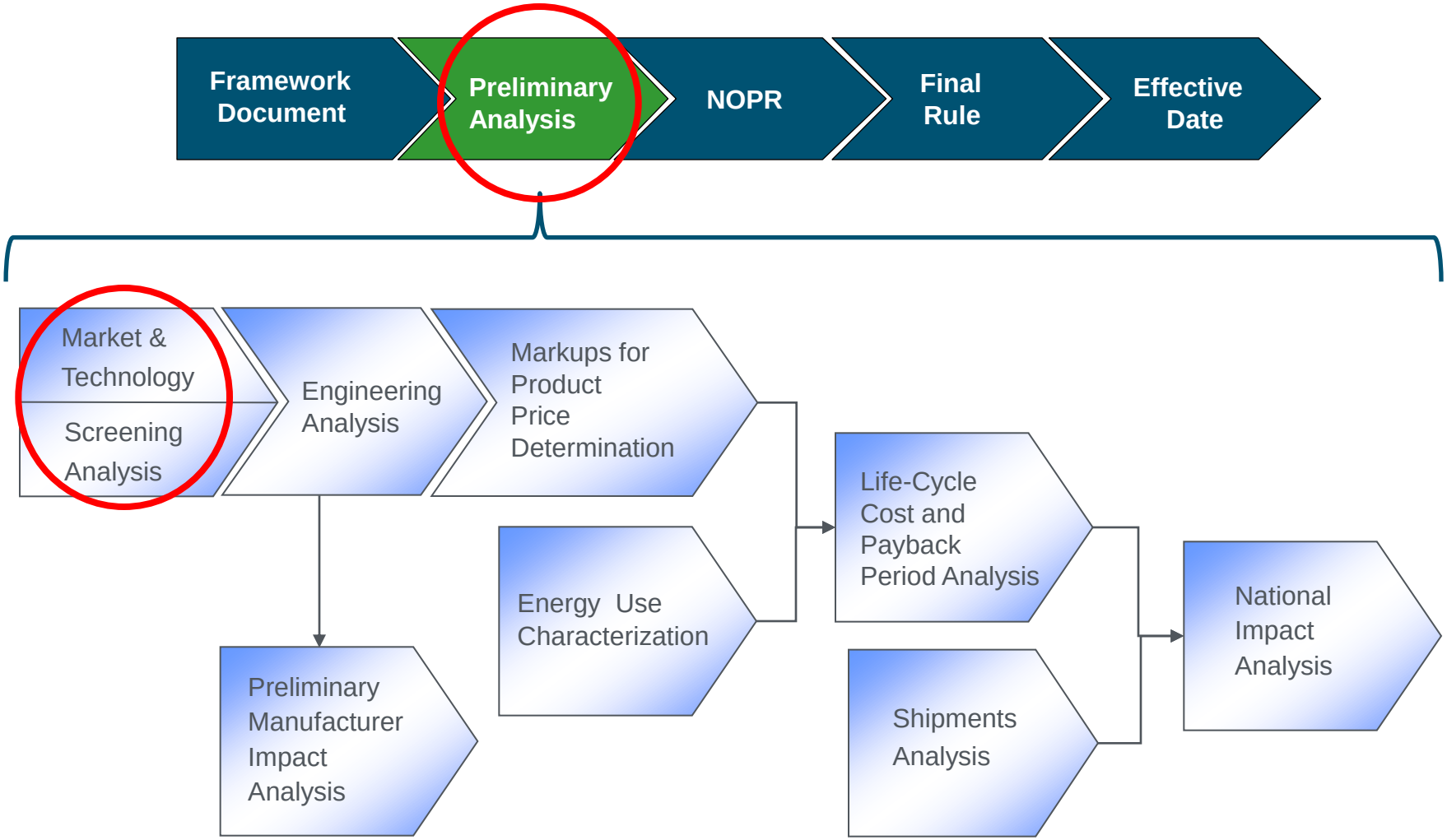
Preliminary Analysis



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Preliminary Analysis

Market and Technology Assessment

- **Purpose:**
  - Characterize the commercial and industrial pump markets and the measures to improve efficiency

- **Method:**
  - Identify and characterize manufacturers of commercial and industrial pumps
  - Estimate shipments and trends in the market
  - Identify technologies that could improve efficiency
  - Identify regulatory and non-regulatory initiatives intended to improve the efficiency of the equipment covered under this rulemaking

Manufacturer Overview

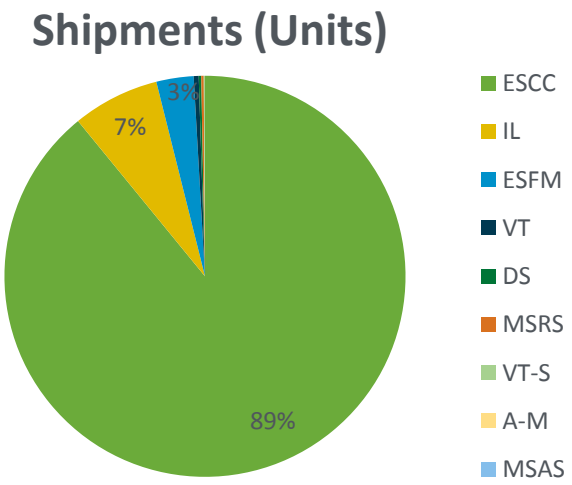
- **In the United States, ten companies represent 60-70% of the total U.S. pumps market: Grundfos, Sulzer, Weir Group, KSB, Xylem, Flowserve, Ebara, Pentair, Roper Industries, and ITT Goulds.**

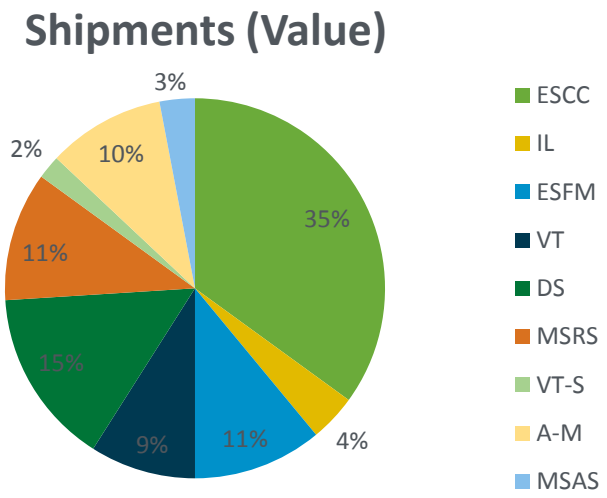
- **There has been significant consolidation in the global pump market in the past 25 years, and these ten companies comprise approximately 70 brands or divisions.**

- **A list of major suppliers and their parent companies is available on page 44 of the Framework Document.**

Shipments Overview

- **DOE examined census data for pumps.**
  - Pages 46-51 in the Framework document shows mapping of product codes to DOE pump equipment categories, estimated allocations of imports and exports to equipment categories, and estimated percent of pumps that are clean water.
- **DOE estimates that 89% of shipments of covered pumps are ESCC – but only 35% by value.**





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Market Assessment

Request for Comment

<u>Item 3-1:</u> DOE requests information that would contribute to the market assessment for the pumps that would be covered in this rulemaking, especially for those equipment classes designated in section 3.2. Examples of information sought include current equipment features and efficiencies, equipment feature and efficiency trends, and historical equipment shipments and prices.

<u>Item 3-2:</u> DOE requests input on its identification of product codes in the U.S. Census data that match the equipment classes proposed for coverage in this rulemaking.

<u>Item 3-3:</u> DOE requests feedback on its estimates of the disaggregation of pump exports and imports to product codes, its estimates of the percentage of shipments of clean water pumps, and its estimates of the percent of shipments sold with motors by the pump manufacturer.

Market and Technology Assessment

Considered Equipment Classes

Pump Type	Sub-Type	Stages	DOE Terminology	Design Speed
End Suction	Close Coupled	Single	End Suction Close Coupled (ESCC)	3,500
				1,750
	Own Bearings/ Frame Mounted	Single	End Suction Frame Mounted (ESFM)	3,500
				1,750
In-Line		Single	In-Line (IL)	3,500
				1,750
Axial Split		Single	Double Suction (DS)	3,500
				1,750
		Multi	Axially Split Multi-Stage (AS)	3,500
				1,750
Radial Split		Multi	Radially Split Multi-Stage (RS)	3,500
				1,750
Vertical Turbine	Non-Submersible	Any	Vertical Turbine (VT)	3,500
				1,750
	Submersible	Any	Submersible (VT-S)	3,500
				1,750
Axial/Propeller and Mixed Flow		Any	Axial/Propeller and Mixed (A-M)	3,500
				1,750

- **If DOE uses regulatory regimes 2 or 3, equipment class sets for pumps sold with motors or VSDs would likely mirror the set shown above.**

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Equipment Classes

Request for Comment

Item 3-4: DOE welcomes comments on which performance-related features or design characteristics DOE should consider to define pump equipment classes.

Item 3-5: DOE requests information regarding the utility of different pump categories proposed for coverage that would warrant separate equipment classes. For example, could end suction pumps be a single equipment class, or are the breakdowns shown necessary to preserve equipment utility that would affect performance? Could axially and radially split multi-stage pumps be a single equipment class? Could all vertical turbine pumps (both submersible and non-submersible) be a single equipment class?

Item 3-6: DOE requests information on whether any of the equipment proposed for coverage provides utility that requires further breakdown from the categories shown in Table 3.8 (Slide 83). For example, do multi-stage pumps with a double suction first stage require a separate equipment class? Do vertical turbine can pumps require a separate equipment class from vertical turbine lineshaft pumps?

Item 3-7: DOE requests comment on whether equipment classes can be developed for pump categories that would always be used in variable load applications.

Equipment Classes – Design Speed

- **The EU regulation contains separate efficiency standards for pumps operating at 1450 rpm and pumps operating at 2900 rpm (equivalent to 1750 and 3500 in the US).**
  - This captures a size effect, in which a larger pump running at lower speed is assumed to be more efficient than a geometrically similar smaller pump running at higher speed (4 pole > 2 pole).
- **Having separate standards for pumps at different speeds has implications for a single pump offered at multiple speeds.**
  - As shown in Framework Table 3.9, depending on the method of creating efficiency equations, predicted efficiency for a single pump is sometimes higher at 2 pole and sometimes at 4 pole, and the difference between the same pump at 2 pole and 4 pole may be as much as 7% points.
- **DOE wants to make sure the method of determining minimum efficiency produces appropriate results at all speeds.**

Equipment Classes – Design Speed

- **Regardless of whether DOE sets equipment classes based on design speed, DOE must determine speed for testing and compliance.**
  - May be difficult to select a single speed for testing because of variation in each equipment class
  - Could require calculating minimum efficiency at multiple speeds and require testing and compliance at the speed with the most stringent efficiency

Equipment Classes – Design Speed

Request for Comment

<u>Item 3-8:</u> DOE requests comment on whether it should consider using Reynolds number instead of flow in setting minimum efficiency standards for pumps and whether this choice would prevent adding design speed as an additional parameter. DOE notes that there are multiple methods of calculating Reynolds number for pumps and that all calculations do not produce the same relative results. As a result, DOE seeks comment on the most appropriate form of Reynolds number for pumps.

<u>Item 3-9:</u> DOE requests comment on which method of surface fitting produces the most appropriate results for both cases: (1) a smaller pump at higher speed compared to a larger pump at lower speed; and (2) identical pumps running at two different speeds. DOE requests comment on whether these relationships are expected to differ by equipment class.

Equipment Classes – Design Speed

Request for Comment

<u>Item 3-10:</u> DOE requests comment on the use of pump design speed as a feature that distinguishes equipment classes. In particular, DOE seeks comment on whether pumps designed for different rotating speeds perform differently enough to warrant separate equipment classes. DOE also requests comment on any physical differences between pump models offered at different speeds and the nature of those differences, including whether DOE could determine by physical inspection at what speeds a pump can safely operate.

<u>Item 3-11:</u> DOE requests comment on the testing and compliance burden on manufacturers under the approaches set forth above.

<u>Item 3-12:</u> DOE requests comment on whether it could require all pumps in a given equipment class to be tested at (a) certain speed(s) and, if so, which speed(s) is (are) most appropriate.

<u>Item 3-13:</u> DOE requests comment on how manufacturers in the EU are determining the minimum efficiency required for a pump offered at multiple speeds.

Representative Classes

- **DOE may determine an appropriate subset of representative equipment classes to analyze for the engineering analysis.**
  - DOE would extrapolate the results to the remaining equipment classes.
  - Typically each representative equipment class would represent the majority of shipments.
- **ESCC and ESFM pump wet-ends are often identical but supplied with different motors.**
  - ESFM would be preferred in terms of accuracy of pump efficiency measurement, but ESCC represent more shipments.
- **Vertical turbine and submersible vertical turbine pumps could be represented by one class depending on choice of metric.**

Representative Units

- **Selection based on identification of units that are functionally equivalent in all aspects except efficiency**
  - For pumps, this is expected to be pumps with approximately constant BEP flow and specific speed but with different efficiency levels.

- **A representative unit represents multiple models of pumps – one at baseline level, and one or more at higher efficiency levels.**

- **DOE will scale the engineering analysis results for the representative units to cover the full range of flow and specific speeds within the equipment class.**

Representative Classes and Units

Request for Comment

<u>Item 5-2:</u> DOE welcomes comment from interested parties on the best methodology for scaling cost-efficiency curve results from the representative units to the representative equipment classes and extrapolating from the representative equipment classes to the remaining equipment classes not directly analyzed.

<u>Item 5-3:</u> DOE seeks comment on its selection of representative classes: which classes could be grouped together for this analysis, and which class should be tested.

<u>Item 5-4:</u> DOE welcomes comment on the selection of representative units in terms of appropriate flow and specific speed ratings within each equipment class.

Baseline Models

- **Baseline models serve as a reference point to calculate cost and energy savings of more efficient models in the engineering analysis.**
- **Typically a model that just meets current standards**
  - For pumps, should represent least efficient, most typical pump offered
- **DOE is considering the appropriate method to develop baseline efficiency levels.**
- **Shipments data will help identify levels, as baseline level should have significant shipments.**

Baseline Models

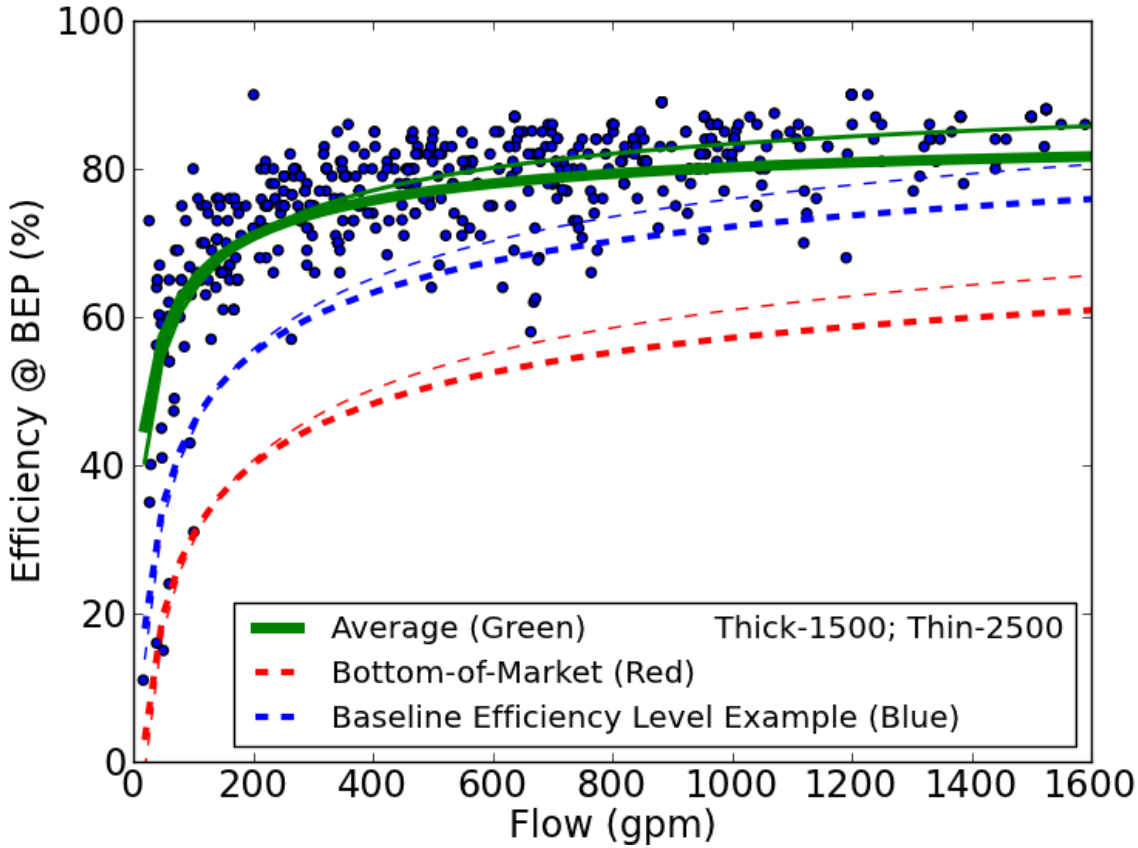

Figure 5.1 Example Baseline Efficiency Levels for ESCC Pumps (Ns=1500-2500)

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Market and Technology Assessment

Efficiency Levels

- DOE will conduct the engineering analysis (and LCC and PBP analyses) on all equipment classes for which it suggests efficiency levels.
- DOE is required to analyze maximum technologically feasible ("max tech") efficiency levels.
- DOE will seek interested party input on the appropriate max-tech levels.
- DOE will analyze design options and costs associated with improving efficiency from the baseline through the max-tech model.
- DOE is considering how to define max-tech based on market maximums.

Market and Technology Assessment

Efficiency Levels

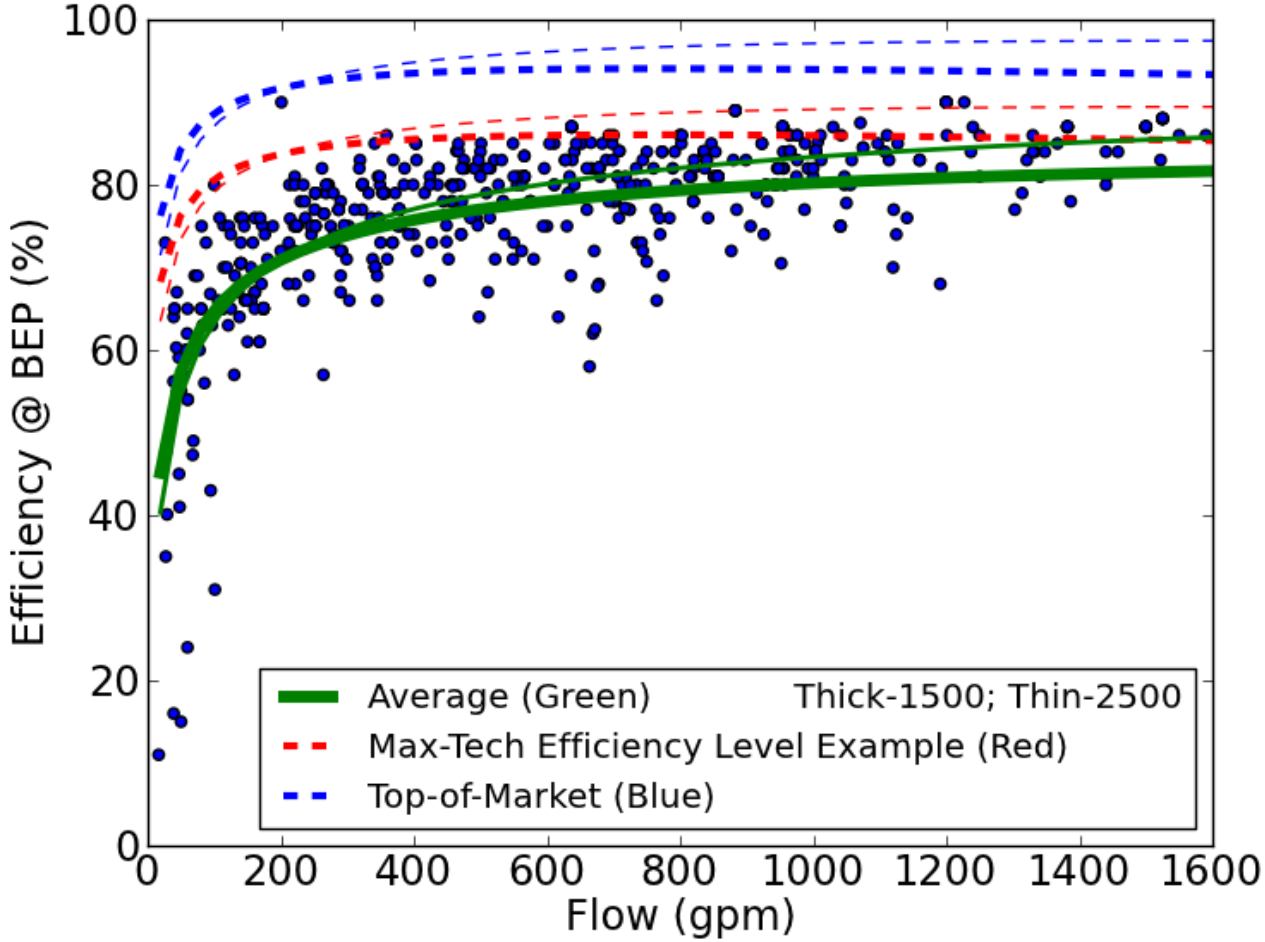

Figure 5.2 Example Max-Tech Efficiency Levels for ESCC Pumps (Ns=1500-2500)

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Baseline Models and Efficiency Levels

Request for Comment

<u>Item 5-5:</u> DOE seeks comment on the selection and performance characteristics of baseline models for each equipment class. DOE will consider such comments in defining the characteristics of the proposed baseline models.

<u>Item 5-6:</u> DOE seeks input from stakeholders regarding the range of efficiency levels that should be examined as part of its analysis.

<u>Item 5-7:</u> DOE seeks input from interested parties on a methodology that would be appropriate for determining the max-tech models for each pump analyzed.

Initial Technology Options to Improve Efficiency

- **Pumps**
  - Improving hydraulic design
  - Smoothing surface finish
  - Reducing running clearances
  - Reducing mechanical friction in seals
- **Pumps+Motors(+VSD)**
  - Adding a VSD (which enables users to reduce speed when possible)
  - Improving VSD efficiency
  - Reducing VSD standby and off mode power usage
- **Other?**

Technology Options

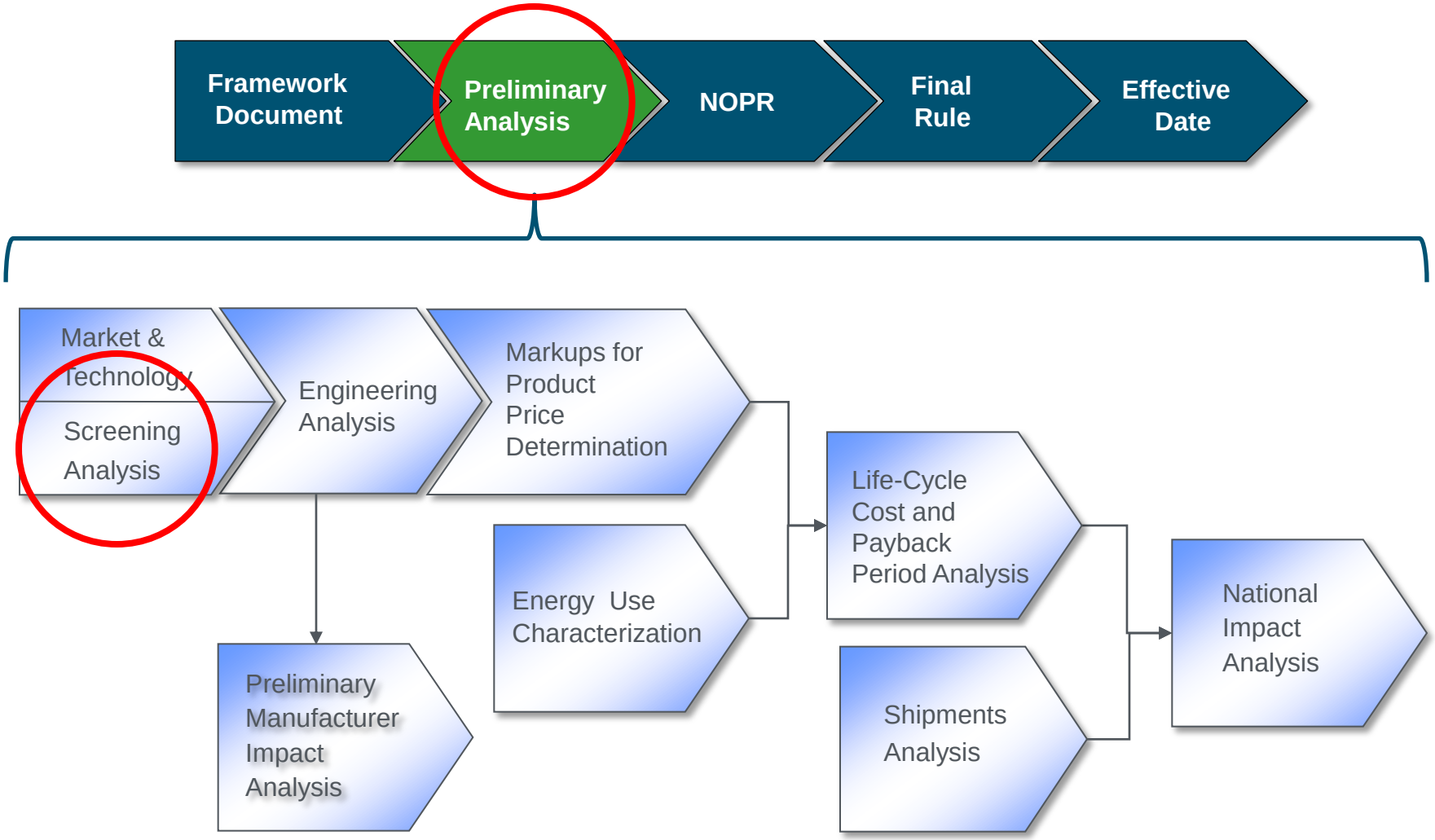
Request for Comment

<u>Item 3-14:</u> DOE welcomes comment on the technology options identified in this section, including further details on methods (such as lists of specific methods for each listed broad option) and potential efficiency gains, as well as information on whether the method in question is applicable to all pumps in a given equipment class or only pumps with certain design characteristics). DOE also welcomes comment on whether there are other technology options that it should also consider.

<u>Item 3-15:</u> DOE welcomes comment on the relevance of the technology options identified to pumps sold with smaller impellers than the full impeller on which DOE is tentatively proposing to base a standard. In particular, would these design options be carried through to pumps with all impeller sizes?

<u>Item 3-16:</u> DOE requests information related to various impeller types used in clean water pump designs and the efficiency impacts of each type.

Preliminary Analysis



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Screening Analysis

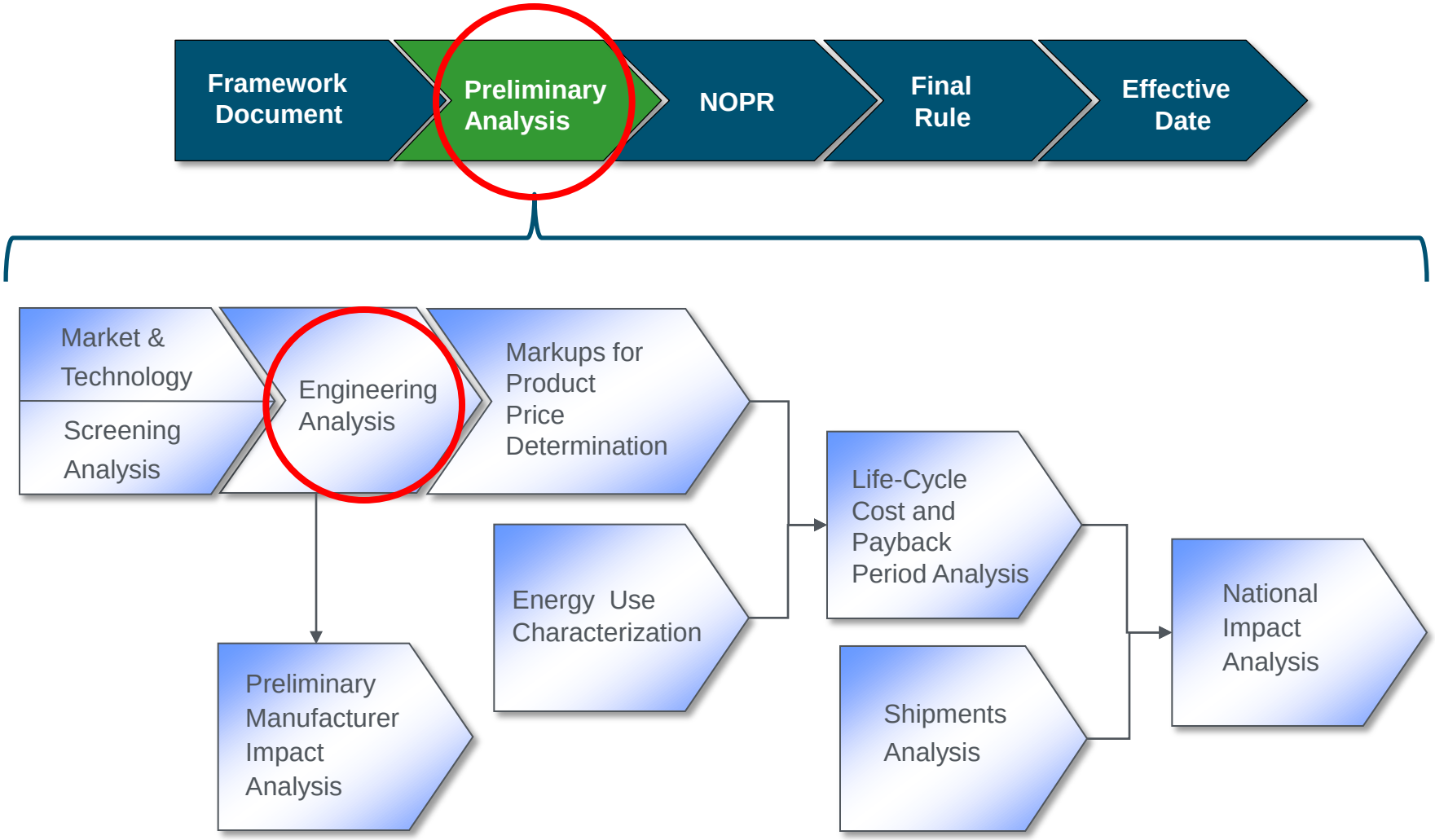
- **Purpose:**
  - Screen out technology options that DOE will not consider in the engineering analysis for commercial and industrial pumps

- **Method:**
  - DOE will evaluate each technology option based on the following criteria:
    - Technological feasibility
    - Practicability to manufacture, install and service on a commercial scale at the time compliance with any final standards would be required
    - Impacts on product utility or available to consumers
    - Impact on health and safety

Screening Analysis

Request for Comment
<u>Item 4-1:</u> Are there any technologies, including those listed in the Framework Document, that DOE should not consider because of any of the four screening criteria? If so, which screening criteria apply to the cited technology or technologies?

Preliminary Analysis



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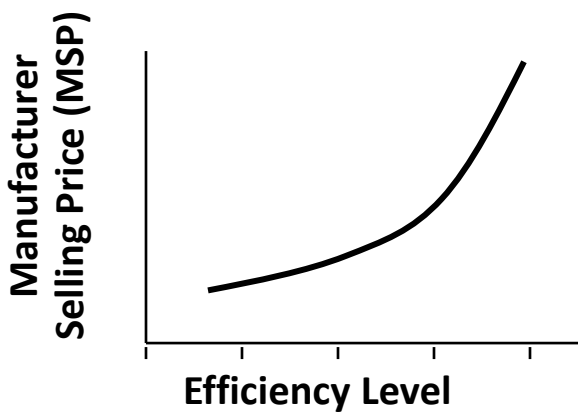
Engineering Analysis

Purpose

- Develop the cost-efficiency curve, which characterizes the relationship between manufacturer selling price (MSP) and energy efficiency.
- The cost-efficiency curves for the examined equipment classes are key inputs for the downstream rulemaking analyses.

Manufacturer Selling Price – Efficiency Relationship



Rulemaking Analyses

- Life-Cycle Cost and Payback Period Analysis
- Manufacturer Impact Analysis
- Employment Impact Analysis

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Engineering Analysis

Approach

- **Design Option Approach:** Determination of costs and efficiency improvement potential based on individual and groups of design options.
- **Efficiency Level Approach:** Determination of costs at predetermined efficiency levels to represent the cost/efficiency relationship.
- **Reverse Engineering Approach:** Calculation of costs for the efficiency levels associated with reverse-engineered products using a manufacturing cost model.

DOE will consider using any one or a combination of these approaches, employing available data sources to develop the cost-efficiency relationships.

Engineering Analysis

Methodology

Define Baseline Models

- Determine characteristics of common or typical models which will serve as reference points to assess changes due to energy conservation standards.

Teardown and Testing

- Conduct tests to verify efficiency ratings.
- Perform equipment disassembly to identify design options and provide input to manufacturing cost models to determine designs and costs associated with each efficiency level.

Data Collection and Interviews

- Collect available cost data on efficient pump designs.
- Conduct interviews with manufacturers to enhance understanding of efficiency improvements and associated costs.

Develop Cost-Efficiency Relationships

- Develop cost-efficiency relationship based on reverse-engineering and cost data from available sources including manufacturer interviews.

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Methodology

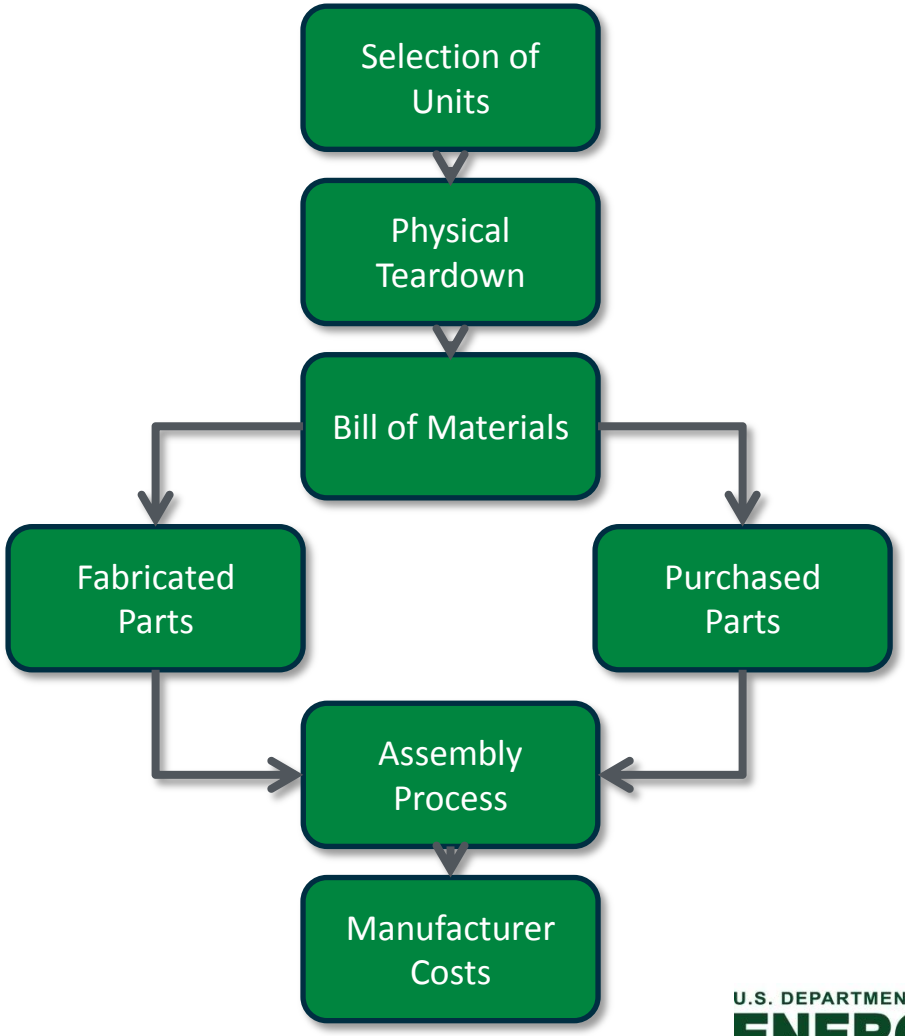
Request for Comment

<u>Item 5-1:</u> DOE seeks input on the methods and approaches used by manufacturers to improve the efficiency of pumps and, in particular, how frequently hydraulic re-design would be the only method employed.

<u>Item 5-8:</u> For each equipment class, DOE welcomes comments on methods and approaches that DOE intends to employ to determine potential efficiency improvements for pumps. Detailed information on the pump performance and the incremental manufacturing costs (e.g., material costs, labor costs, overhead costs, building conversion capital expenditures, capital expenditures for tooling or equipment conversion associated with more efficient designs, R&D expenses, and marketing expenses) would be useful.

Engineering Analysis

Teardown & Test Methodology



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Manufacturer Cost Estimate

- **Equipment Costs (MSP)**
  - Includes manufacturer production costs (MPC) as well as non-production costs, such as maintenance, depreciation, and taxes
  - *Markups* will be used to represent non-production costs and convert the MPC to the MSP.
  - DOE intends to estimate manufacturer markups based on publicly available financial information and manufacturer interviews.
- **Conversion Costs**
  - Includes the difference in investments required to build production facilities required for higher-efficiency designs as compared with investments for production facilities used for current designs
  - DOE typically does not include conversion costs in the engineering analysis.
  - One option to improve pump efficiency is hydraulic re-design. The non-recurring R&D costs required to develop such new designs also would not be part of the MSP calculated in the engineering analysis.

Methodology and Manufacturer Cost Estimates

Request for Comment

<u>Item 5-9:</u> DOE welcomes comment on the markup approach proposed for developing estimates of manufacturer selling prices.

<u>Item 5-10:</u> DOE welcomes comment on the approach to determining the relationship between manufacturer selling price and pump efficiency.

<u>Item 5-11:</u> DOE welcomes comment on the conversion costs required to improve the efficiency of the pumps to various levels, as well as what portion of these costs would be passed on to the consumer.

Engineering Analysis

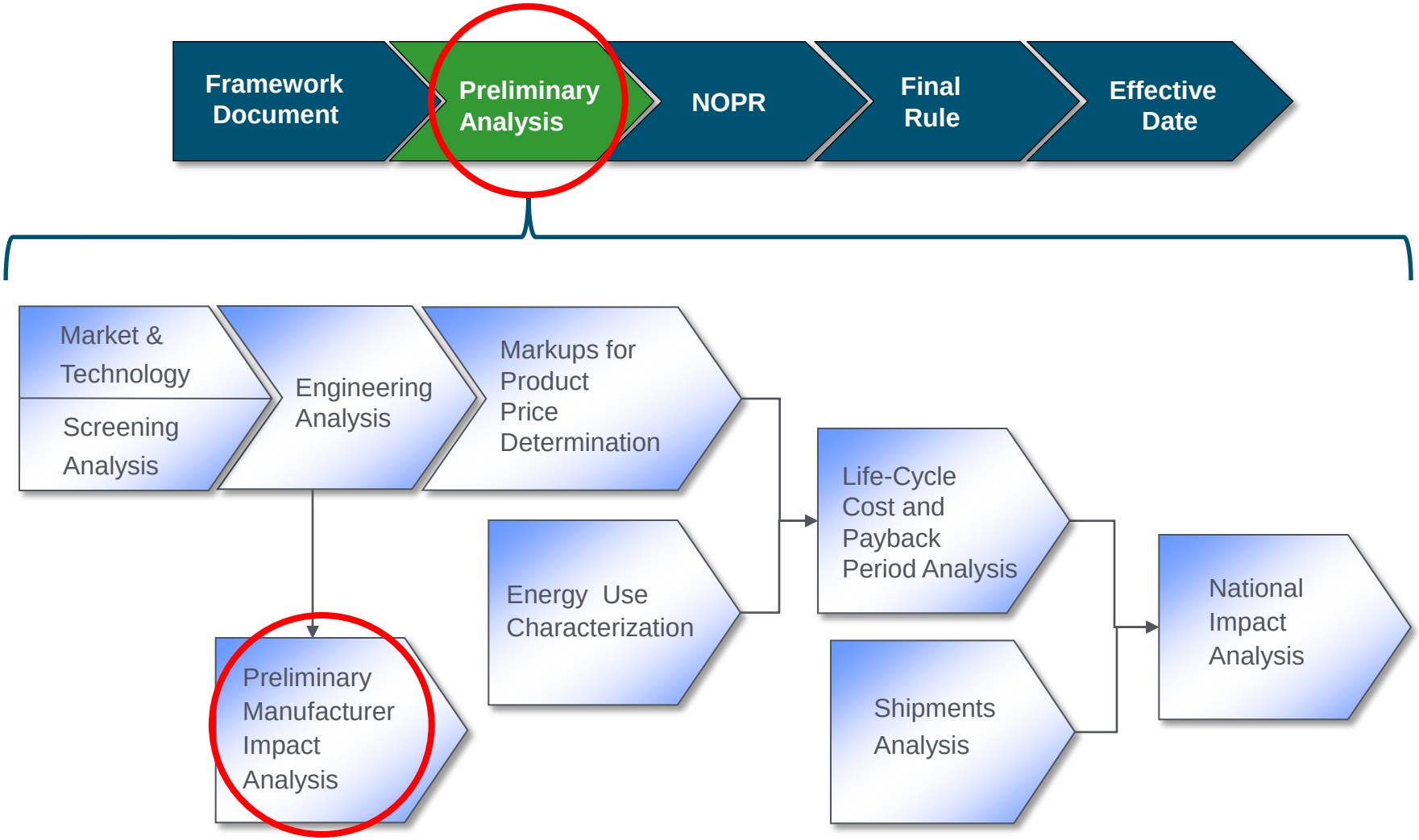
Outside Regulatory Changes

- DOE will consider the effects of other DOE energy conservation standards and regulatory changes outside DOE's rulemaking process that can impact manufacturers of covered equipment.
- Some regulatory changes can also affect the efficiency or energy consumption of the pumps covered under this rulemaking.
- DOE will attempt to identify any outside engineering issues. that could impact the engineering analysis.

Request for Comment

<u>Item 5-12:</u> DOE welcomes comment on whether there are outside regulatory changes that DOE should consider in its engineering analysis of pumps.

Preliminary Analysis



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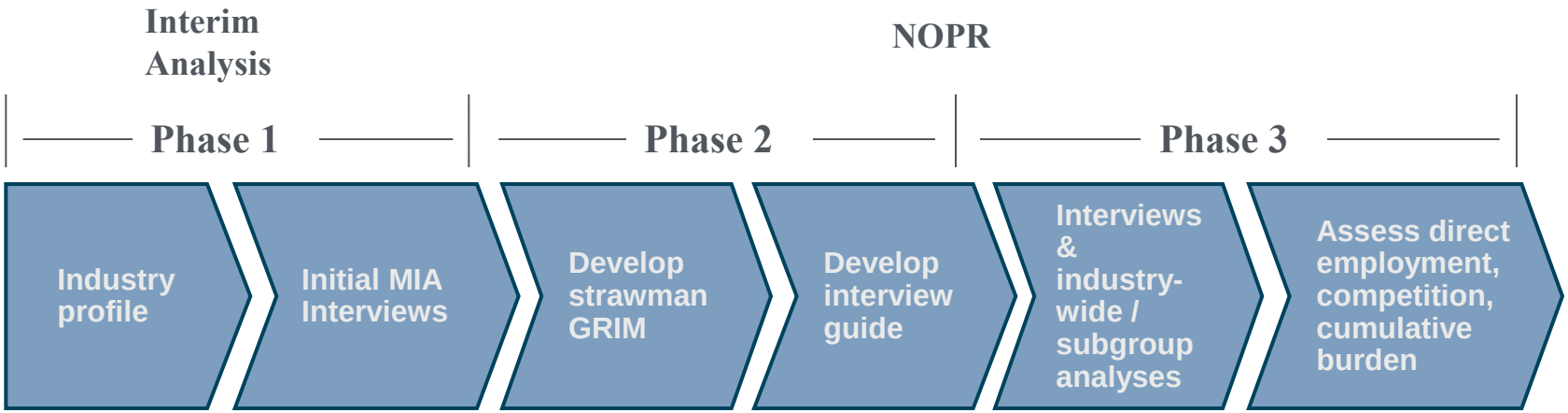
Manufacturer Impact Analysis

- **Purpose:**
  - Assess the impacts of standards on manufacturers
  - Identify and estimate impacts on manufacturer subgroups that may experience greater impacts than the industry as a whole
  - Examine the impact of cumulative regulatory burden on the industry

- **Method:**
  - Analyze industry cash flow and NPV through use of the Government Regulatory Impact Model (GRIM)
  - Interview manufacturers to refine inputs to the GRIM, develop subgroup analyses, and address qualitative issues

Manufacturer Impact Analysis

The MIA consists of three main phases:



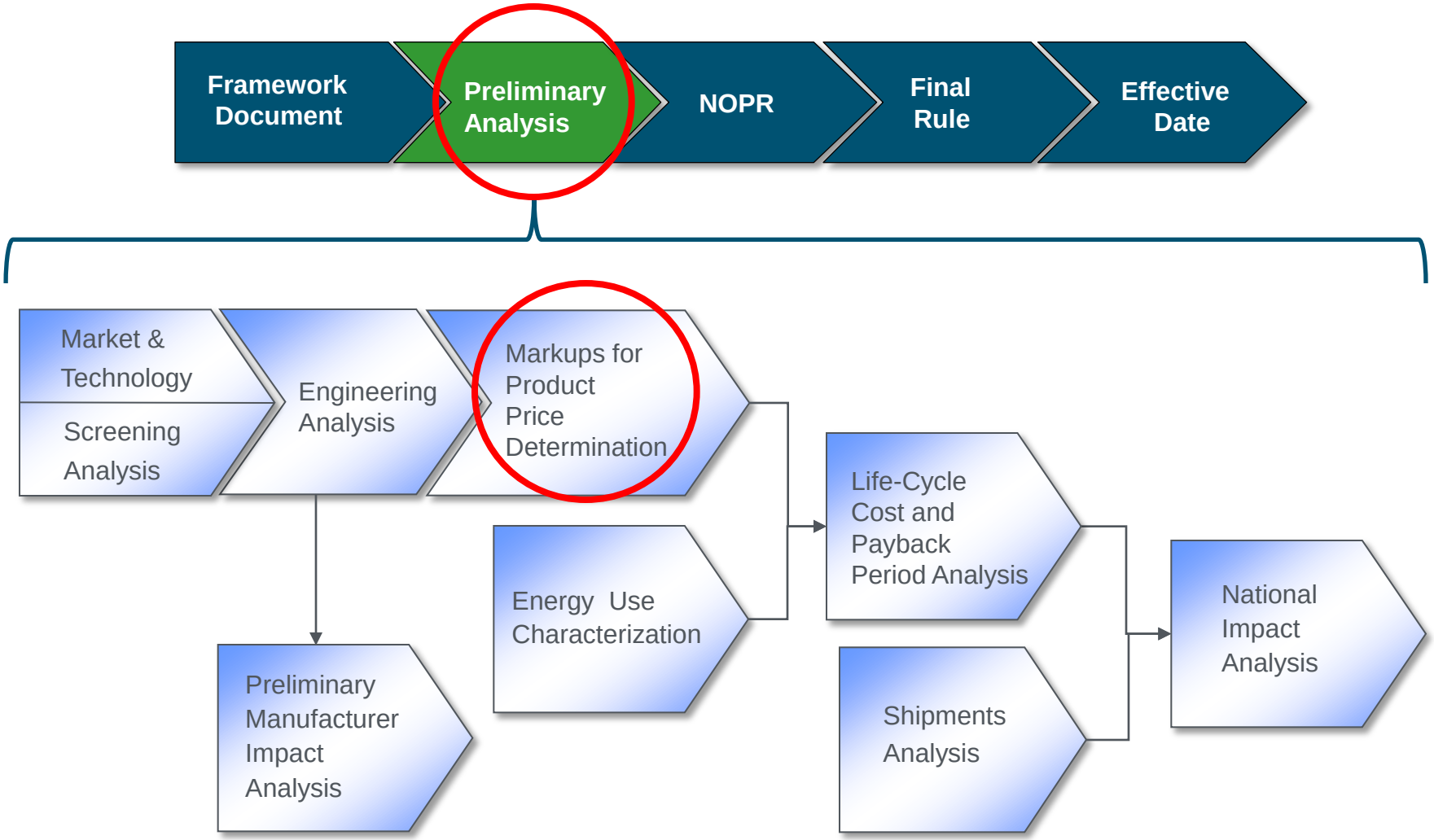
Request for Comment

Item 12-1: DOE seeks comments on the subgroups of pump equipment manufacturers that it should consider in a manufacturer subgroup analysis.

Item 12-2: DOE seeks comments on what other existing regulations or pending regulations it should consider in its examination of cumulative regulatory burden.

Item 12-A: DOE seeks comment on small businesses that could be impacted by potential energy conservation standards for commercial and industrial pumps, as well what these impacts might be.

Preliminary Analysis



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Mark-Ups Analysis

- **Purpose:**
  - Convert manufacturer selling price estimates from the engineering analysis to customer prices

- **Method:**
  - Identify distribution channels
  - Estimate how equipment is marked up in the distribution chain

Mark-Ups Analysis

Approach

- **Distribution Channels**

Manufacturer → Customer	(Direct End-User Channel)
Manufacturer → OEM → OEM Distributor → Customer	(OEM Channel)
Manufacturer → Wholesaler → Customer	(Distributor Channel)
Manufacturer → Wholesaler → Contractor → Customer	(Contractor Channel)

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Mark-Ups Analysis

Types of Markups in Distribution Chain

- **Baseline Markups:**
  - Markups relate end-user price to manufacturers selling price (MSP) averaged over all distribution channels.
  - Baseline markups relate price to MSP for all currently sold equipment.
  - Baseline markups indicate a consumer price that covers all of a distributor's or contractor's current expenses plus profit.
- **Incremental Markups:**
  - Incremental markups relate the incremental change in end-user price to the incremental change in MSP due to higher efficiency designs.
  - Some of the distributor's costs, such as direct labor costs (salaries, payroll, rental and occupancy), do not vary with efficiency induced changes and are excluded from the calculation of incremental markups.
  - Incremental markups cover only expenses that are expected to vary with higher cost of equipment sold e.g., business promotion, interest and insurance etc.

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Mark-Ups Analysis

Request for Comment

<u>Item 6-1:</u> DOE requests information on the distribution channels under consideration.

<u>Item 6-2:</u> DOE requests comments and additional information on the appropriate way to establish distribution channel percentages across equipment classes and application (market) segments for the current rulemaking. In particular, DOE seeks information on the percentage by market segment (i.e., agriculture, municipal, commercial, industrial, and other markets) of direct sales, OEM sales, wholesaler to customer sales, wholesaler to contractor sales, and other sales. DOE seeks this information over the total market.

<u>Item 6-3:</u> DOE seeks comment on other sources of relevant data that could be used to characterize markups for commercial and industrial pumps.

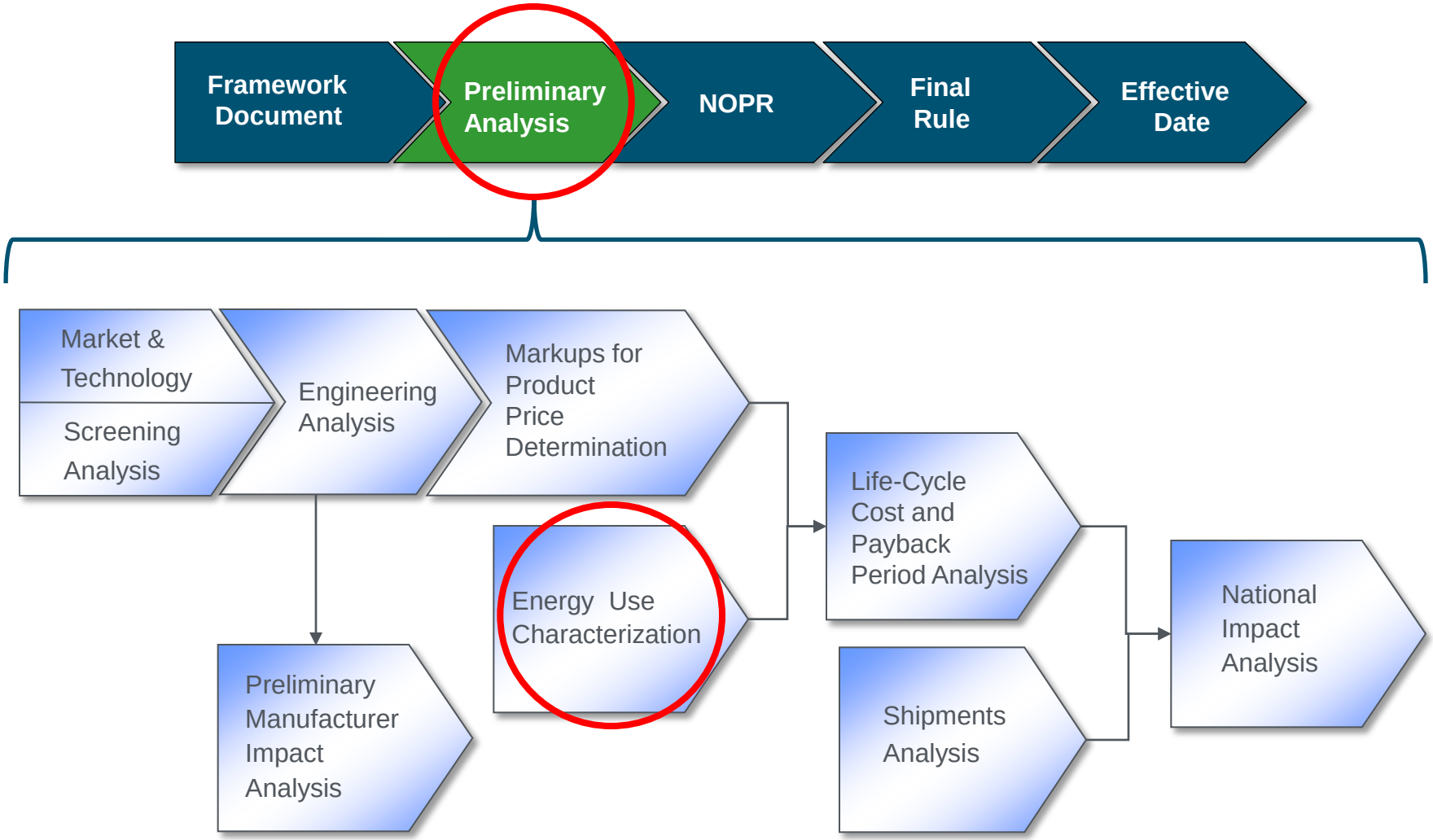
Mark-Ups Analysis

Request for Comment

<u>Item 6-4:</u> DOE requests feedback on its proposal to use incremental distribution channel markups.

<u>Item 6-5:</u> DOE seeks comment on appropriate transportation and shipping costs to include in the analysis and whether those costs are likely to vary for higher efficiency commercial and industrial pumps.

Preliminary Analysis



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Energy Use Analysis

- **Purpose:**
  - Identify how pumps are actually operated by users and to determine the energy savings potential of more efficient designs in the field
  - Estimate annual energy consumption (AEC) for baseline and higher-efficiency designs using the load profiles developed for each application

- **Issues:**
  - End-use duty profiles are expected to vary across the equipment classes and application segments.
  - Pumps are often designed to exceed the flow rate capacity and head requirements as an engineering precaution.
  - Pumps are often selected based on the peak load or maximum system capacity.

Energy Use Analysis

Approach

- **Estimate annual energy consumption (AEC) for baseline and higher-efficiency designs using the load profiles developed for each application:**

$$AEC = \left(\sum_{i=1}^{\text{All_operating_points}} (Q_i \times H_i / \eta_{overall})_i \times N_i \right) \times (Sp.Gr) / 5{,}308$$

  - Where
    - *AEC* = annual energy consumption (kWh),
    - Q_i = flow rate at the operating point i, gallons per minute (gpm),
    - H_i = pump head at the operating point i, (ft),
    - N_i = operating hours at the operating point i,
    - $\eta_{Overall} = \eta_F \times \eta_T \times \eta_M \times \eta_C$ at the operating point i,
      - η_F = pump efficiency,
      - η_T = transmission efficiency,
      - η_M = motor efficiency,
      - η_C = control system efficiency,
    - *Sp.Gr* = specific gravity of the fluid, and
    - 5,308 is a unit conversion constant.

- **Develop statistical models describing the expected range of duty profiles for pumps in different applications**

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Energy Use Analysis

Request for Comment

Item 7-1: DOE requests input and recommendations for identifying high sales volume and large installed base application segments corresponding to specific applications for which the pumps used may have similar duty profiles.

Item 7-2: DOE welcomes recommendations on sources of data or analysis methods that would provide end-use duty profiles for each of the equipment classes of pumps covered under this rulemaking in the major application segments.

Item 7-3: DOE requests input on ways to characterize pump sizing and selection practices for different equipment classes and applications.

Item 7-4: DOE requests comment on the degree of oversizing prevalent in different application segments.

Item 7-5: DOE welcomes comment on methods for determining nominal (non-market segment specific) duty profiles for pump equipment classes considered in this rulemaking.

Energy Use Analysis

Request for Comment

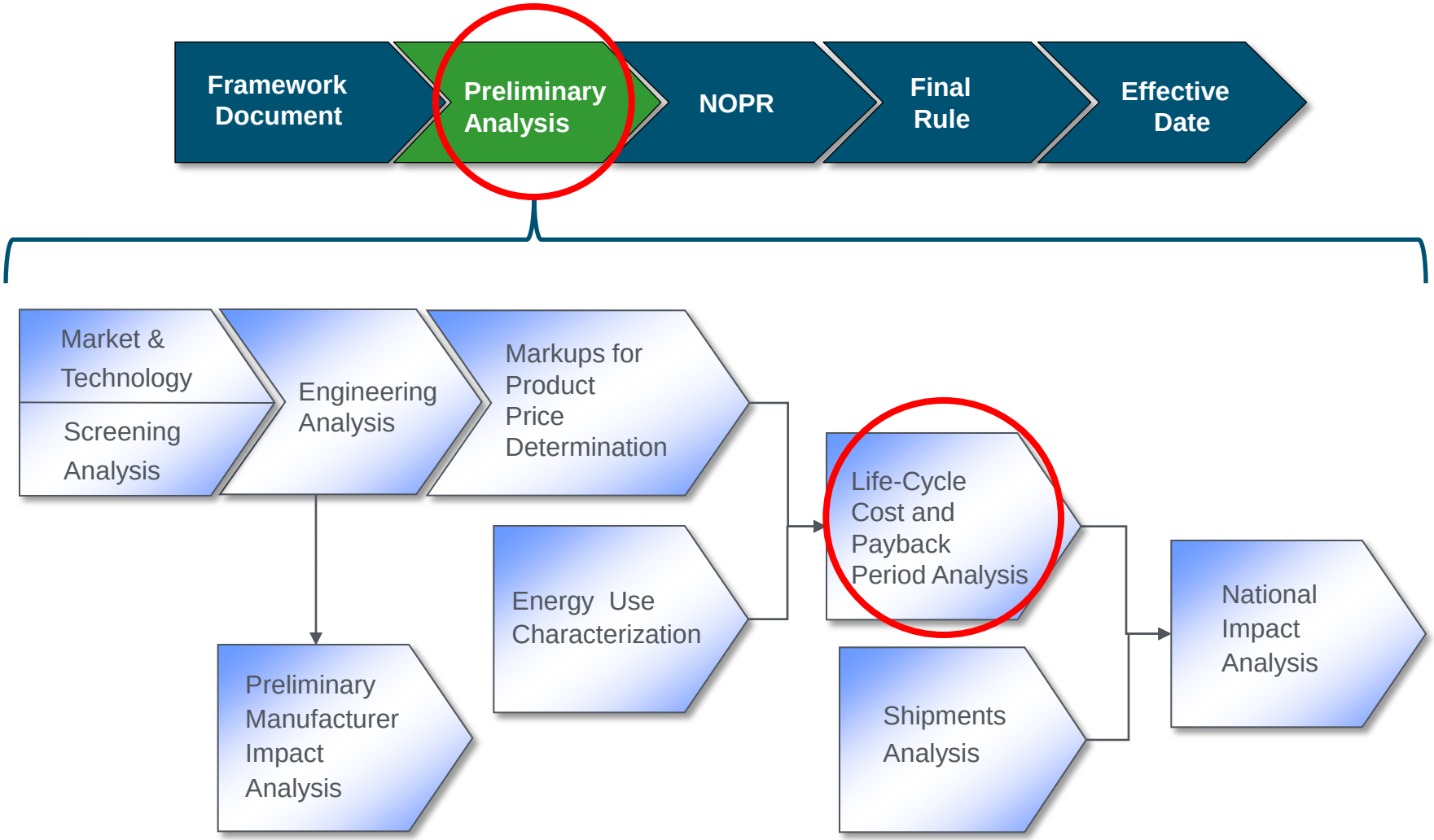
Item 7-6: DOE welcomes comment on the current penetration level of VSDs in the installed base of equipment in each application segment for each of the equipment classes considered in this rulemaking. DOE also welcomes comment on the baseline condition for applications without VSDs, such as running at full load, use of a throttling valve, etc.

Item 7-7: DOE requests comment and recommendation on the range and number of sizes over which the analysis should be carried out for each specific speed in different classes of equipment.

Item 7-8: DOE requests information on current industry practices and recommendations on the selection of representative operating points for a given specific speed. DOE welcomes comment on whether the analysis should be extended to a range of operating points away from BEP.

Item 7-9: DOE requests comment and estimates to establish the mean value and the ranges of likely values for transmission, motor, and motor control efficiencies, as well as the impact of a control on motor performance and efficiency.

Preliminary Analysis



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Preliminary Analysis

Life-Cycle Cost and Payback Period Analysis

- **Purpose:**
  - Assess the net life-cycle cost (LCC) impacts of differing efficiency levels on the customer

- **Method:**
  - LCC equals customer price plus the sum of annual operating costs (including repair and maintenance costs) discounted to a particular base year.
  - Economic evaluation from the customer perspective
  - Results are expressed as LCC difference (baseline minus standard level).
  - Payback Period (PBP) is also calculated and reported in this analysis.

Life-Cycle Cost and Payback Period Analysis

Approach

- **For each of the representative units in each representative equipment class:**
  - Consider the pump selection process to reflect product choices by customers
    - Some customers will not be affected by the standard
  - Develop distribution of equipment efficiencies expected for the compliance year
  - Aggregate the annual energy consumption over a pump's lifetime
  - Develop probability distributions to characterize operating costs
  - Model uncertainty and variability in the inputs using a Monte Carlo simulation method and probability distributions

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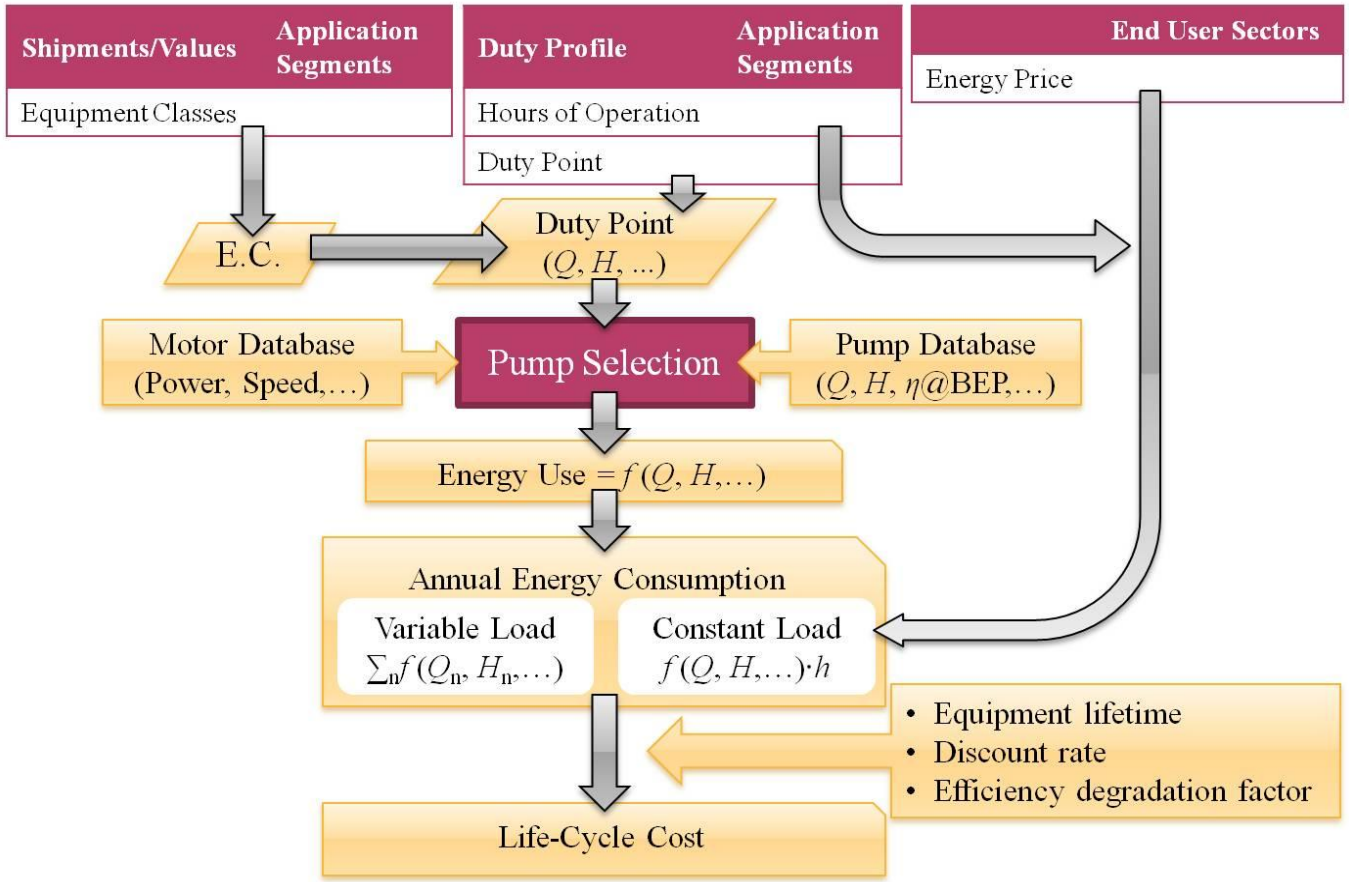
Life-Cycle Cost and Payback Period Analysis

Approach



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Life-Cycle Cost and Payback Period Analysis

Approach

- **Installation Costs**
  - Consist of labor (including overhead) and any miscellaneous materials and parts
- **Energy Prices**
  - DOE will survey commercial and industrial energy tariffs as a means of establishing marginal electricity prices.
  - DOE will use EIA's Annual Energy Outlook to estimate future energy prices.
  - DOE will also survey reactive power prices.
- **Maintenance & Repair Costs**
  - DOE expects that maintenance and repair costs will not change with incremental increases in equipment efficiency, but may change with significant improvements in efficiency.

Life-Cycle Cost and Payback Period Analysis

Approach

- **Equipment Lifetime**
  - DOE believes that the average pump lifetime is 10-15 years, with a maximum of around 25 years.
  - Lifetime varies based on whether the clean water pump is immersed in a liquid; values of pump head, horsepower, and speed; and temperature of the fluid being pumped.
  - Smaller, less expensive pumps are treated as “throwaway” pumps.
  - Larger pumps are repaired, with the repair cycle repeated for up to the life of the plant or building (30-50+ years).
- **Discount Rates**
  - DOE will derive the discount rates for commercial and industrial users by estimating the capital costs for companies that purchase pumps.

Life-Cycle Cost and Payback Period Analysis

Request for Comment

Item 8-1: DOE welcomes comment on whether installation costs for pumps increase with higher efficiency equipment.

Item 8-2: DOE welcomes input on the proposed methodology for estimating current and future electricity prices.

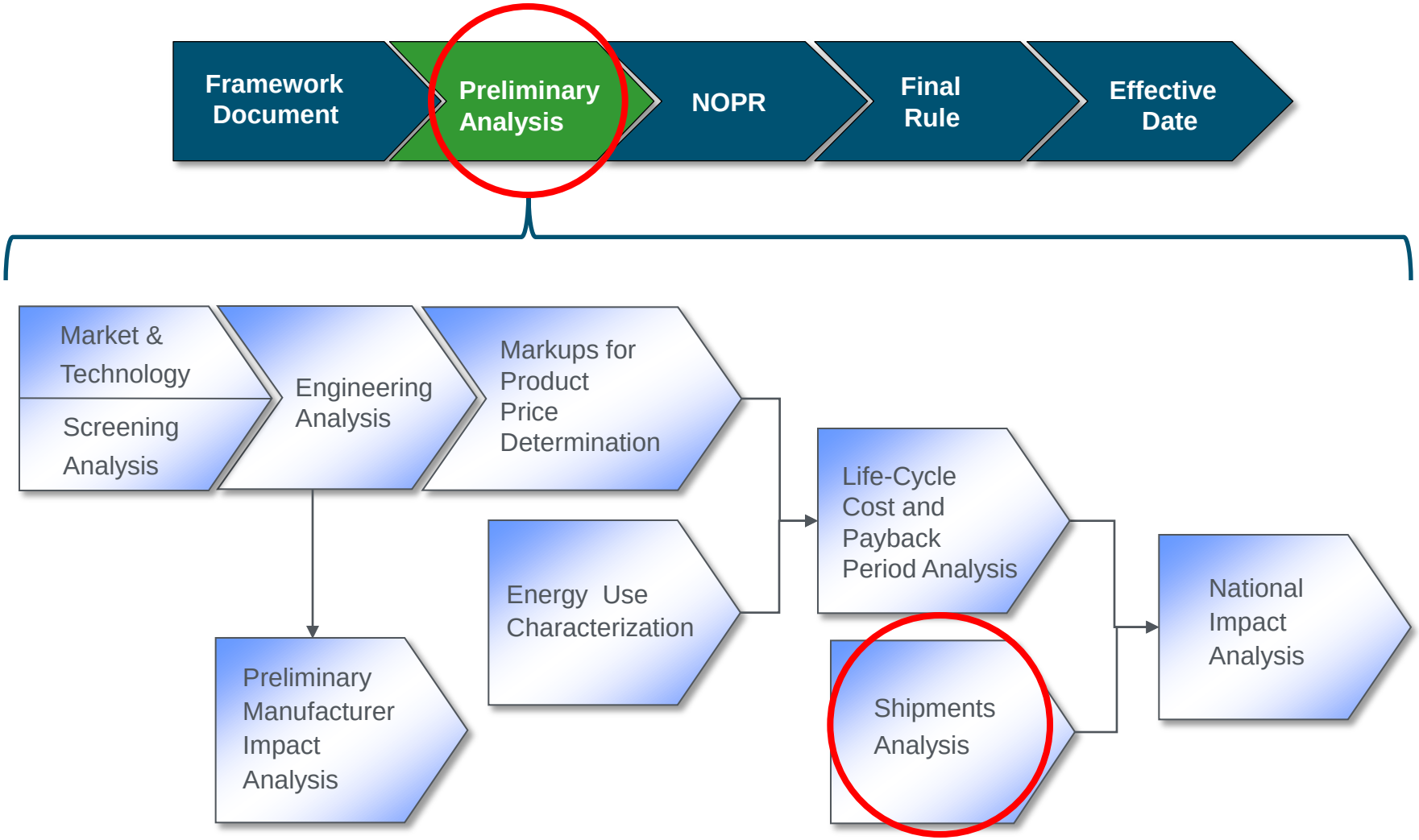
Item 8-3: DOE invites comment on how repair costs may change for more efficient pumps.

Item 8-4: DOE welcomes comment on appropriate pump lifetimes for the equipment classes covered in this rulemaking, as well as data regarding correlation between pump end-use patterns and pump lifetime.

Item 8-5: DOE requests data on the degradation of pump efficiency over a pump's lifetime.

Item 8-6: DOE welcomes input on the proposed approaches for estimating discount rates for pump customers.

Preliminary Analysis



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Shipments Analysis

- **Purpose:**
  - Project future shipments by equipment class

- **Method:**
  - The shipments model will rely on a range of data sources.
  - The model will only consider shipments of covered products.

Shipments Analysis

Approach

- **DOE typically projects shipments for a 30-year period beginning in the expected compliance date of any standards.**
- **DOE will characterize the production of pumps.**
  - Use appropriate growth indices as an indicator of the performance of industrial and commercial sectors where pumps are used
  - Use private fixed investment data for equipment incorporating pumps from the U.S. Department of Commerce's Bureau of Economic Analysis
- **DOE may use different shipments projection in the standards case as compared to the base case.**
  - Shipments may drop as purchase price increases.

Shipments Analysis

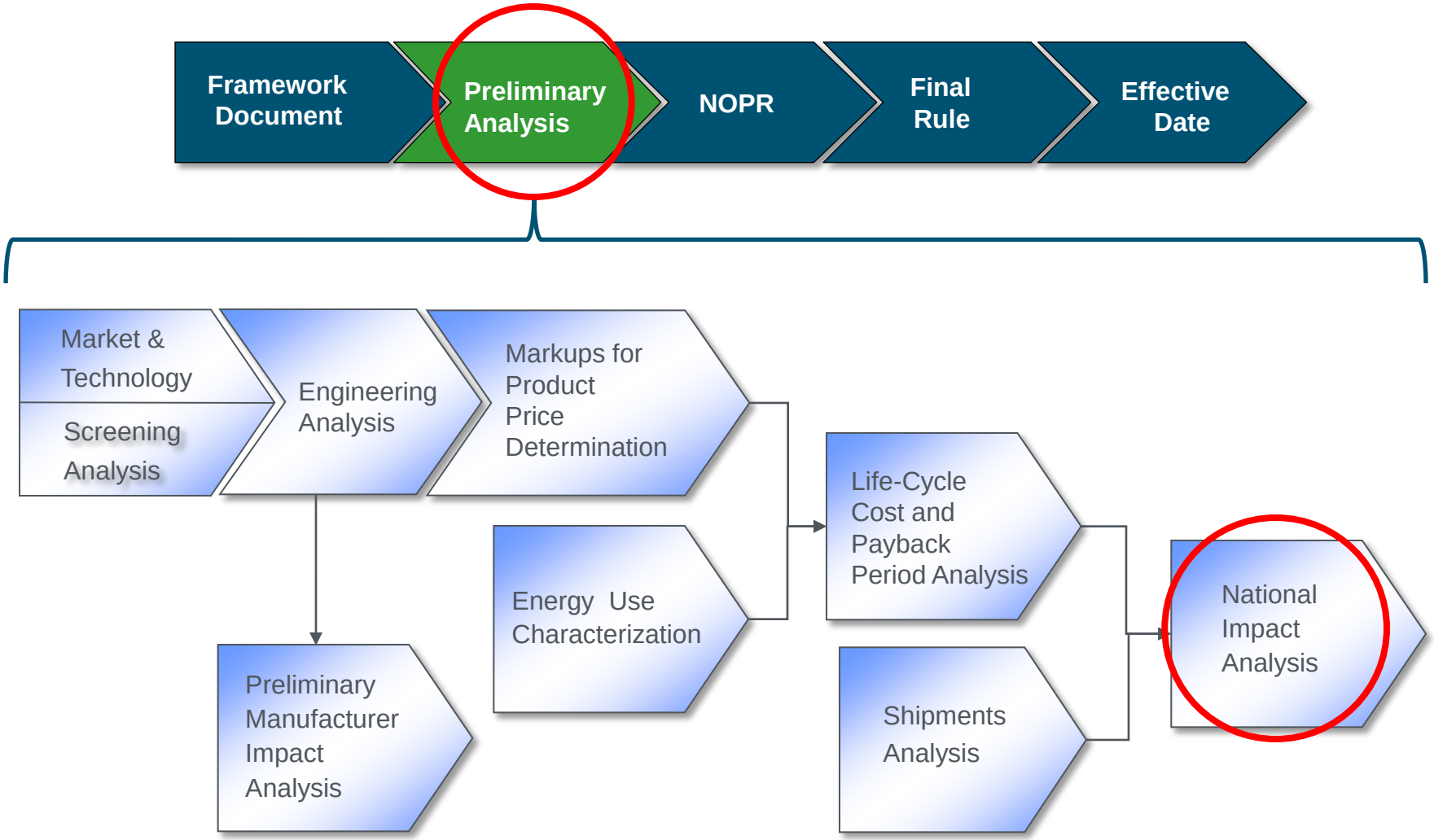
Request for Comment

<u>Item 9-1:</u> DOE welcomes comment on the shipments projection methodology. DOE invites comments regarding the selection of appropriate economic drivers and sources of data for historical shipments and shipment breakdowns by equipment class.

<u>Item 9-2:</u> DOE requests historical shipments or bookings data for each of the considered equipment classes, with further breakdowns where available including, but not limited to, flow, head, specific speed, horsepower, or efficiency.

<u>Item 9-3:</u> DOE welcomes comment on how any standard for pumps might impact shipments of the equipment in this rulemaking.

Preliminary Analysis



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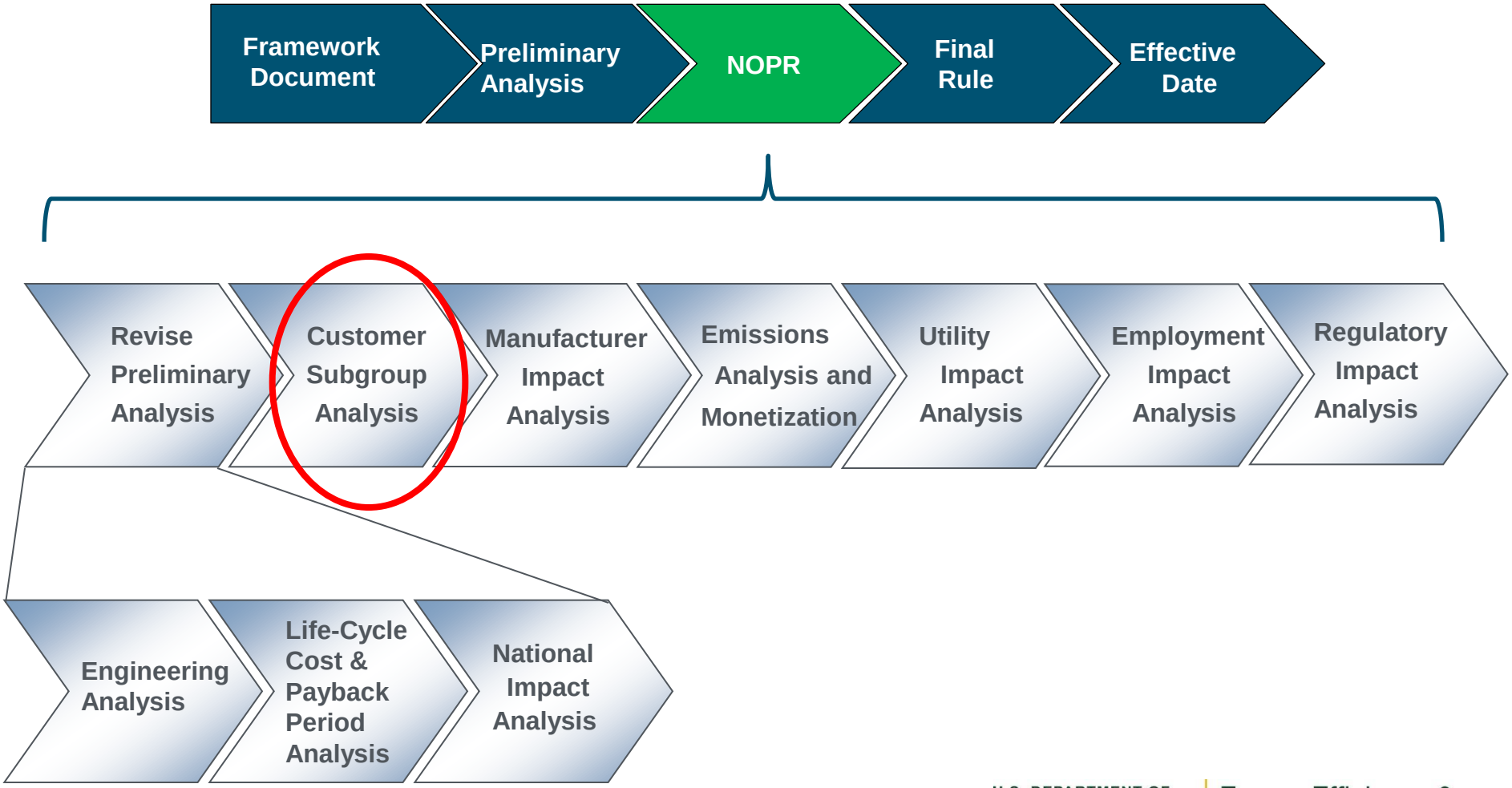
National Impact Analysis

- **Purpose:**
  - Determine the projected national energy savings (NES) and net present value (NPV) of total customer benefits

- **Method:**
  - Develop annual series of national energy and economic impacts
  - Utilize the shipments model to estimate equipment stock each year
  - Utilize the LCC to estimate cost and energy use per unit in any year
  - Project a trend in efficiency in base case and standards case
  - Aggregate the costs and energy use for all years in the analysis period
  - Report NES in primary and full fuel cycle (FFC) savings
  - Report change in national customer NPV (in constant year dollars)
  - Account for the time-value of money though defined discount rates

NOPR Analysis



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NOPR Analysis

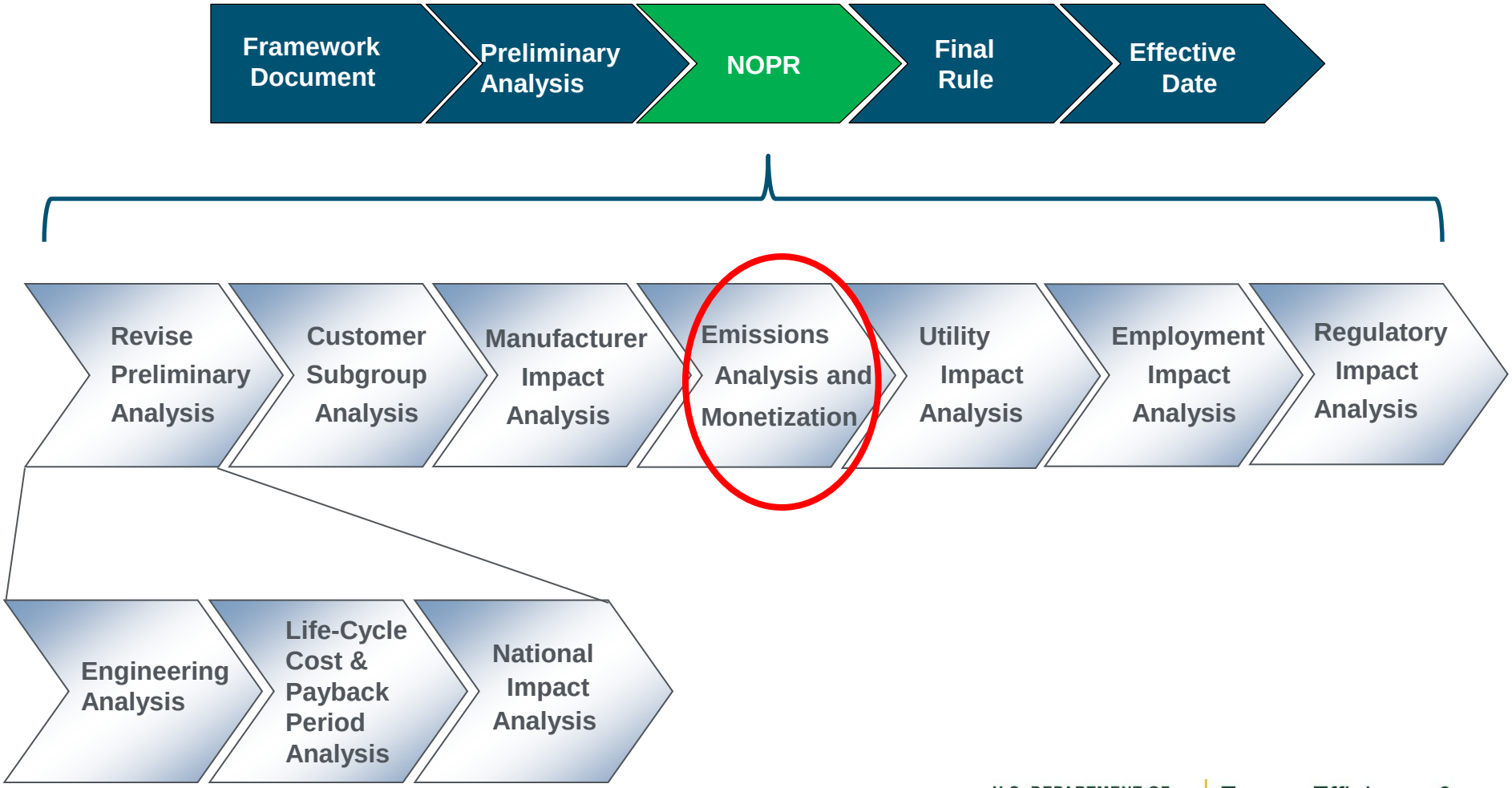
Customer Subgroup Analysis

- **Purpose:**
  - Analyze the economic impacts of standards on customers, including subgroups who may be disproportionately impacted compared with the general user population

- **Method:**
  - Extend the LCC analysis to examine the impacts for defined subgroups

Request for Comment
<u>Item 11-1:</u> DOE welcomes comment on what, if any, user subgroups are appropriate in setting standards for pumps.

NOPR Analysis



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Emissions Analysis

- **Purpose:**
  - Estimate environmental impacts from potential energy conservation standards for pumps including changes in Full Fuel Cycle (FFC) emissions

- **Method:**
  - DOE will base the emission factors for FFC on EIA's Annual Energy Outlook, supplemented by data from other sources.
  - The following emissions are assessed:
    - Carbon dioxide (CO_2)
    - Sulfur dioxide (SO_2)
      - SO_2 emissions from affected electric generating units are subject to nationwide and regional emissions cap and trading programs
    - Nitrogen oxides (NO_x)
      - Clean Air Interstate Rule (CAIR) permanently caps NO_x emissions in 28 eastern States and DC
    - Methane (CH_4)
    - Nitrous Oxide (N_2O)
    - Mercury (Hg)

NOPR Analysis

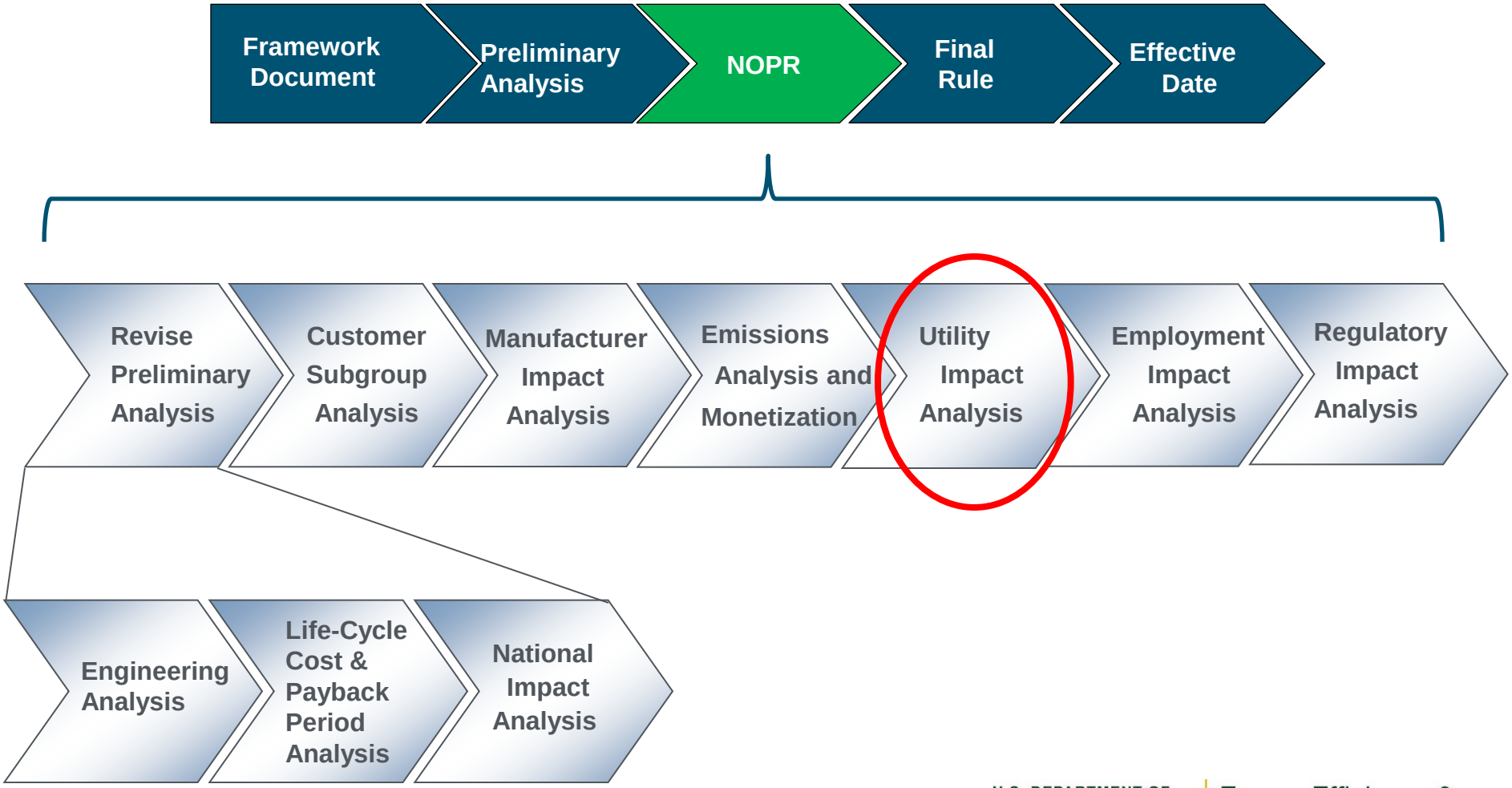
Monetization of Emissions Reductions

- **DOE intends to use the most current Social Cost of Carbon (SCC) values developed by interagency reviews.**
  - SCC is intended to be a monetary measure of the incremental damage resulting from greenhouse gas (GHG) emissions, including but not limited to agricultural productivity loss, human health effects, property damage from rising sea level, and changes in the ecosystem.
- **At present, the most recent interagency estimates of the potential global benefits resulting from reduced CO2 emissions in 2015, expressed in 2011$, were $6.1, $25.4, $41.0, and $77.7 per metric ton avoided.**
  - For emission reductions that occur in later years, these values grow in real terms over time.
- **DOE will also estimate the potential monetary benefit of reduced NO_x emissions resulting from the considered standard levels.**

Emissions Analysis and Monetization of Emission Reductions

Request for Comment
<u>Item 13-1:</u> DOE seeks input on its approach to conducting the emissions analysis for commercial and industrial pumps. **<u>Item 14-1:</u> DOE requests comment on the approach it plans to use for estimating monetary values associated with emissions reductions.**

NOPR Analysis



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Utility Impact Analysis

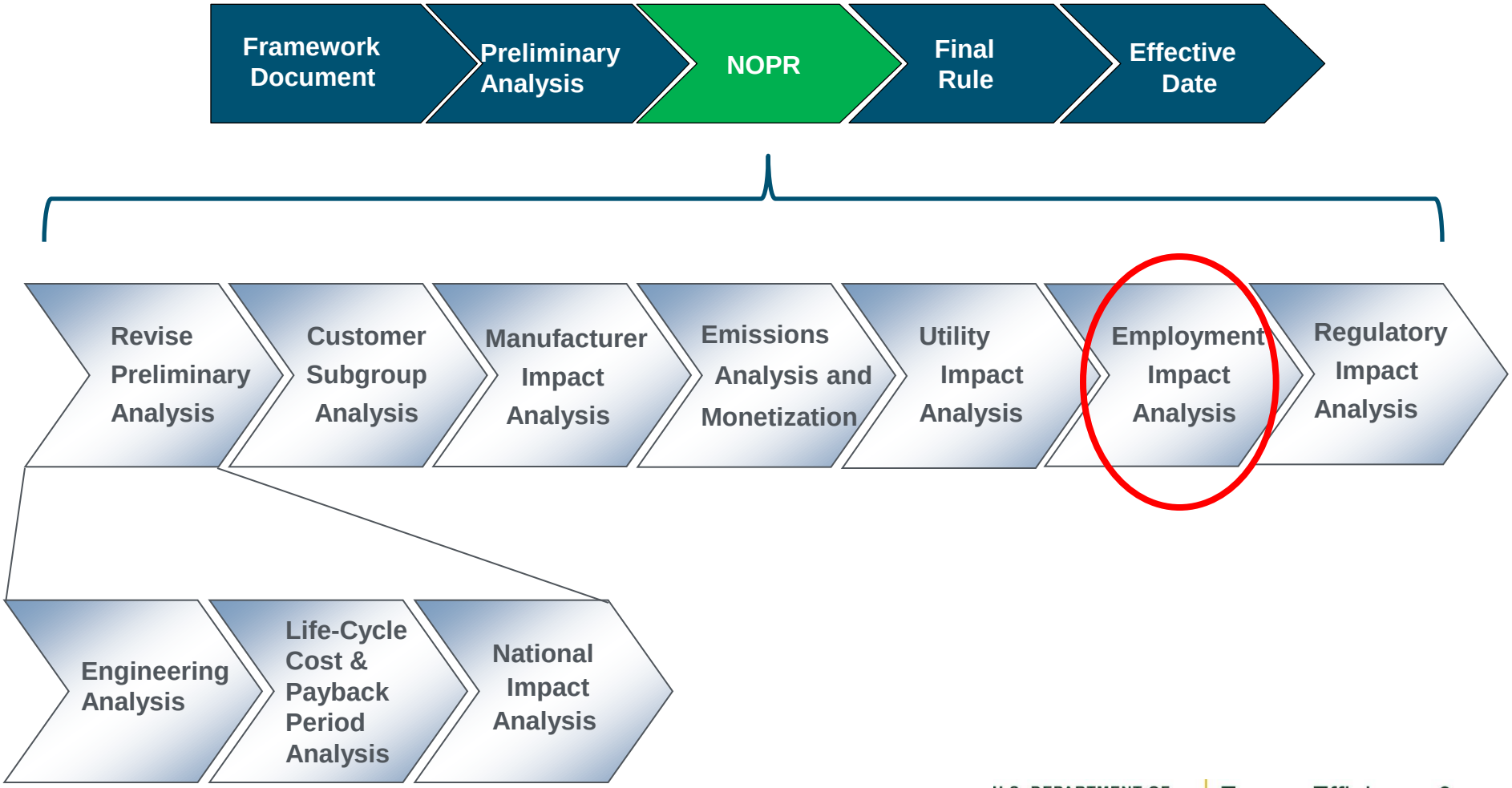
- **Purpose:**
  - Assess the overall impacts on domestic energy supplies that would result from the imposition of standards

- **Method:**
  - DOE proposes to use NEMS-BT, a variant of the NEMS (National Energy Modeling System) developed and used by DOE/EIA for their Annual Energy Outlook (AEO) report, as the basis of the Utility Impact Analysis.
  - Outputs of the utility impact analysis include projections of electricity sales, price, and avoided capacity resulting from a comparison of base and standards cases.
  - DOE will model the energy savings impacts from potential energy conservation standards using NEMS-BT to generate projections that deviate from the AEO reference case.

Utility Impact Analysis

Request for Comment
<u>Item 15-1:</u> DOE welcomes input from interested parties on its proposed approach to conduct the utility impact analysis.

NOPR Analysis



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Employment Impact Analysis

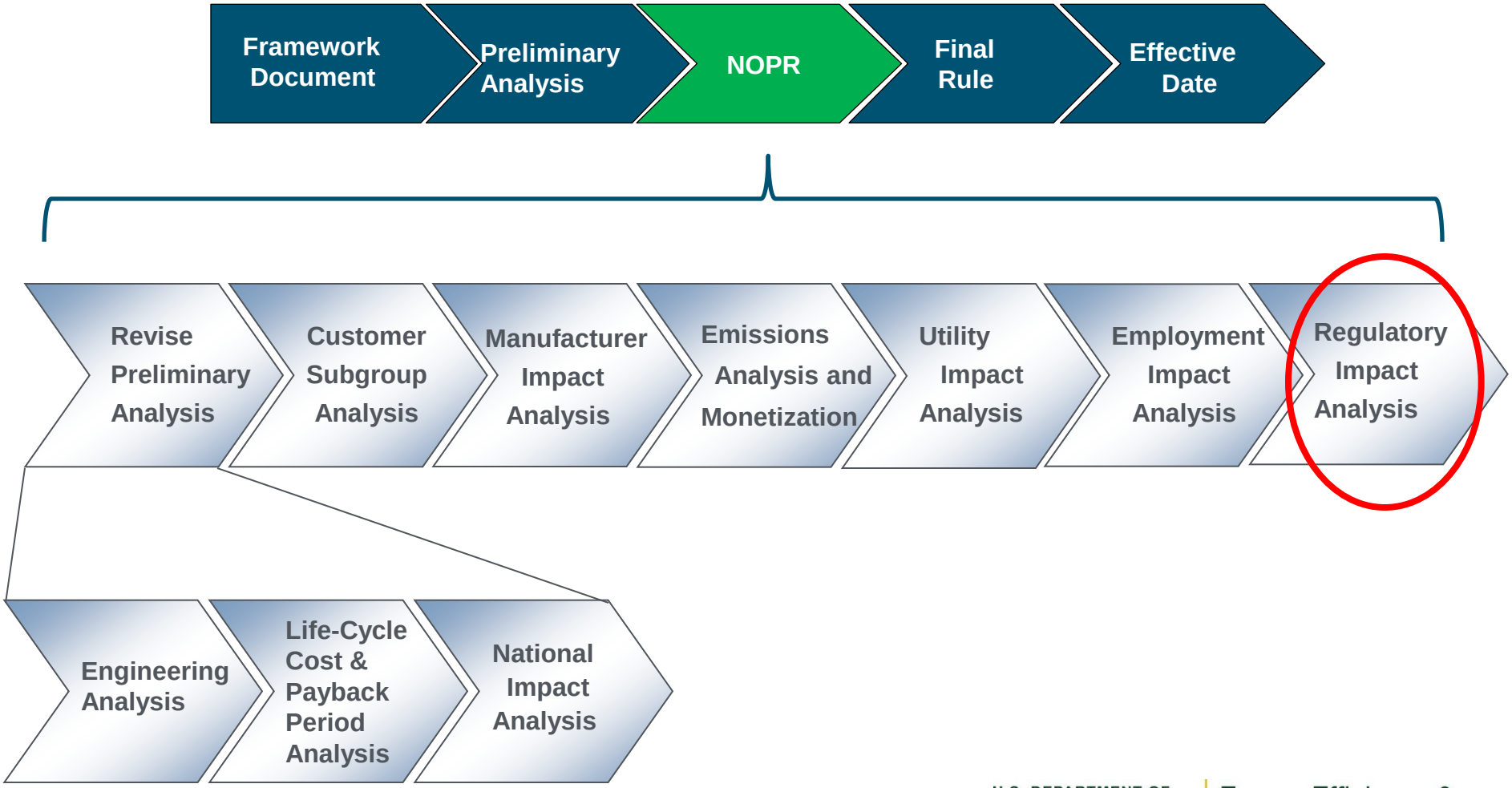
- **Purpose:**
  - Assess the overall impact on national employment from the imposition of efficiency standards at differing levels
  - Include both direct and indirect employment impacts
    - Direct employment impacts are estimated in the manufacturer impact analysis.
    - Indirect employment impacts result from shifting consumer expenditures among goods and services (“substitution effect”) and changing equipment and energy costs (“income effect”).

- **Method:**
  - DOE intends to use the ImSET (Impact of Sector Energy Technologies) model for the evaluation of indirect employment impacts.

Employment Impact Analysis

Request for Comment
<u>Item 16-1:</u> DOE welcomes feedback on its proposed approach to assessing national employment impacts.

NOPR Analysis



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NOPR Analysis

Regulatory Impact Analysis

- **Purpose:**
  - Explore the potential for non-regulatory alternatives to new energy efficiency standards

- **Method:**
  - Base the assessment on the actual impacts of any such initiatives to date, but consider information presented regarding the impacts that any existing initiative might have in the future.

Public Meeting Agenda

1	Introduction
2	Rulemaking Process Overview
3	Legislative History & Coverage
4	Regulatory Regimes & Metrics
5	Test Procedure
6	Rulemaking Analyses
7	Closing Remarks

Closing Remarks

Instructions for Submitting Written Comments

- **In all correspondence, please refer to this Commercial and Industrial Pumps Rulemaking by:**
  - Docket # EERE-2011-BT-STD-0031, and/or RIN 1904-AC54
- **Electronic:** Pumps2011STD0031@ee.doe.gov OR www.regulations.gov
- **Postal Mail:** Ms. Brenda Edwards
  U.S. Department of Energy
  Building Technologies Program, Mailstop EE-2J
  1000 Independence Avenue, SW.
  Washington, D.C. 20585-0121
- **Courier:** Ms. Brenda Edwards, 950 L'Enfant Plaza, SW., 6th Floor
- **Phone:** (202) 586-2945

Comment period closes May 2, 2013