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

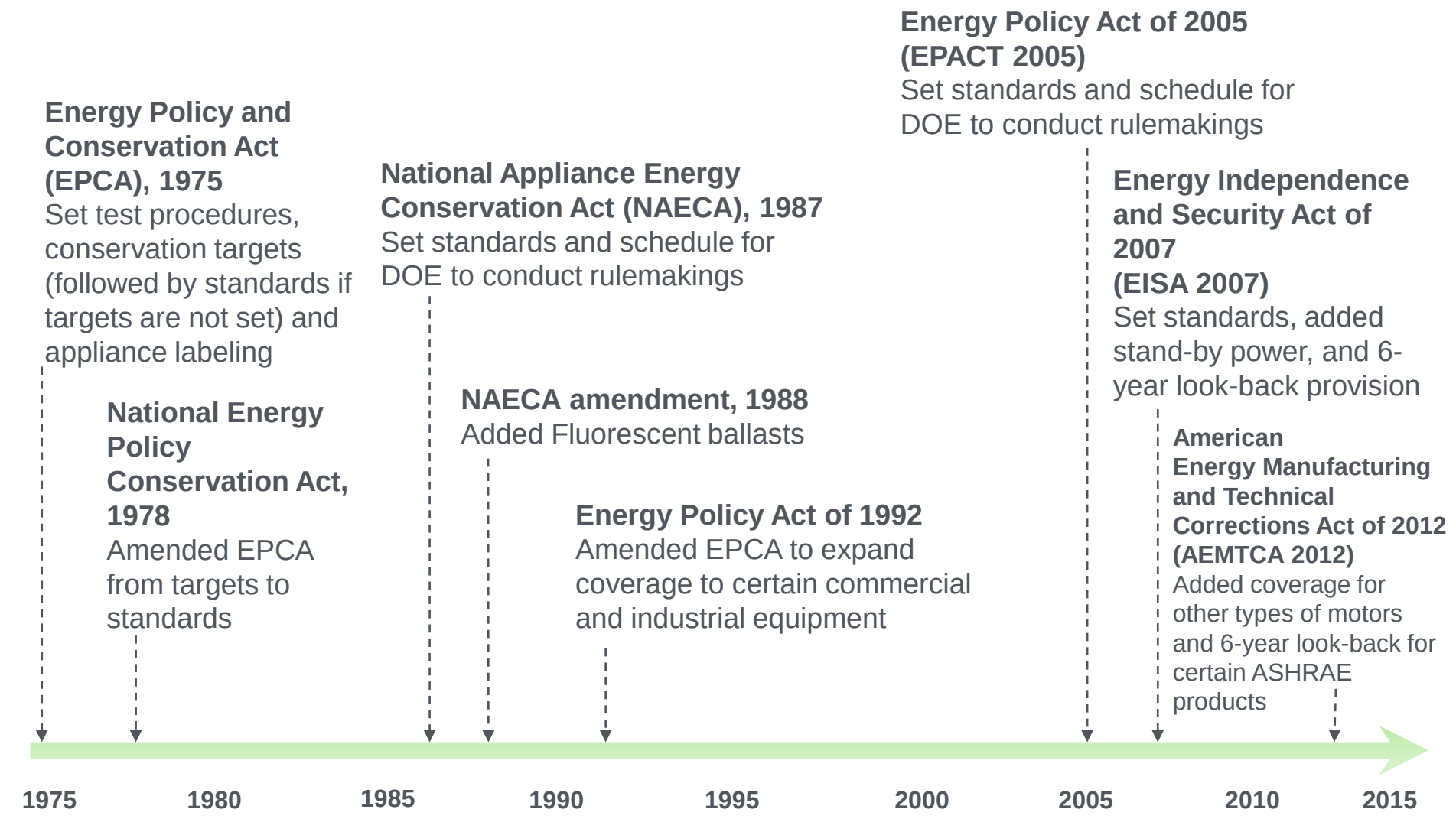
Appliance and Equipment Standards Program

Buildings Technology Office

Analysis Methodology Discussion

November 19, 2019

Legislative history



Legislative requirements

DOE must follow specific statutory criteria for prescribing new and amended standards for covered products and equipment

- 42 USC 6295(o)(2)(A) requires that any new or amended energy conservation standard prescribed by the Secretary for any type (or class) of covered product shall be designed to achieve the maximum improvement in energy or water efficiency, which the Secretary determines is technologically feasible and economically justified.
  - In deciding whether a proposed standard is economically justified, DOE must determine whether the benefits of the standard exceed its burdens.
  - DOE must make this determination after receiving comments on the proposed standard.
- DOE may not adopt any standard that would not result in the significant conservation of energy.

Legislative requirements - continued

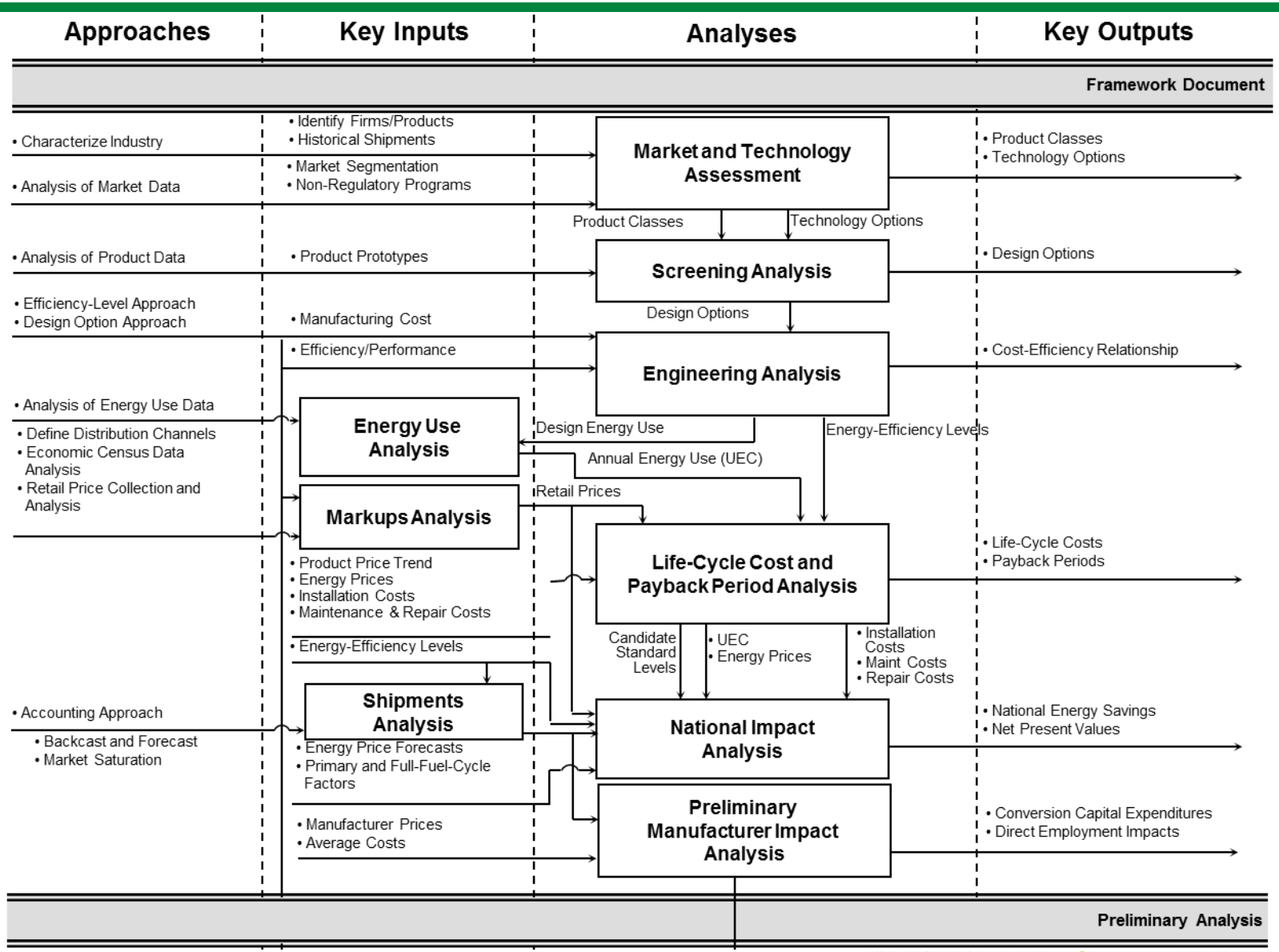
- 42 USC 6295(o)(1) states that The Secretary may not prescribe any amended standard which increases the maximum allowable energy use, or, in the case of showerheads, faucets, water closets, or urinals, water use, or decreases the minimum required energy efficiency, of a covered product.
- 42 USC 6295(o)(4) states that The Secretary may not prescribe an amended or new standard if the standard is likely to result in the unavailability in the United States in any covered product type (or class) of performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as those generally available in the United States at the time of the Secretary's finding.
- For standards, DOE must issue a determination not to amend the standards or a proposal within 6 years of the previous final rule.

Analytical methodology

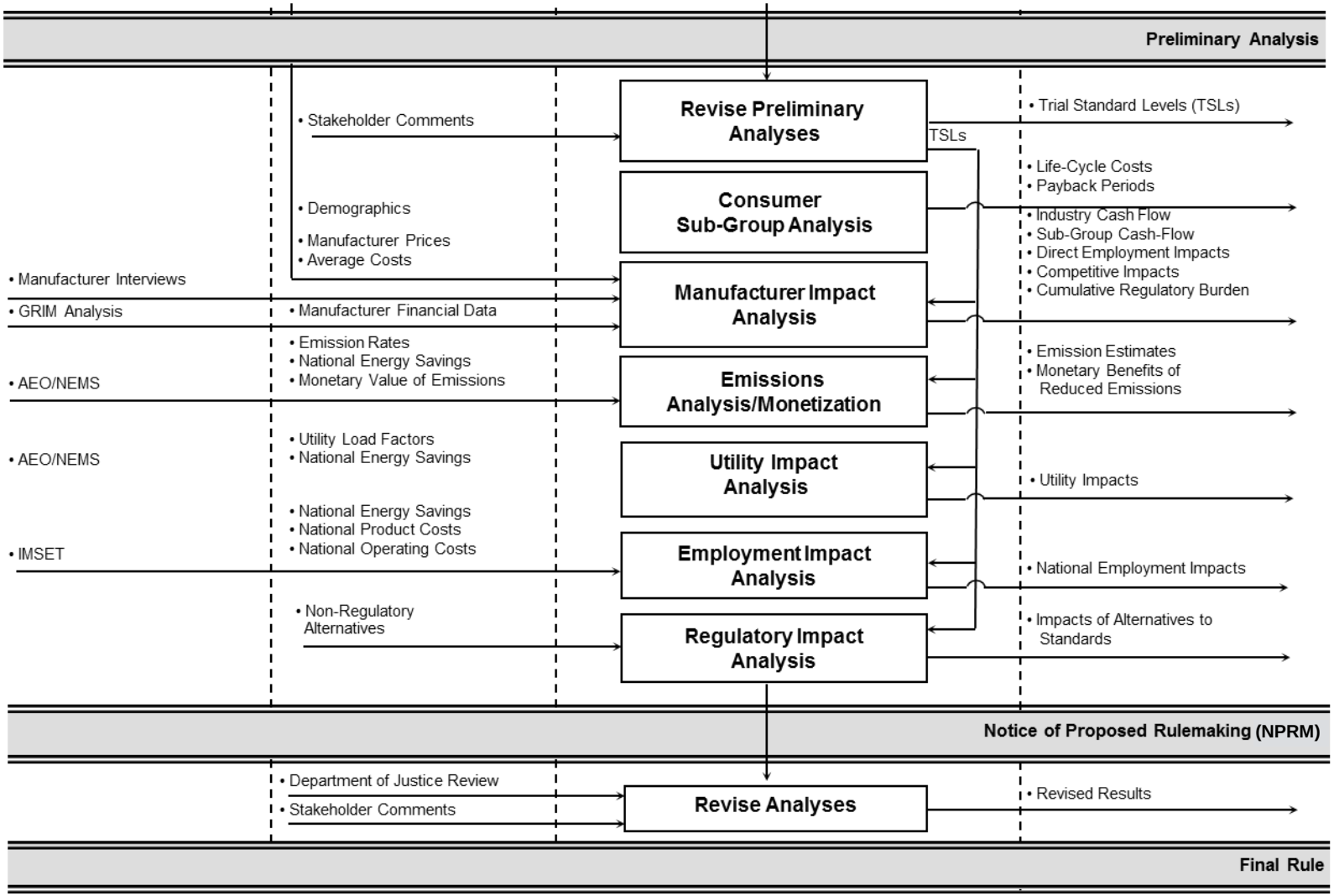
DOE analyses to evaluate statutorily-required factors

EPCA Criteria	Analysis DOE Performs to Address Factor	Rulemaking Stage
1. Economic impact of standard on consumers and manufacturers	Life-Cycle Cost (LCC) and Payback Analysis (including Markups)	Pre-NPRM
	LCC Subgroup Analyses	NPRM
	Manufacturer Impact Analysis	NPRM
2. Lifetime operating cost savings resulting from standard	Life-Cycle Cost and Payback Analysis (including Markups)	Pre-NPRM
3. Total projected energy savings resulting from standard	National Impact Analysis (including Shipments)	Pre-NPRM
4. Impact of standard on utility or performance of products	Screening Analysis	Pre-NPRM
	Engineering Analysis	Pre-NPRM
5. Impact of any lessening of competition likely to result from standard	Manufacturer Impact Analysis	NPRM
6. Need for national energy conservation	National Impact Analysis (including Shipments)	Pre-NPRM
7. Other factors the Secretary considers relevant	Environmental Assessment	NPRM
	Utility Impact Analysis	NPRM
	Employment Impact Analysis	NPRM
	Regulatory Impact Analysis	NPRM

Analytical methodology



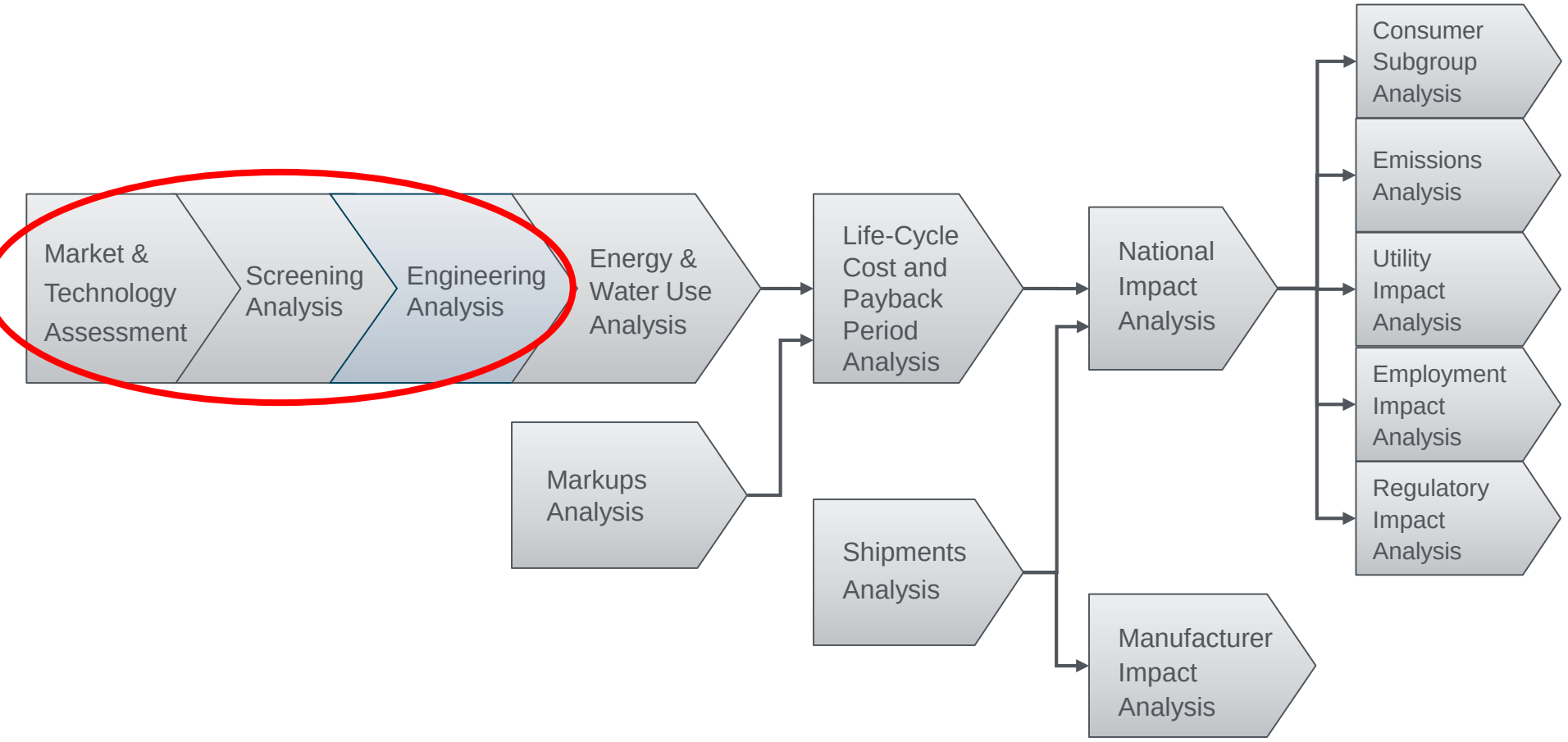
Analytical methodology



Methodological choices

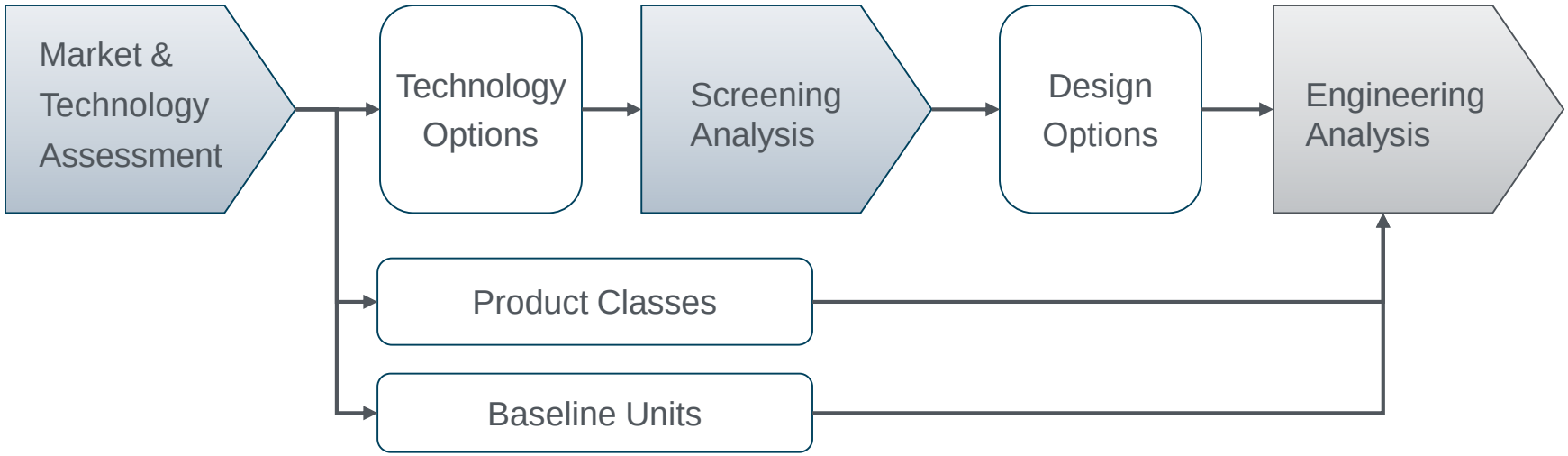
- Analyses have evolved over time in response to various stakeholder comments, OIRA review comments, improved data availability, progress in academic literature
  - Uncertainty analysis, probabilistic inputs, distribution of impacts, elasticities, price projections, consumer choice modeling, field studies & consumer survey studies, online retail data
- Some aspects of analyses are standardized for consistency
  - Time Horizon: 30 year (longest lived product) and 9 year (time between rulemakings for many consumer products), life-cycle cost (LCC) discount rates, emission factors
- Some methodological approaches are required
  - 3% and 7% discount rates in National Impact Analysis, payback period (PBP) analysis

Energy conservation standard analyses



Market & technology assessment

- Purpose:
  - Characterize the industry and market
  - Define **product classes** warranting separate standards
  - Determine **baseline units** for analysis
  - Identify **design options** for improving efficiency
- These serve as inputs to the Engineering Analysis



Technology options and screening analysis

- DOE uses information about commercially available technology options and prototype designs as input in identifying technologies used to attain higher energy efficiency levels.

- DOE screens out certain technology options from further consideration based on the following criteria:
  (1) Technological feasibility.
  (2) Practicability to manufacture, install, and service.
  (3) Impacts on product utility or product availability.
  (4) Adverse impacts on health or safety.

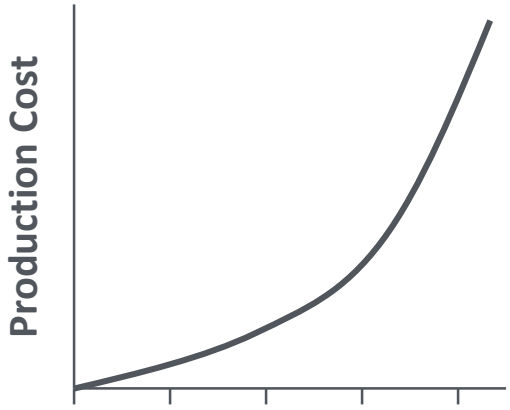
- In addition, DOE does not consider proprietary designs in the engineering analysis and only analyzes ELs met with such designs if there are other non-proprietary technologies capable of achieving the same efficiency level.

- Technologies are also removed from consideration if they don't have an effect on efficiency as measured by the applicable test procedure

Engineering analysis overview

In the Engineering Analysis, cost-efficiency relationships are developed, estimating manufacturer's costs of achieving increased efficiency levels, and determining the maximum technologically feasible efficiency level

Equipment Cost - Efficiency Relationship



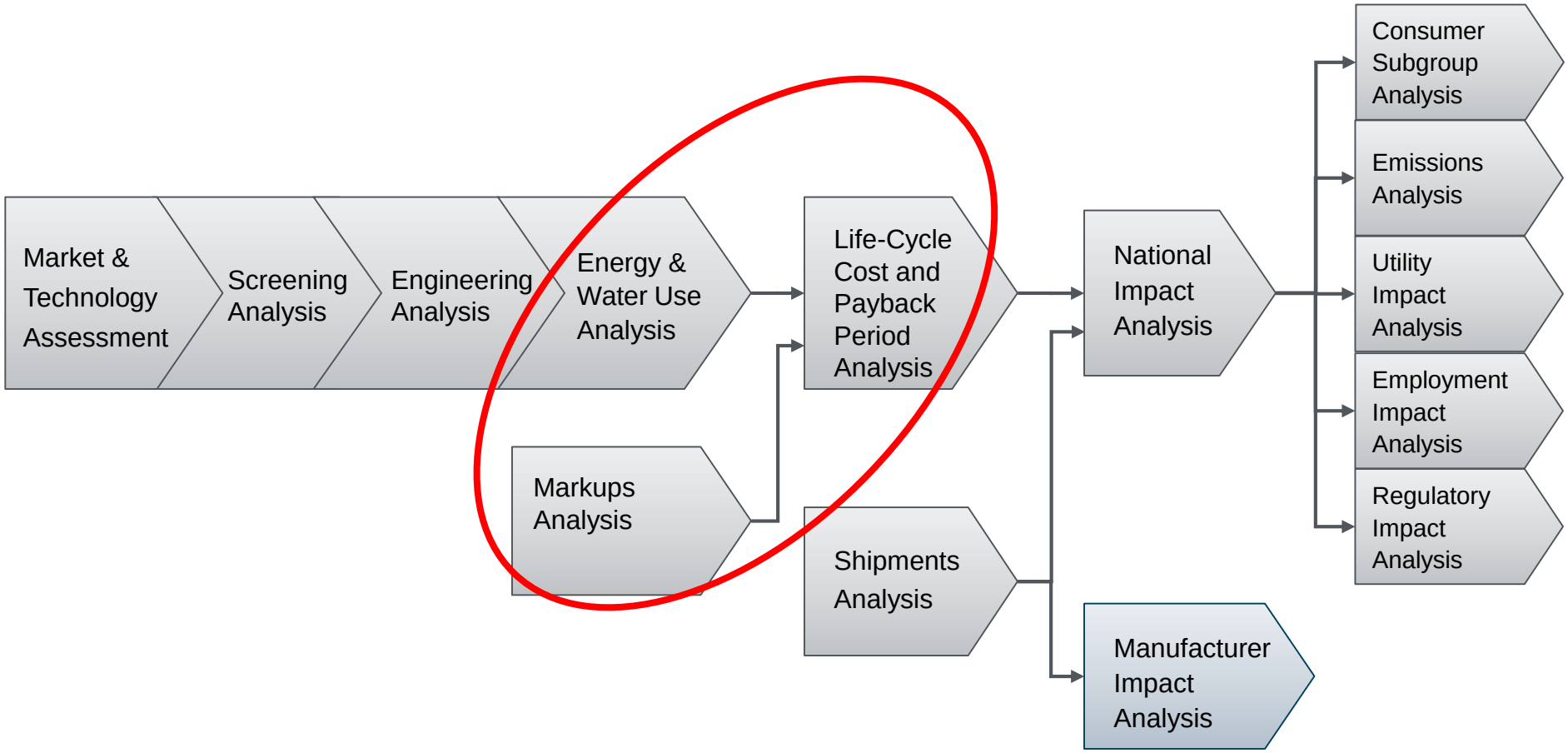
Downstream Analyses

- Consumer Life-Cycle Cost
- Manufacturer Impact
- Employment Impact

Incremental manufacturer production cost (MPC)

- Estimate incremental manufacturer production cost (MPC)
  - Disassemble ("tear down") products from multiple manufacturers, at multiple efficiency levels.
  - For each teardown, measure size, weight, method of manufacture, and manufacturing details for each component as the unit is disassembled to a Bill of Materials (BOM) to generate cost estimates of units taken apart
  - Modify BOMs as applicable to incorporate more efficient design options.
- Apply derived manufacturer markups to the MPCs to calculate the manufacturer selling prices (MSPs).
- Construct Cost-Efficiency curves
- As feasible, compare cost-efficiency curves to existing market efficiency and prices data and/or stakeholder-provided data

Energy conservation standard analyses



Markups analysis

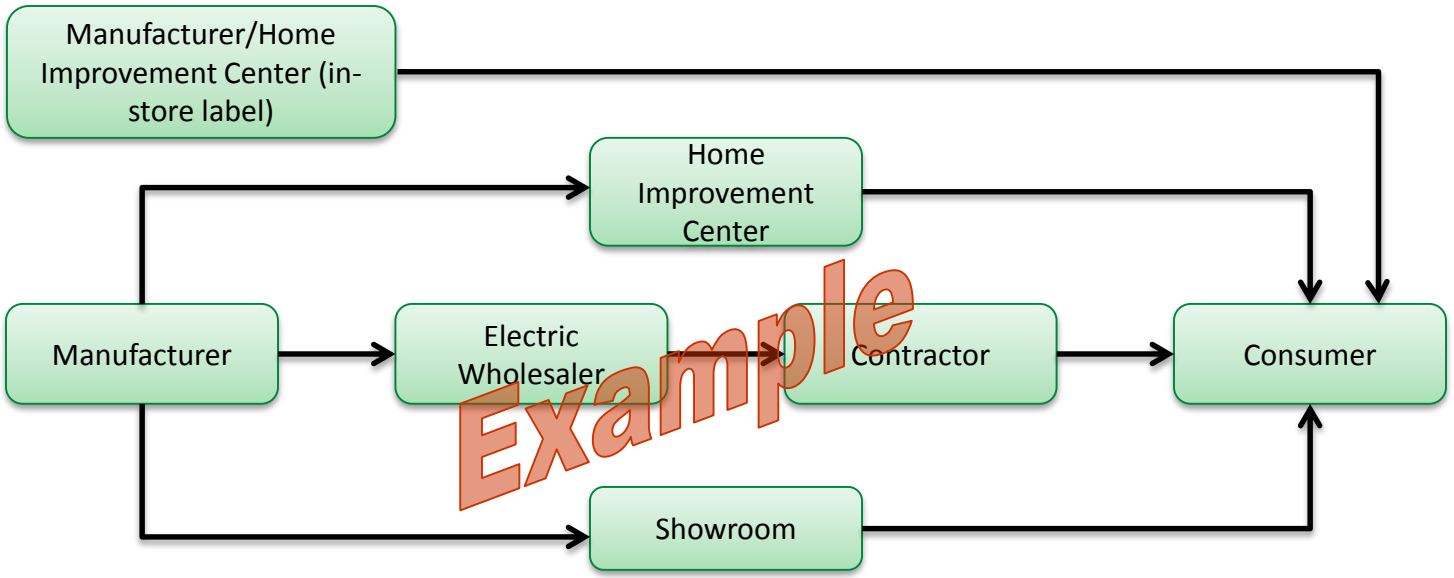
Markups to Determine Equipment Price

- **Purpose**
  - Determine consumer retail or customer equipment prices under a standards scenario based on manufacturer costs.
  - Characterize equipment distribution channels and market segments.
  - For all the parties downstream from the manufacturer that distribute and sell the equipment to consumers, describe their direct costs, expenses, and profits.
- **Inputs**
  - Firm balance sheets, trade association reports, U.S. Census Bureau data and U.S. Securities and Exchange Commission 10-K reports.
    - For example for distributors: Distributors: U.S. Census Bureau Financial Data for Merchant Wholesalers, Machinery, Equipment, and Supplies
- **Output**
  - Baseline and incremental markups for each distribution channel.

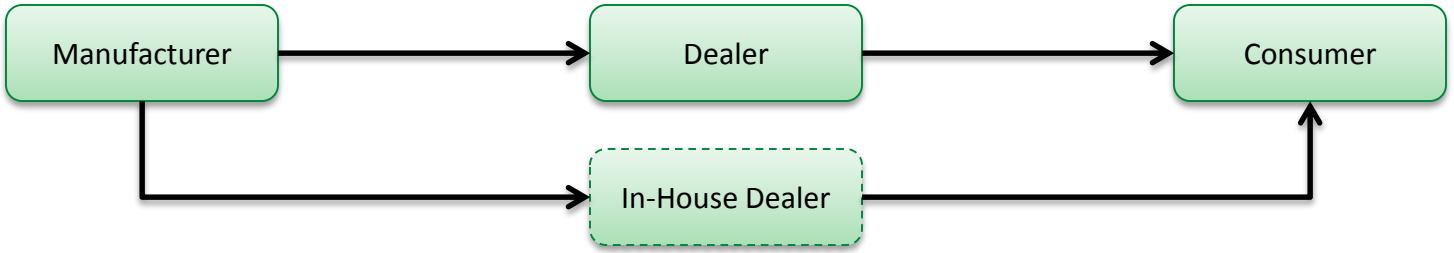
Markups analysis

Distribution channels consist of several parties

Ceiling Fan Distribution Channels for Huggers, Standard and VSD



Distribution Channels for Large-Diameter and HSSD Ceiling Fans



Life-cycle cost and payback period analysis

- **Purpose**
  - Provide an economic evaluation from the consumer's perspective.
  - Life-Cycle Cost (LCC) is the total consumer cost over the life of the equipment.
  - Payback Period (PBP) is the time required to recover the increased purchase price of more energy-efficient equipment through reduced operating costs.

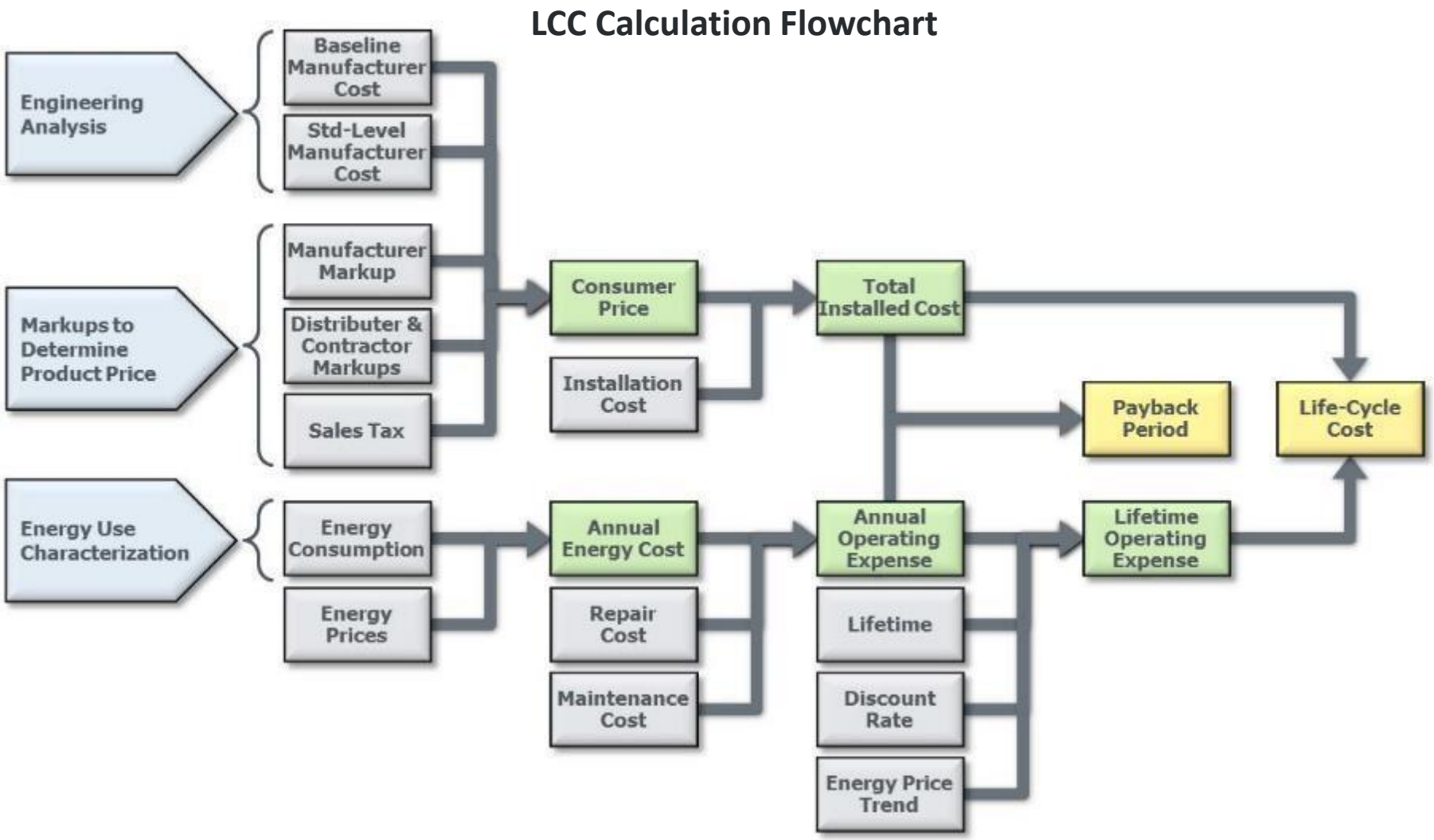
- **Method**
  - Use consumer samples typically developed from RECS and/or AHS for residential products and CBECS for commercial equipment.
  - Determine total installed costs for baseline and each potential efficiency level (EL).
  - Determine first-year and equipment lifetime operating costs.
  - Calculate PBP by dividing average increase in installed cost by average decrease in first-year operating cost.
  - Calculate LCC by adding installed cost and lifetime operating costs.
  - Calculate LCC savings by subtracting LCC of each EL from LCC of the EL that customer would purchase in the absence of a new standard.

Life-cycle cost and payback period analysis

Consumer Sample and Monte Carlo Simulation

- **Consumer samples are based on the households or buildings using the appliance or equipment.**
  - Each household or building has a weight indicating its representativeness in the U.S. housing or building stock.
- **Monte Carlo simulation "runs through" the consumer sample a single household at a time.**
  - Household selected based on its weight (a representative weight provided by RECS and CBECS).
  - Inputs that are not correlated to building characteristics are randomly assigned.
  - LCC and PBP analysis spreadsheet or program is distributed specifying a "seed" value for the simulation.
    - Random number generation uses same sequence.
    - Yields same simulation results on the same computer and likely across different computers.
    - Without a "seed" value specified simulation results will differ only slightly.
  - Monte Carlo simulation for DOE analysis run with 10,000 iterations, which produces a distribution of LCC and PBP results.

Life-cycle cost and payback period analysis

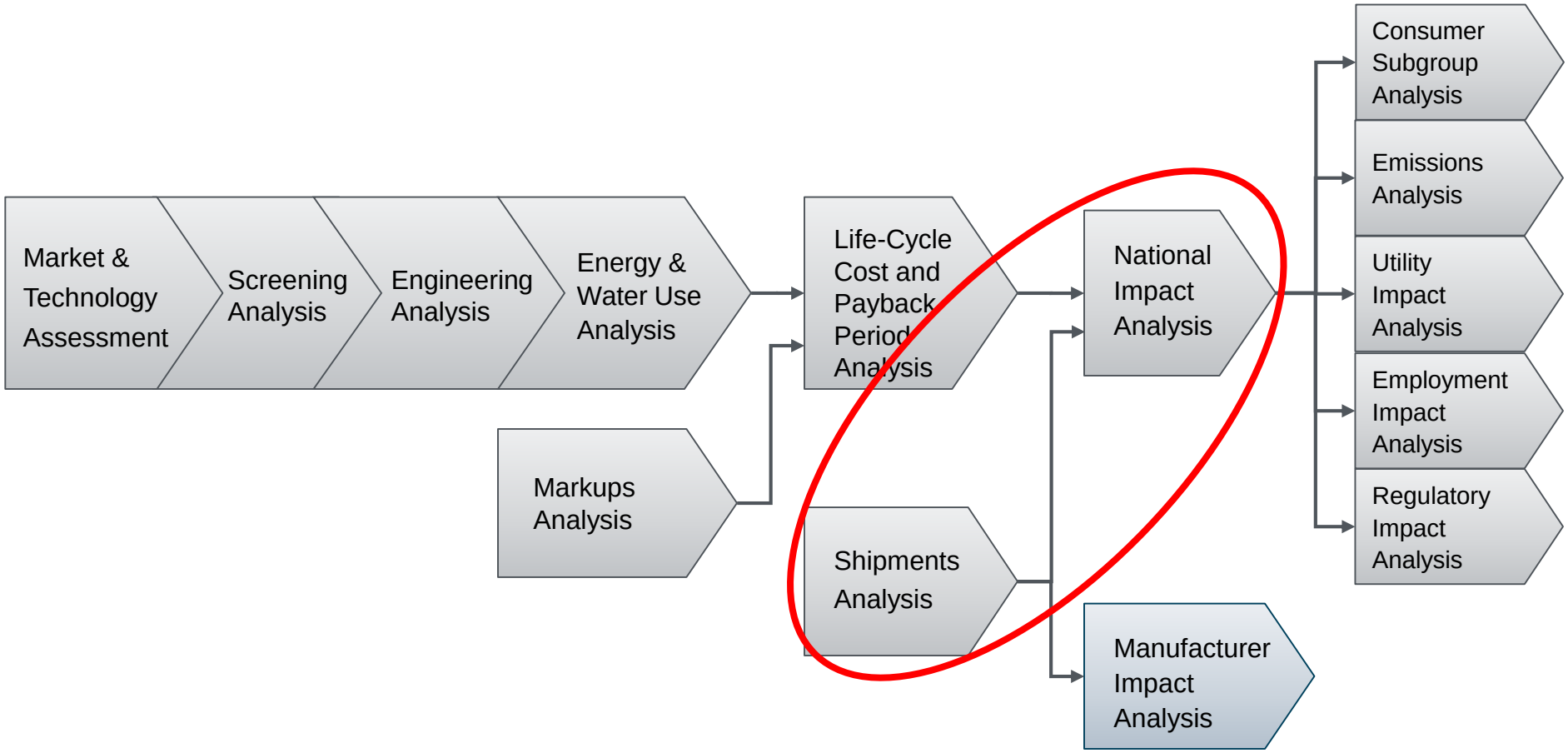


Life-cycle cost and payback period analysis

Discount Rates

- **Used to convert the future value of cash flows (operating costs) to a present value.**
- **For LCC, rates are based on the finance cost of raising funds to purchase appliances or equipment.**
  - Financial cost of any debt incurred to purchase equipment for a given consumer.
  - Opportunity cost of any equity used to purchase equipment for a given consumer.
  - Rates differ from NIA, which analyses impacts from the perspective of the entire Nation.
- **Residential Rates**
  - Weighted-average real rate associated with various household equity (e.g., savings bonds, stocks, CDs) and debt (e.g., credit card, home equity loans).
  - Primary data source: Federal Reserve Board's *Survey of Consumer Finances.*
- **Commercial Rates**
  - Calculated from the weighted-average cost of capital to the firm (WACC) to obtain equity and debt financing using capital asset pricing model (CAPM).
  - Damodaran Online is a source of information about company debt and equity financing.
    - Financial cost of any debt incurred to purchase equipment.
    - Opportunity cost of any equity to purchase equipment.
  - Discount rates estimated for the types of firms on whose premise a piece of equipment is located.
    - Sectors for which discount rates are developed: Retail, Property Owners, Medical Services, Lodging, Food Service, Offices, Industrial, and Public.

Energy conservation standard analyses



Shipments analysis

- **Purpose**
  - Project new equipment shipments under possible standards.
  - Track the stock of equipment, by vintage, over the analysis period.

- **Method**
  - **The life cycle of equipment is modeled as a "birth–death" process in which equipment changes from one state to another**
    - New equipment is purchased and shipped to the site where it is installed.
    - Equipment operates for some number of years.
    - The equipment is retired.
  - **The model is probabilistic**
    - The change from one state to another is determined by a probability function.
  - **A new purchase is influenced by several factors**
    - Consumer choice modeling.
    - Equipment failures.
    - New building construction rates.
  - **The model is calibrated to historical shipments and market saturation data**

Shipments analysis

Consumer Choice Modeling

- A consumer-choice model projects market share of efficiency by efficiency level and product class
- Model is set up so that consumer chooses amongst set of finite options based on sensitivity to first cost, operating cost, utility, and any other relevant factors
- Prior analyses have utilized a variety of methods to model specific choices, for example:
  - Decision trees such as repairing vs. replacing (e.g., HVAC equipment), switching to alternative product/product classes with differing fuels (e.g., gas equipment), determination of equipment specifications based on industry metrics (e.g., transformers)
  - Conditional logit models sensitive to first cost only (e.g., ceiling fans) and models sensitive to first cost and operational costs (e.g., general service fluorescent lighting)
- Analysis requires significant historical data to develop and calibrate a robust model
- This continues to be an active area of research and refinement in ongoing rulemakings

National impact analysis

Differences between LCC Analysis and NIA

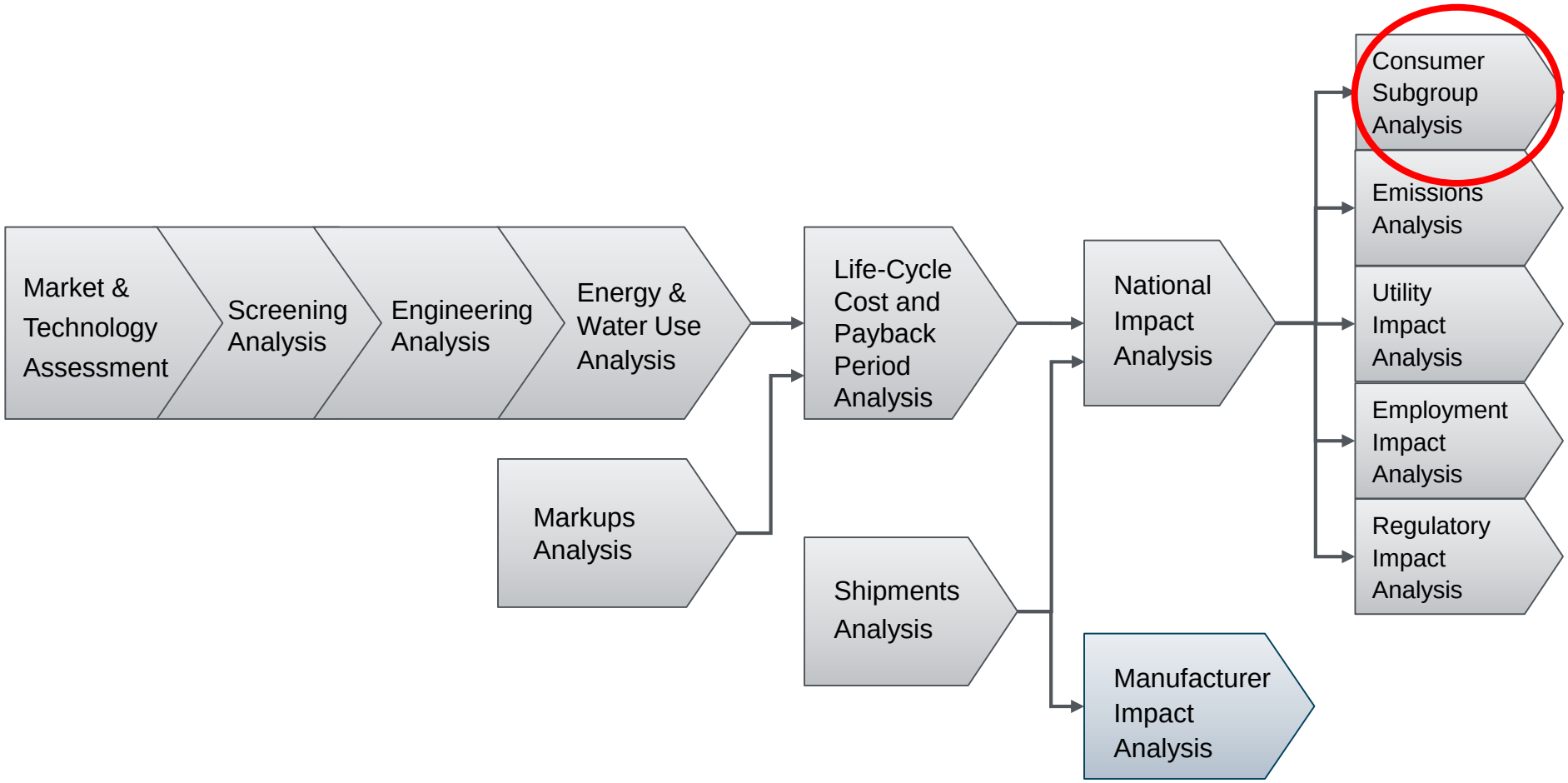
Life-Cycle Costs	National Impact

• Static difference as if all equipment purchases are made in the same year
• Net LCC savings (or costs) from statistically representative cross-section of individual consumers
	• Difference between two time-dynamic scenarios –without and with new energy efficiency standards
	• Aggregate national impacts
	  • Energy savings
	  • Net Present Value

National impact analysis

- **Purpose**
  - To estimate the National Energy Savings (NES) efficiency standards at different levels.
    - National energy savings calculated for equipment shipped over a 30 year period.
  - To estimate the national economic impact on the nation (or the Net Present Value (NPV)) from standards at different levels.
    - Difference between national total installed cost increases and national operating cost savings.
    - NPV calculated for equipment shipped over 30 years of shipments.
- **Method**
  - Utilize a shipments model to estimate the total stock of units in service in any year.
  - Utilize the LCC analysis to estimate the average cost and energy use per unit in any given year, by efficiency level.
  - Aggregate the costs and energy use, by vintage and efficiency level, for a number of years in the analysis period (typically 30 and 9).
  - Account for energy at the source of production not the site of consumption, including all upstream energy consumption.
  - Account for the time value of money using 3% and 7% discount rate as mandated by OMB.

Energy conservation standard analyses



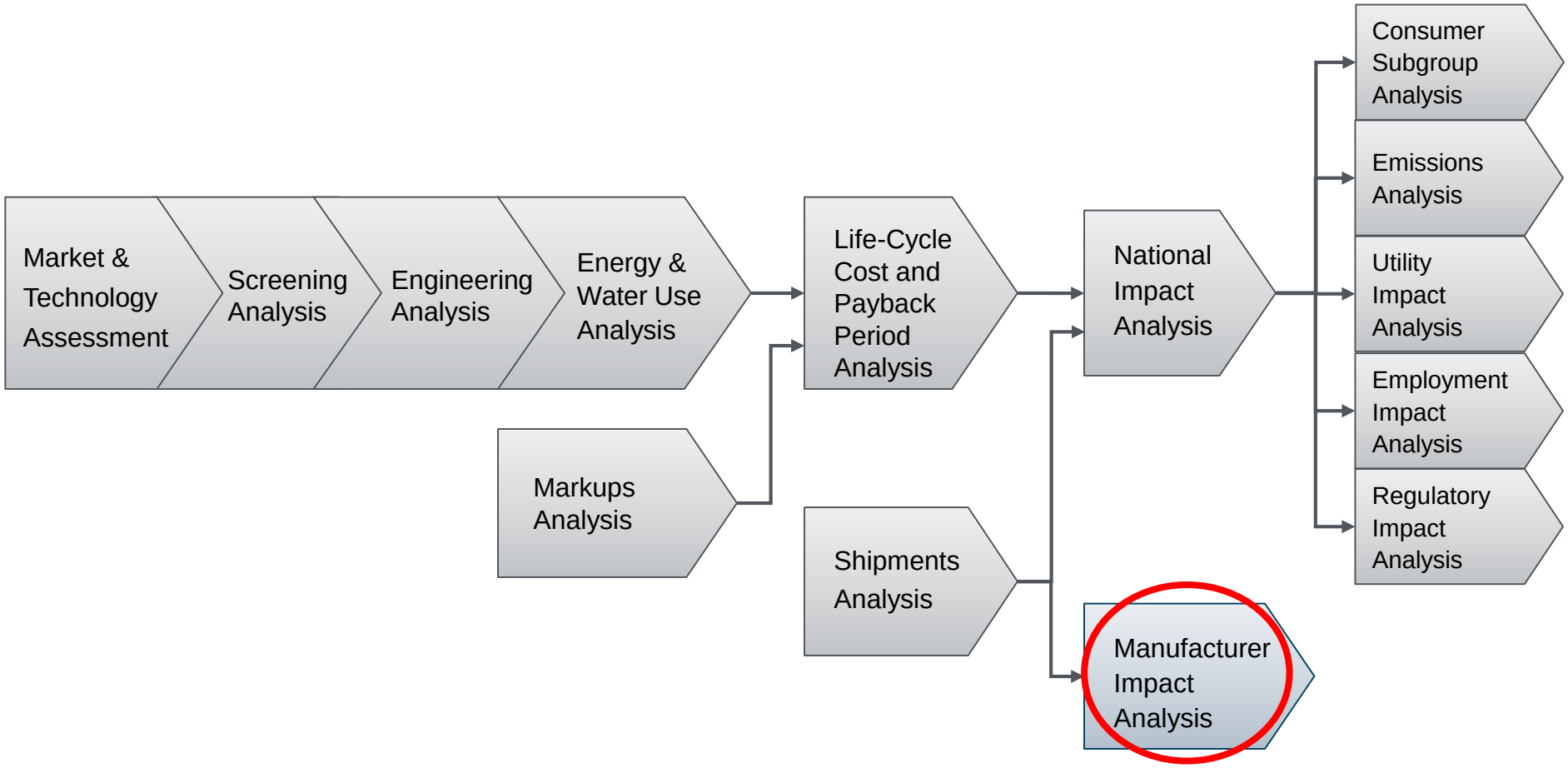
LCC subgroup analysis

Assesses whether significant subgroups of consumers will bear significant adverse impacts

- **Method**
  - Same as the LCC analysis but a smaller sample of consumers are analyzed.
  - Focus is on subgroups that may be disproportionately impacted compared to average consumer

- **Inputs**
  - Typical residential consumer subgroups that may bear adverse impacts.
    - Low-income
    - Seniors
  - Typical commercial consumer subgroups that may bear adverse impacts.
    - Small businesses (i.e., low annual revenues)

Energy conservation standard analyses



Manufacturer impact analysis (MIA)

- Purpose
  - Assess the impacts of standards on industry
    - Model the financial impacts of regulatory scenarios
    - Examine direct employment, cumulative regulatory burden, and competitiveness impacts on industry

- Methodology
  - Phase 1: develop profile of the industry
  - Phase 2: analyze public financials and prepare industry interview guide
  - Phase 3: interview manufacturers, model conversion costs, assess financial and quantitative impacts, report on qualitative impacts

Cumulative regulatory burden (CRB)

CRB is defined at 10 CFR Ch II. Pt. 430, Subpart C., App. A.

- To constitute CRB, a regulation must:
  - Be a Federal regulator action
  - Be product-specific in nature
  - Occur within three years of the effective date of the proposed rule
  - Affect the same manufacturers, or division thereof

Where CRB affects identical manufacturers, products, and revenue streams in the timeframe of the standard, DOE has taken additional steps to integrate CRB into its engineering and MIA analyses.

- Beverage Vending Machines (BVM)
  - DOE analysis estimated and accounted for costs related to EPA SNAP compliance
  - DOE aligned compliance year of the standard with compliance year of the EPA regulation

- Commercial Unitary Air Conditioners
  - Through a negotiated rulemaking, DOE aligned the compliance year of the CUAC standard with the expected timeframe of the Montreal Protocol phaseout of HFCs for air-conditioning applications

MIA: Direct employment analysis

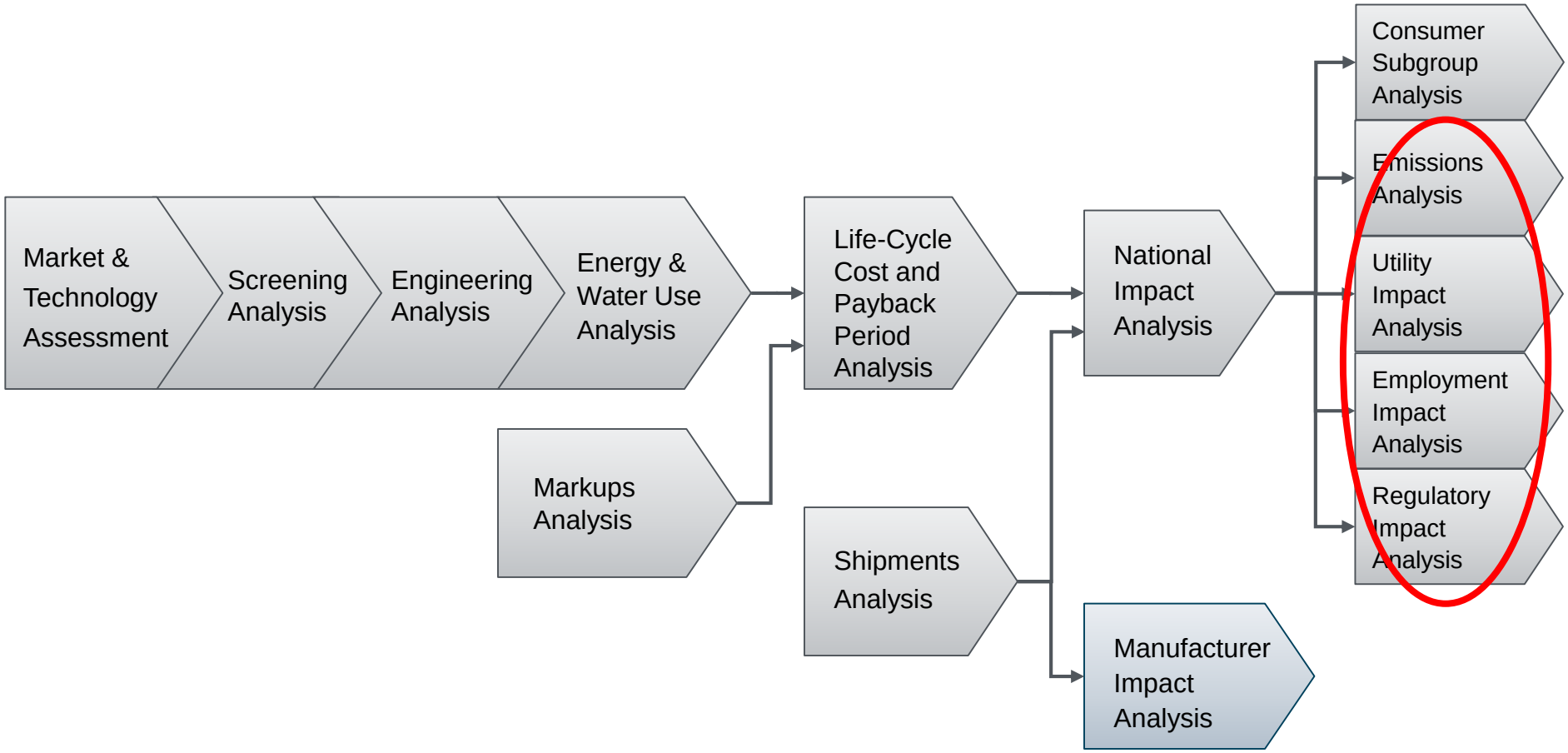
Using the GRIM, DOE assesses the change in employment at the regulated entities (the manufacturers).

The change in direct employment is based on:

- Change in units shipped
- Change in efficiency distribution
- Change in labor content between efficiency levels
- Average production worker wages

Direct employment impacts in the MIA are typically small relative to the broader indirect employment impacts estimated using IMSET in the Employment Impact Analysis.

Other standard impact analyses



Other analyses

Utility Impact Analysis, Environmental Assessment, Employment Impact Analysis, and Regulatory Impact Analysis

- DOE must perform a variety of "other" analyses to fulfill its regulatory requirements and ensure that all potential impacts of proposed standards have been considered
- These "other"analyses include:
  - **Emissions Impact**
    - Estimate full-fuel-cycle emissions reductions resulting from amended energy conservation standards including carbon dioxide (CO_2), sulfur dioxide (SO_2), nitrogen oxides (NO_X), nitrous oxide (N_2O), methane (CH_4), mercury (Hg).
    - Use latest AEO to derive emissions factors applied to annual energy savings from NIA.
  - **Emissions Monetization**
    - DOE used the most current Social Cost of Carbon (SCC) values developed by an interagency process.
    - DOE also monetizes the NO_x emissions reductions resulting from amended standards.
  - **Utility Impact**
    - DOE estimates changes in electric installed capacity and generation that result from amended energy conservation standards (as compared to the base case).
    - Uses cases published from the National Energy Modeling System (NEMS) that incorporate efficiency-related policies to estimate the marginal impacts of reduced energy demand on the utility sector.
  - **Employment**
    - Uses the ImSET (Impact of Sector Energy Technologies) model for the evaluation of indirect employment impacts resulting from amended energy conservation standards.
  - **Regulatory Impact**
    - DOE modifies the NIA to analyze the six non-regulatory alternatives and their impact on purchase price and energy use; presents NES and NPV for these alternatives.

Regulatory Flexibility Act

Regulatory Flexibility Act of 1980 (codified at 5 U.S.C. 601) requires agencies to analyze the impacts of rules on small entities.

- Threshold Analysis:
  - Will the rule have a significant economic impact on a substantial number of small entities?

- Initial Regulatory Flexibility Analysis (IRFA) for proposed rules:
  - Description and estimate number of small entities
  - Estimate of compliance requirements for small entities
  - Significant alternatives

- Final Regulatory Flexibility Analysis (FRFA) for final rules:
  - Summary of significant issues raised by public comments
  - Updated description and estimate number of small entities
  - Updated estimate of compliance requirements for small entities
  - Steps taken to minimize adverse impacts