Energy Systems Fundamentals: Energy Efficiency and Utility Demand-Side Management

USAID – The Fundamentals of Energy Systems for Program Managers
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Overview

1. **The Big Picture**: Framing energy efficiency (EE) policies and programs
   - Definition of energy efficiency
   - The policy and business cases for energy efficiency
   - Energy efficiency policy frameworks
2. **Narrowing the Picture**: Implementing EE in utility demand-side management (DSM)
   - DSM analysis and program planning
     - **Case study: Tanzania**
   - DSM program design and implementation
   - Program evaluation

This session focuses on EE in utility customer end-uses, leaving aside power generation, transport, agricultural, mining sectors.

1. Big Picture: Framing EE Policies and Programs

Definition of Energy Efficiency

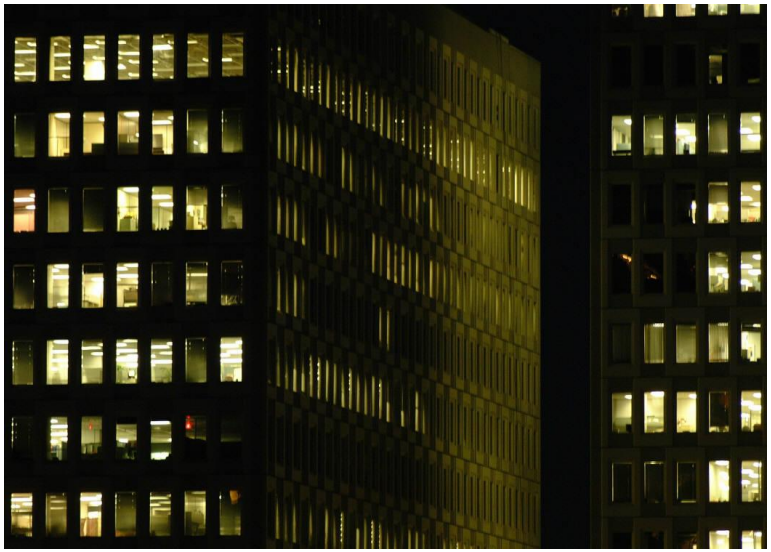
Provides equal or better end-use energy services with less energy supply commodity.

QUESTION: What are some examples?

- Replacing inefficient end-use technologies with more-efficient models
- Retrofitting whole buildings with insulation, better windows, better equipment to improve efficiency
- Operating buildings and industrial plants more efficiently via advanced use of information and control systems

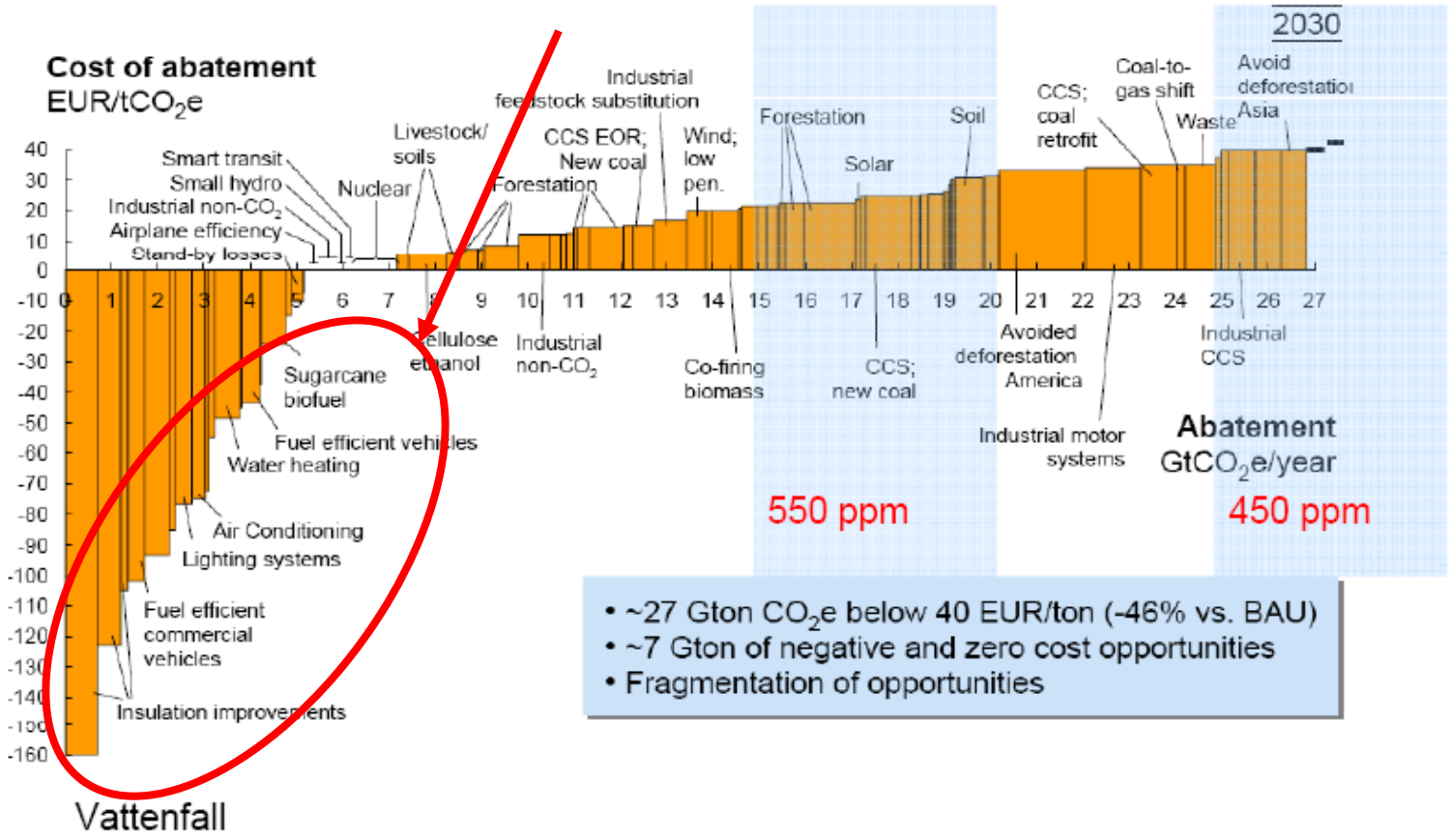
Policy and Business Cases for EE

1. Lowest-cost climate mitigation resource
2. Prerequisite for success in any clean energy strategy
3. Lowest-cost power system resource
4. Practical way for utilities to balance capacity and energy resources with demand



Lowest-Cost Climate Mitigation

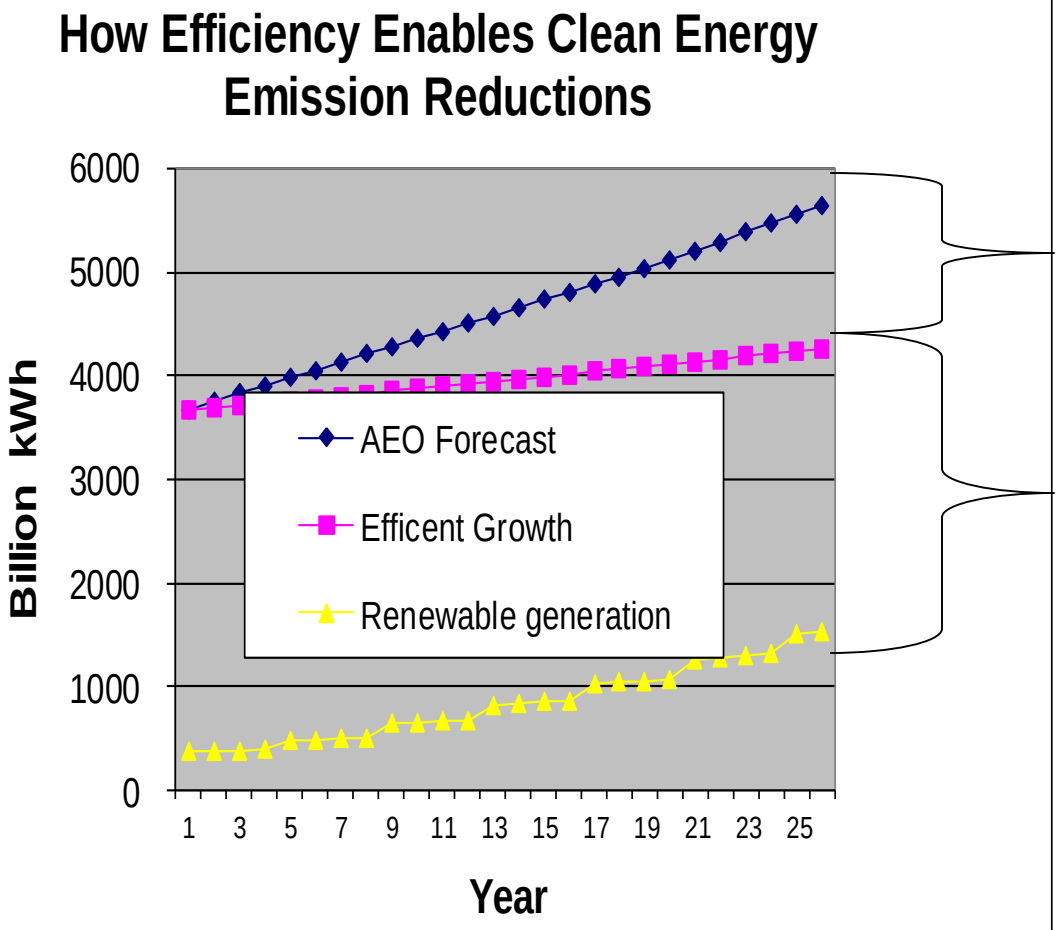
EE technologies cost less than conventional energy



Energy Efficiency features in Indonesia's new convention center

https://www.youtube.com/watch?v=JdjlQjd2j4w

The Key to Clean Energy Success



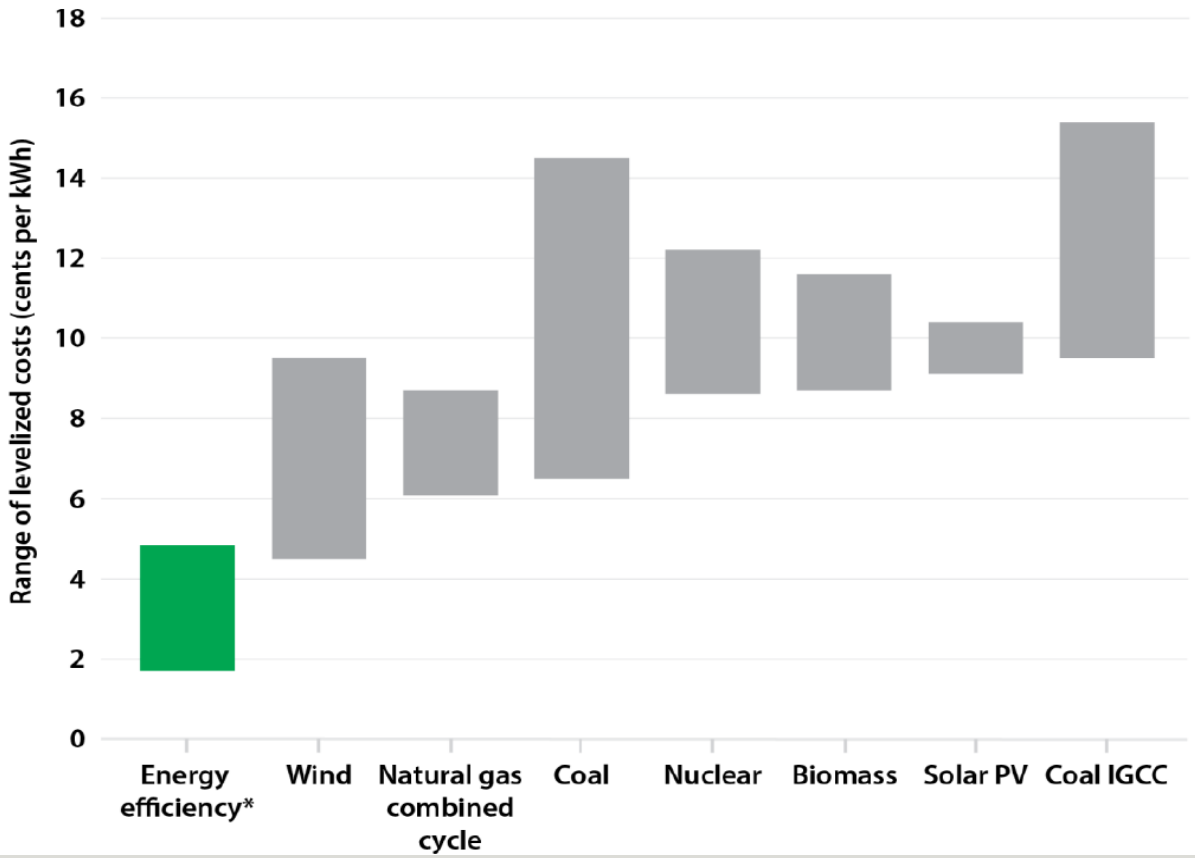
Reducing Demand…

Enables emission reductions as clean energy supply catches up to moderated demand

- ICF Staff Analysis

The Least-Cost Power System Resource

Efficiency is cheaper than conventional power generation technologies



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The Business Case for Utilities

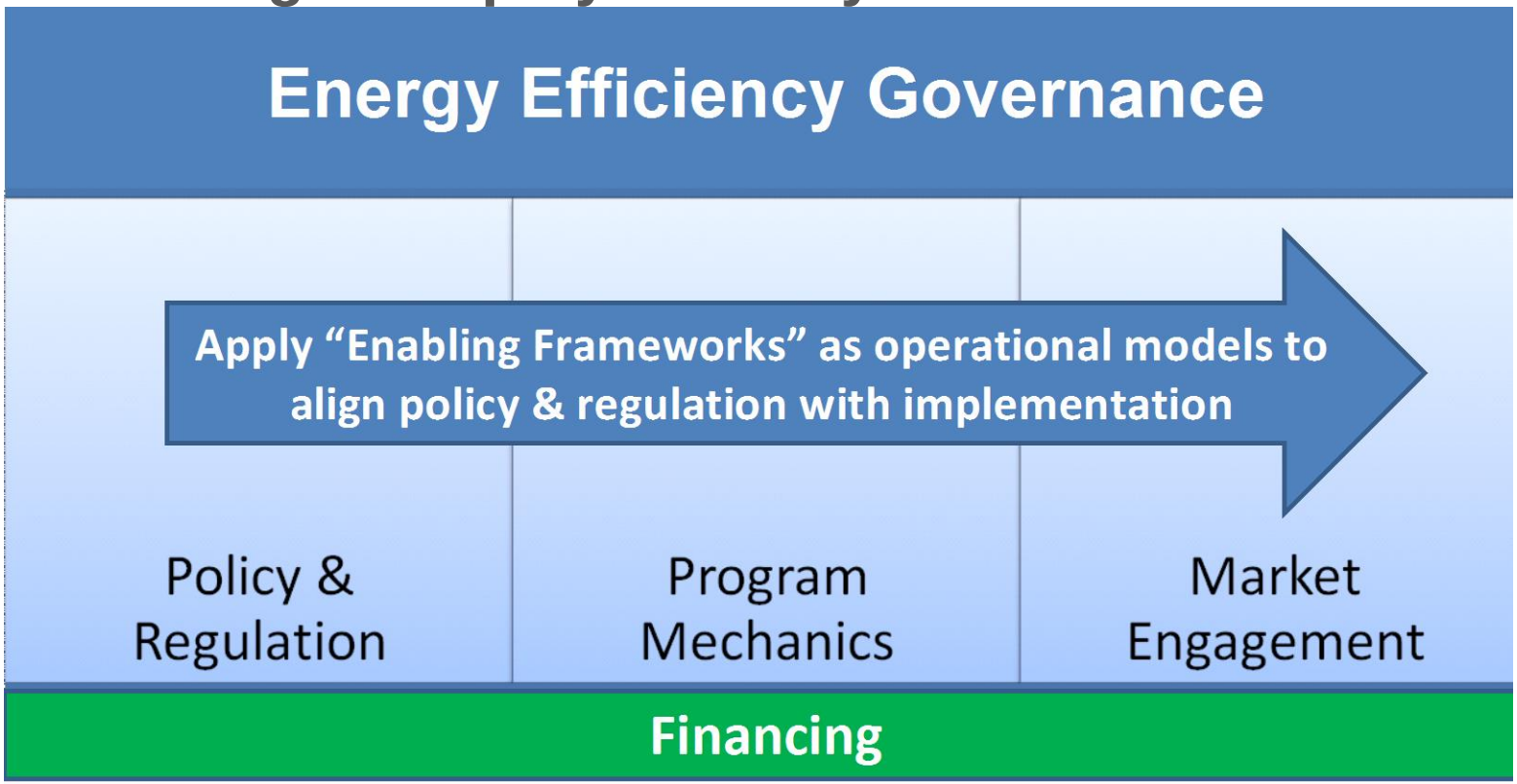
EE and other DSM programs support a variety of utility goals:

- Help customers manage utility bills
- Improve customer satisfaction
- Counter opposition to tariff/price increases
- Free up system capacity to meet current and future demand
- Reduce technical and other system losses

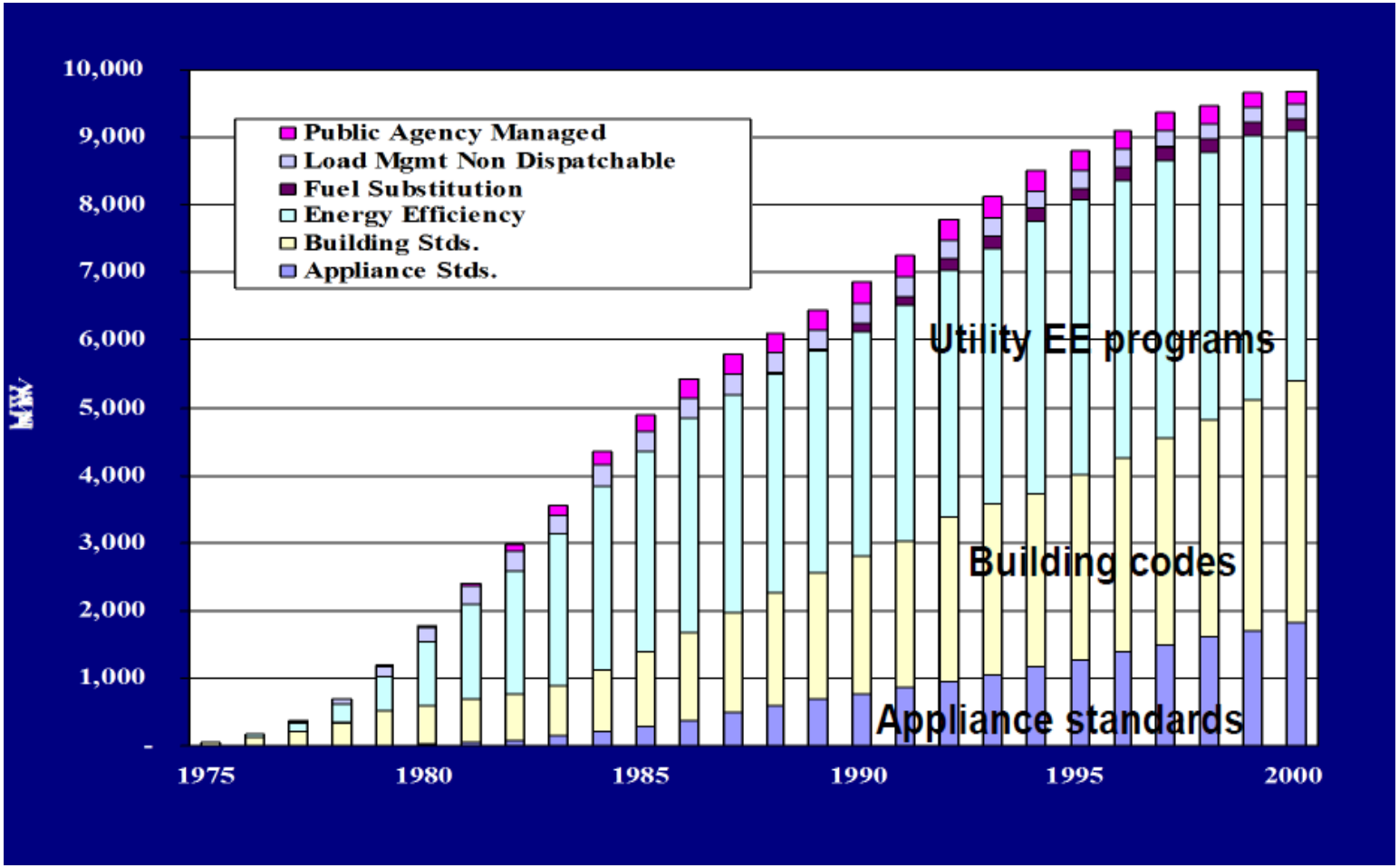
Bottom line: Improve business performance

Efficiency Policy Frameworks

Policy frameworks are essential to getting EE technologies deployed in key markets



California, U.S. Example:
EE Governance Framework Saved 25% in 25 years



[12] Source: California Energy Commission

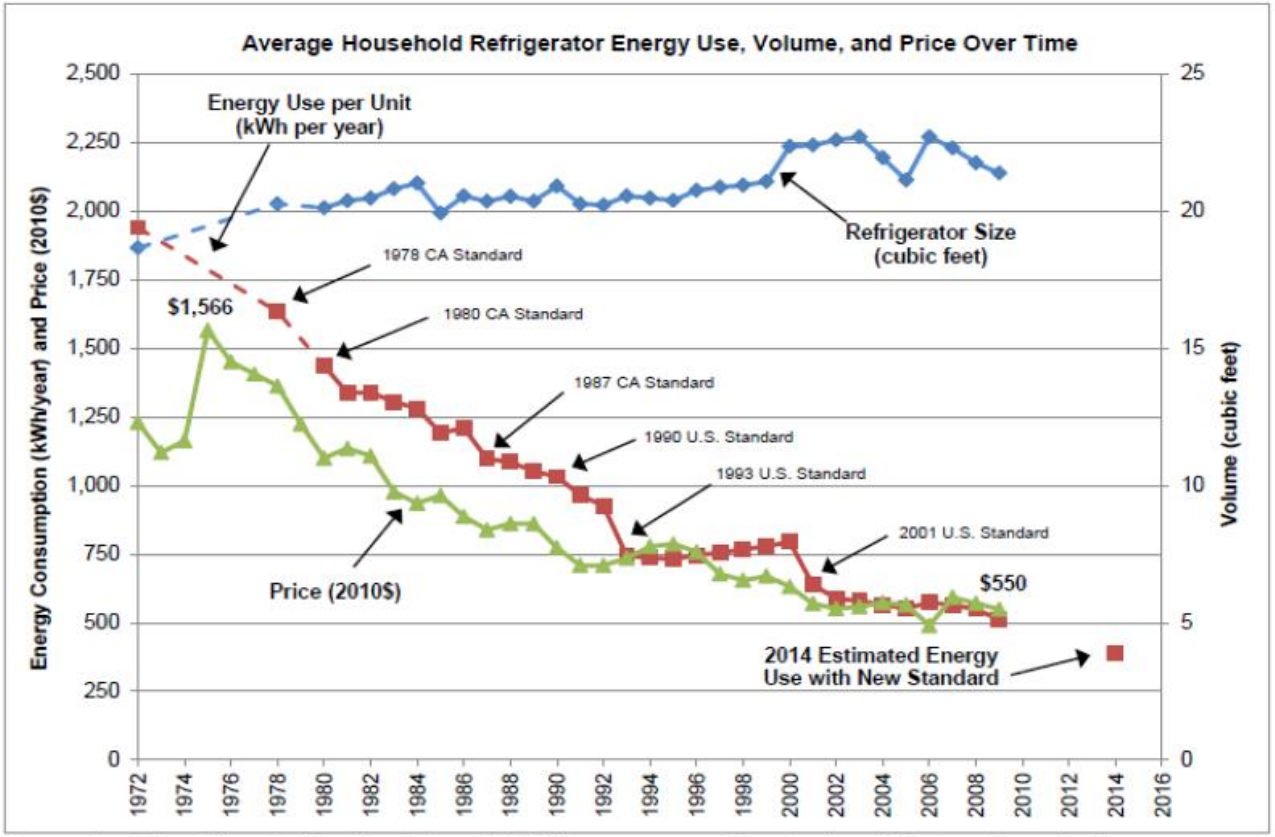
U.S. Policy Example: Refrigerators

1. Government develops test procedure and laboratory accreditation for covered products (1980s)
2. R&D competition for advanced efficient design (early 1990s)
3. Voluntary labeling promotes efficient products (1990s)
4. Utility programs provide incentives to drive market share growth (1990s)
5. Government sets mandatory standard based on efficient design (2001 effective date)
6. **Repeat process! (new standard effective 2014)**

A complete market transformation in <15 years

utility role was a key bridge from policy to market

Policy Success: Fridge Usage Falls 75%



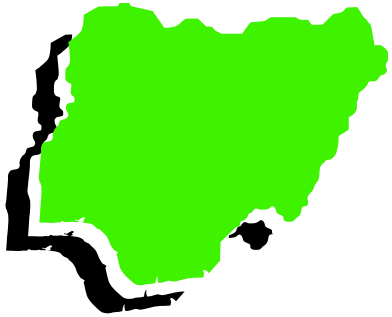
Sources: Association of Home Appliance Manufacturers (AHAM) for energy consumption and volume; U.S. Census Bureau for price

Notes: a. Data includes standard-size and compact refrigerators.
b. Energy consumption and volume reflect the DOE test procedure published in 2010.
c. Volume is adjusted volume, which is equal to the fresh food volume + 1.76 * freezer volume.
d. Prices represent the manufacturer selling price (e.g. excluding retailer markups) and reflect products manufactured in the U.S.

Nigeria Policy Example: *(Current UNDP Project)*

Saving energy through end-use appliances in the residential and public sectors

- Setting up minimum energy performance standards (MEPS) for appliances
- Introducing DSM programs
- Sample of accomplishments:
  - Draft National Energy Efficiency Policy
  - Draft EE Standard for CFLs
  - Training
  - Established Testing Centre for Lighting



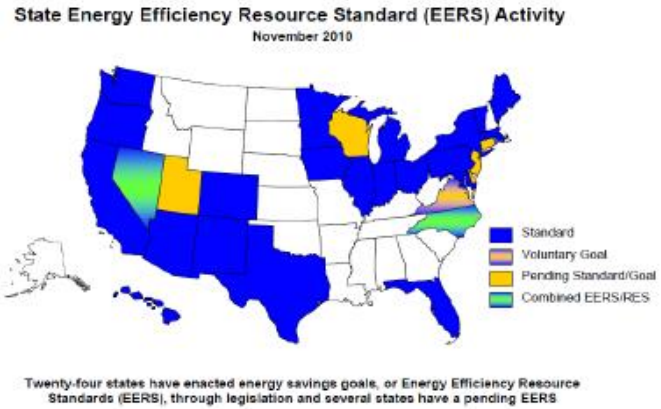
Utility Policy Frameworks

1. Integrated Resource and Resiliency Planning (IRRP)
2. Energy Efficiency Obligations (EEOs) or Resource Standards (EERS)
3. Utility regulation reform to align policy goals with utility business models

IRRP Example: Malawi

- In 2007, with only 7% of Malawians connected to the grid, IRRP undertaken by MCC to support improved energy access and reliability
- IRRP (conducted by ICF) projected 20-year demand and identified resource options
- IRRP results helped MCC justify funding for utility grid improvements

EEOs around the World



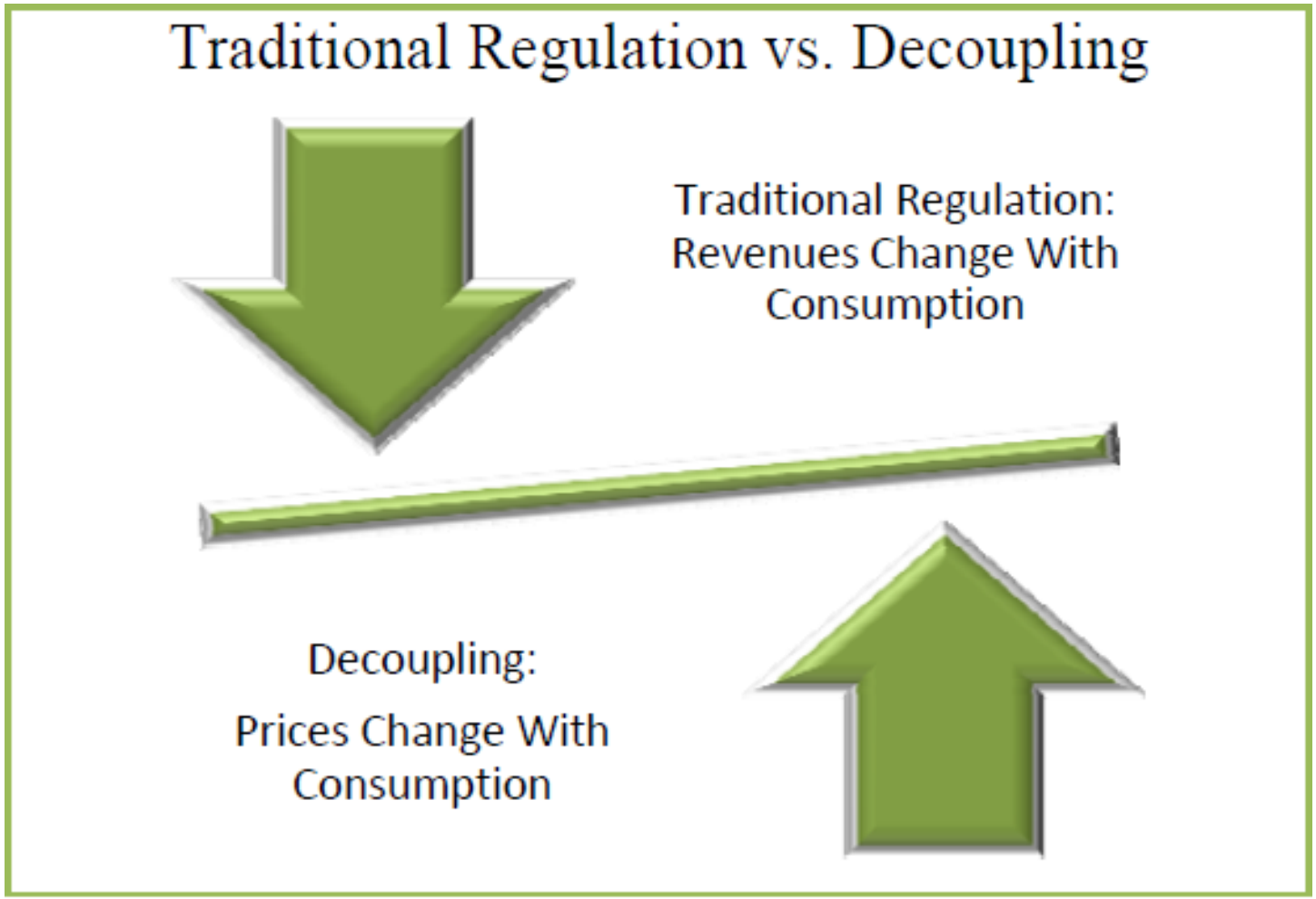
EEOs around the World

- **Europe:** Several Member States or Regions
- **U.S.**: 24 States (“EE Resource Standards” or EERS)
- **Australia:** 3 largest States
- **China:** spending 3-4% of total electric revenues
- **Brazil:** 1.5% of electricity revenues
- **Korea:** over 3% of power revenues support DSM programs
- **Canada:** Ontario

Utility Regulation Reform: Aligning Policies with Utility Interests

1. **Cost recovery**—timely and practical mechanisms for recovering program costs
2. **Revenue stability**–reforming ratemaking so that utilities don't lose money when sales fall
3. **Utility shareholder earnings**—enabling utility shareholders as well as customers to benefit

Revenue Stability: Decoupling



Source: Regulatory Assistance Project

2. Narrowing the Picture: EE in a Utility DSM Framework

DSM: Two Main Flavors

- **Energy efficiency (EE)**
  - Permanent reduction in consumption across the load curve
  - Provides same or better energy service with fewer kWh

- **Demand response (DR)**
  - Temporary reduction in consumption at times of system peak
  - May be associated with curtailment of service

EE or DR require consistent analysis and planning

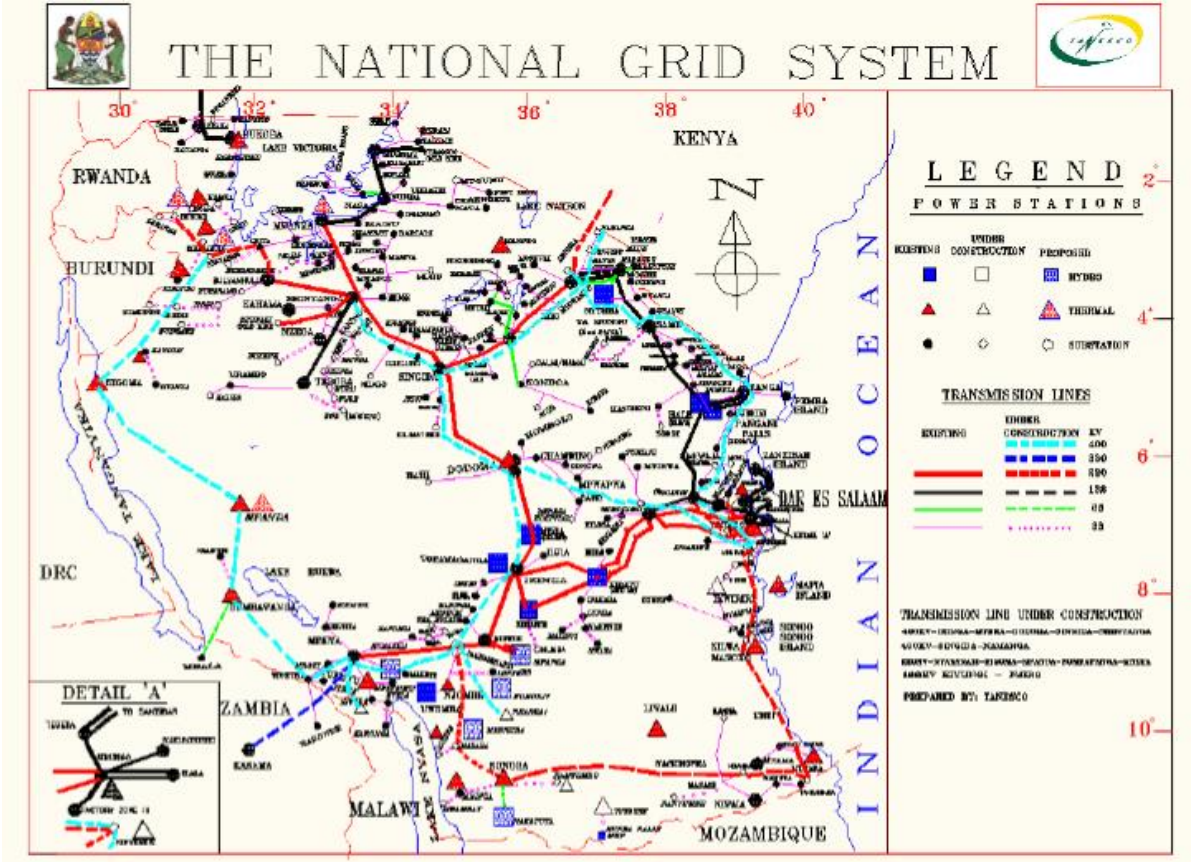
The DSM Planning Process

1. Research and analyze end uses by customer class, technology and load shape
2. Identify EE and DR measures—match most common end uses to best technologies
3. Quantify measure savings and costs
4. Bundle measures into programs by customer class and submarket
5. Project market uptake for DSM programs
6. Project DSM programs total energy and capacity savings
7. Conduct cost-effectiveness analysis

Planning Case Study: Tanzania

TANESCO: the electric utility

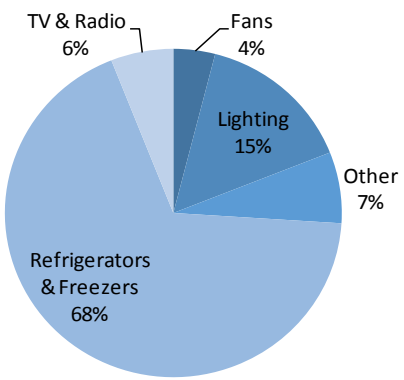
- 800+ MW peak load
- Frequent forced load shedding
- Tariffs do not recover full cost of service
- Technical and theft losses were >20%
- USAID funded DSM potential analysis in 2013



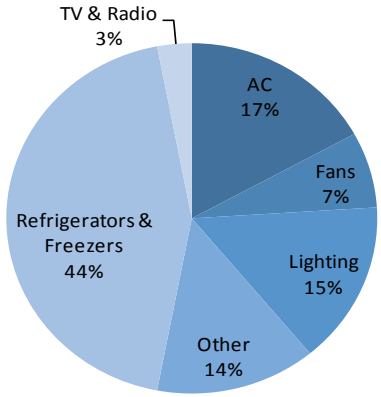
Develop Customer End Use Data

Tariff Class	Customers in Tariff Class	% Total Cust.	Total Sales (GWh)	% Sales	Average Annual Sales per Customer (kWh)
D1—Domestic Low Usage	613,618	47%	515	10%	839
T1—General Usage	699,287	53%	2,203	43%	3,150
T2—Low Voltage Supply	2,483	0.2%	634	12%	255,336
T3—High Voltage Supply	461	<0.1%	1,804	35%	3,913,232
Total	1,315,849		5,156		

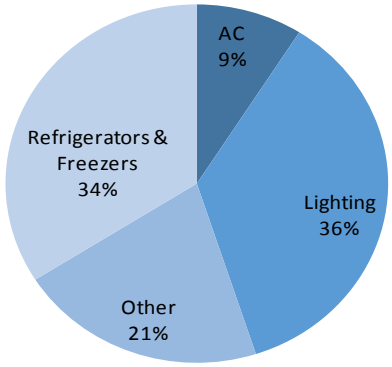
D1



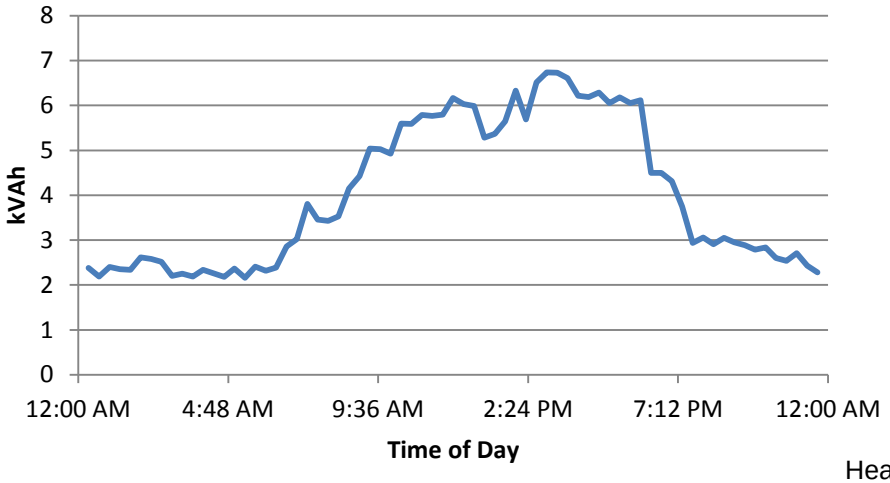
T1--Residential

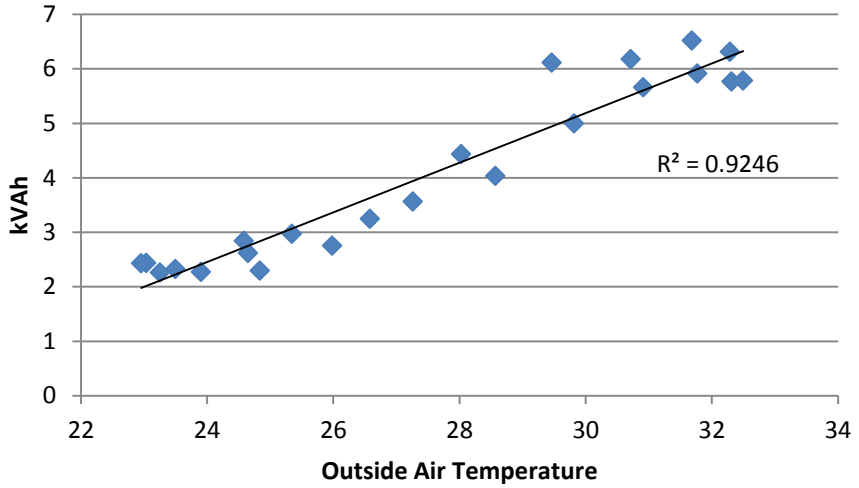


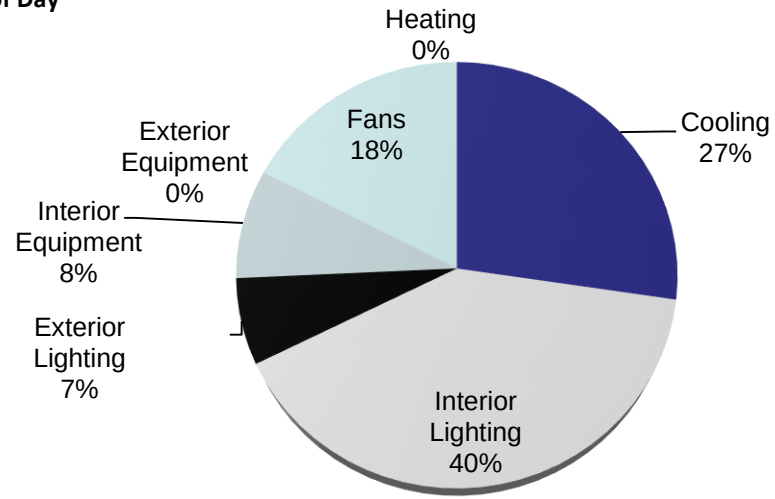
T1--Commercial



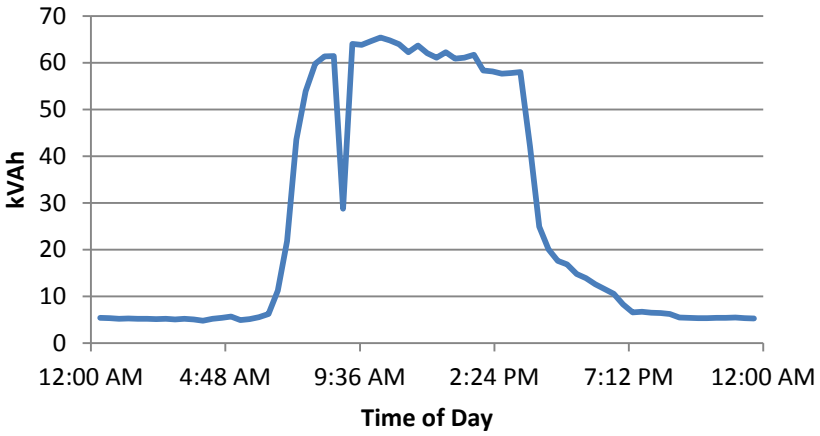
Retail store

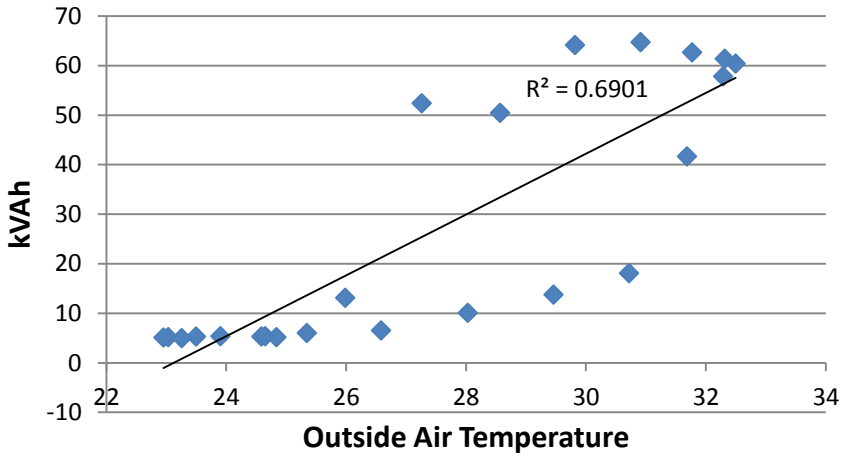


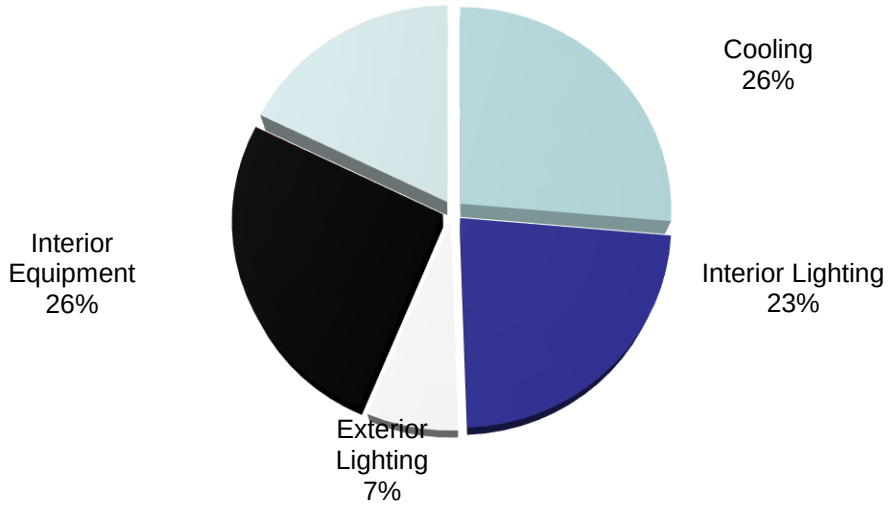




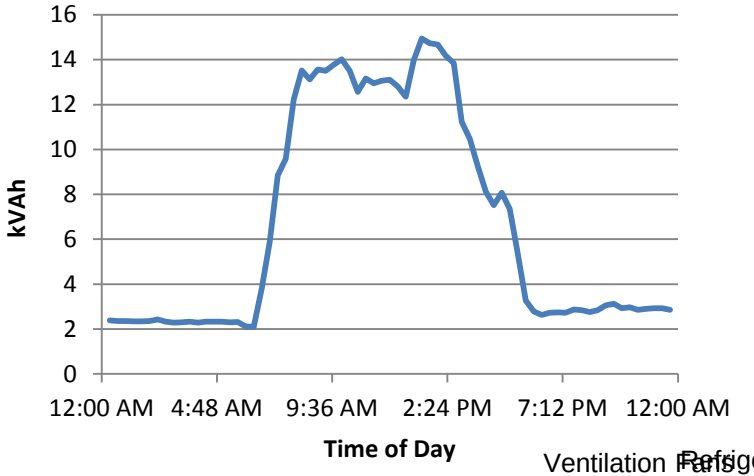
Medium Office

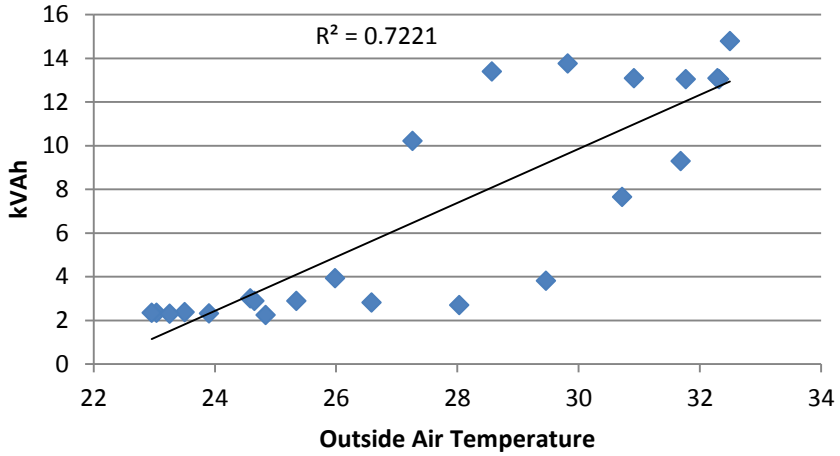


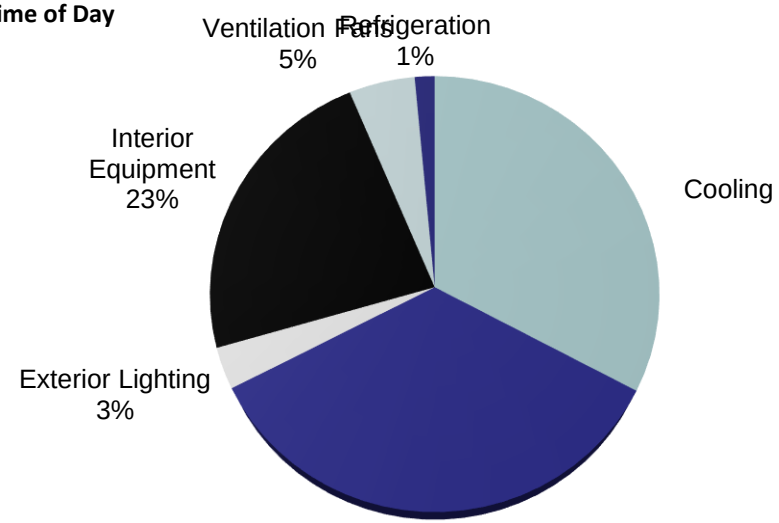




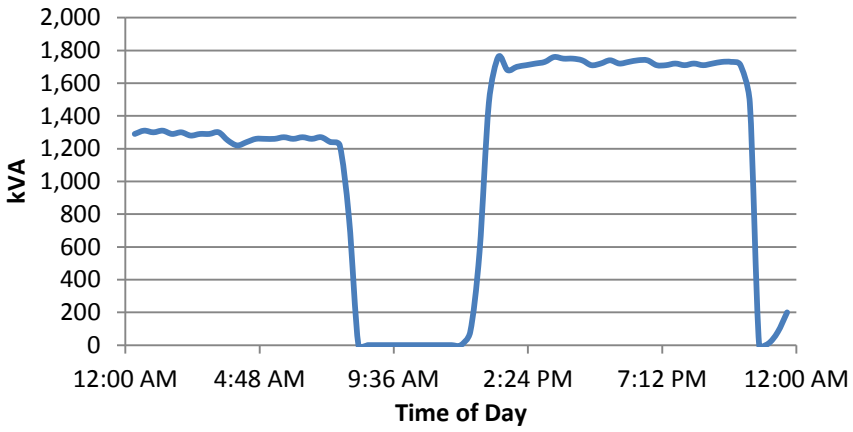
Secondary School

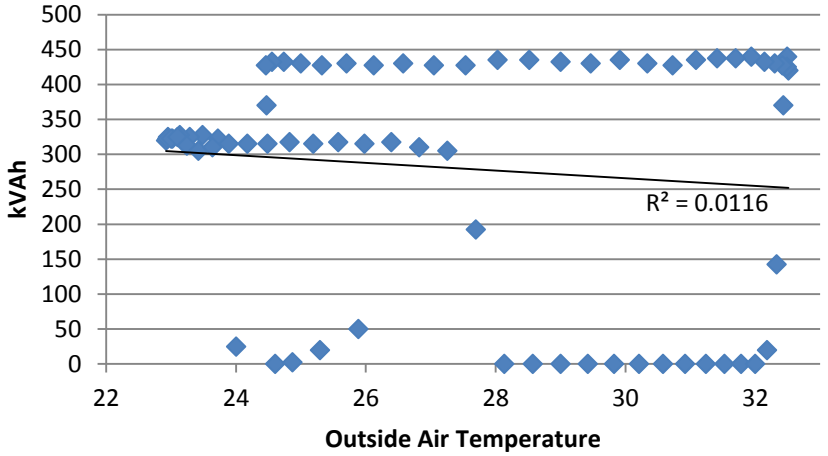


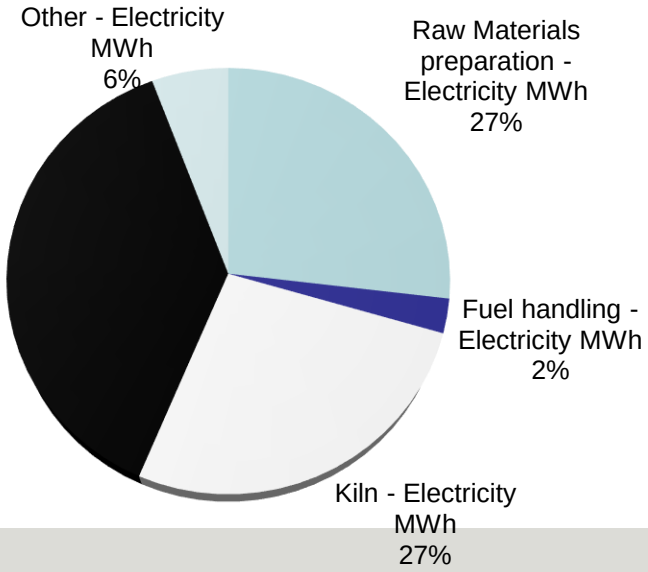




Cement Plant







Develop DSM Measures

Residential

Tariff Class	End Use	Measure Type
D1	Lighting	CFL
	Refrigeration	Efficient Refrigerator
T1	Cooling	Efficient AC
	Envelope	Air Sealing
	Lighting	CFL
	Refrigeration	Efficient Refrigerator

Industrial

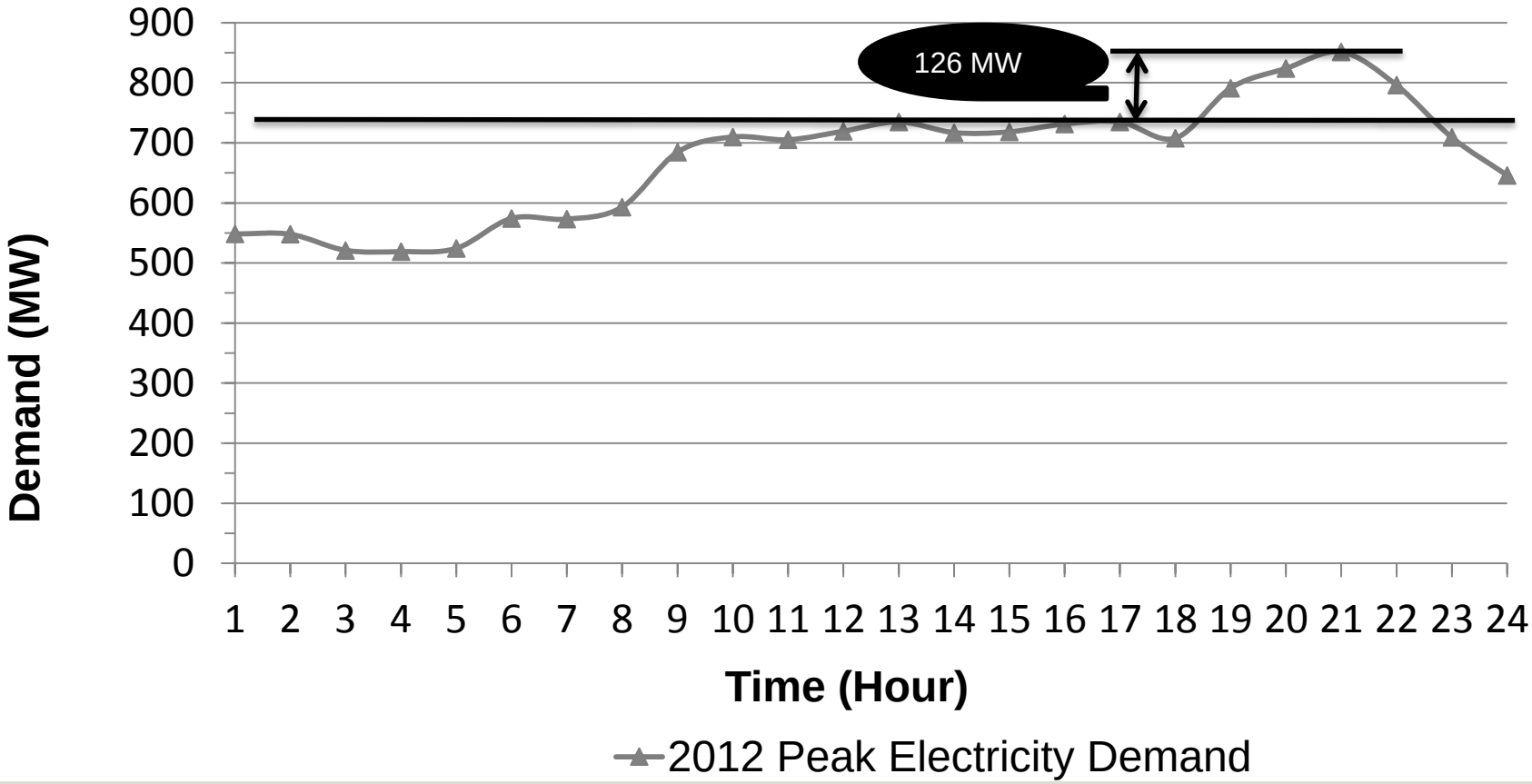
Measure Category	Measure Type
Energy Efficiency	Compressed Air Upgrades
	Custom Project
	Lighting Upgrades
	Motor Upgrades
	Process Cooling Upgrades
	Process Heating Upgrades
	Variable Speed Drives
Demand Response	Time-of-Use Rate

Commercial

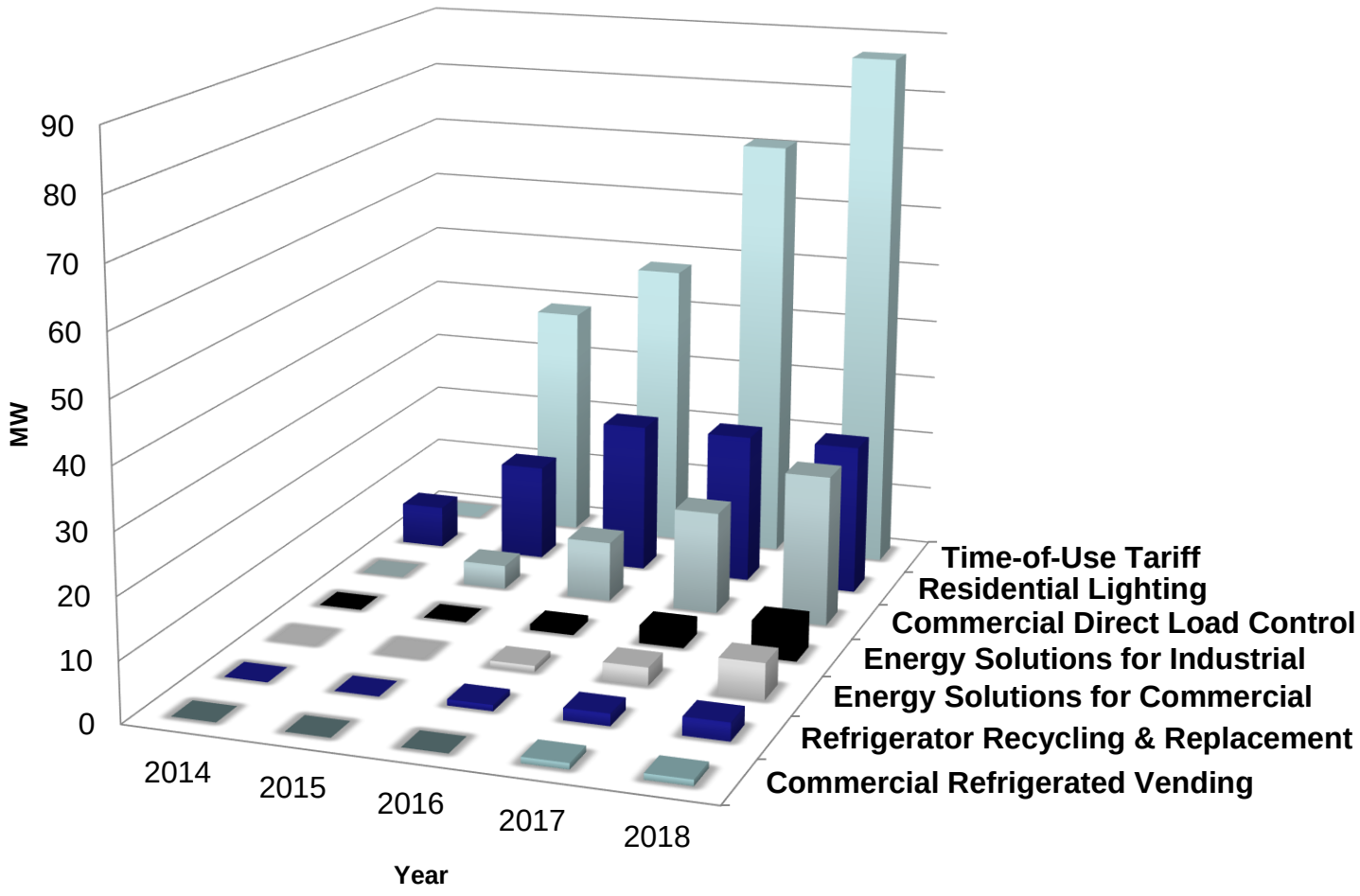
Measure Category	End Use	Measure Type
Energy Efficiency	Cooling	Efficient Split AC
	Envelope	Air Sealing
	Lighting	CFL
		LED Reflector Lamps
		Lighting Occupancy Sensor
		Linear LED Lamps
		T8/T5 Linear Florescent
	Refrigeration	Efficient Refrigerated Case Display
		Efficient Refrigerator
Demand Response	Cooling	AC Direct Load Control

Project DR Potential

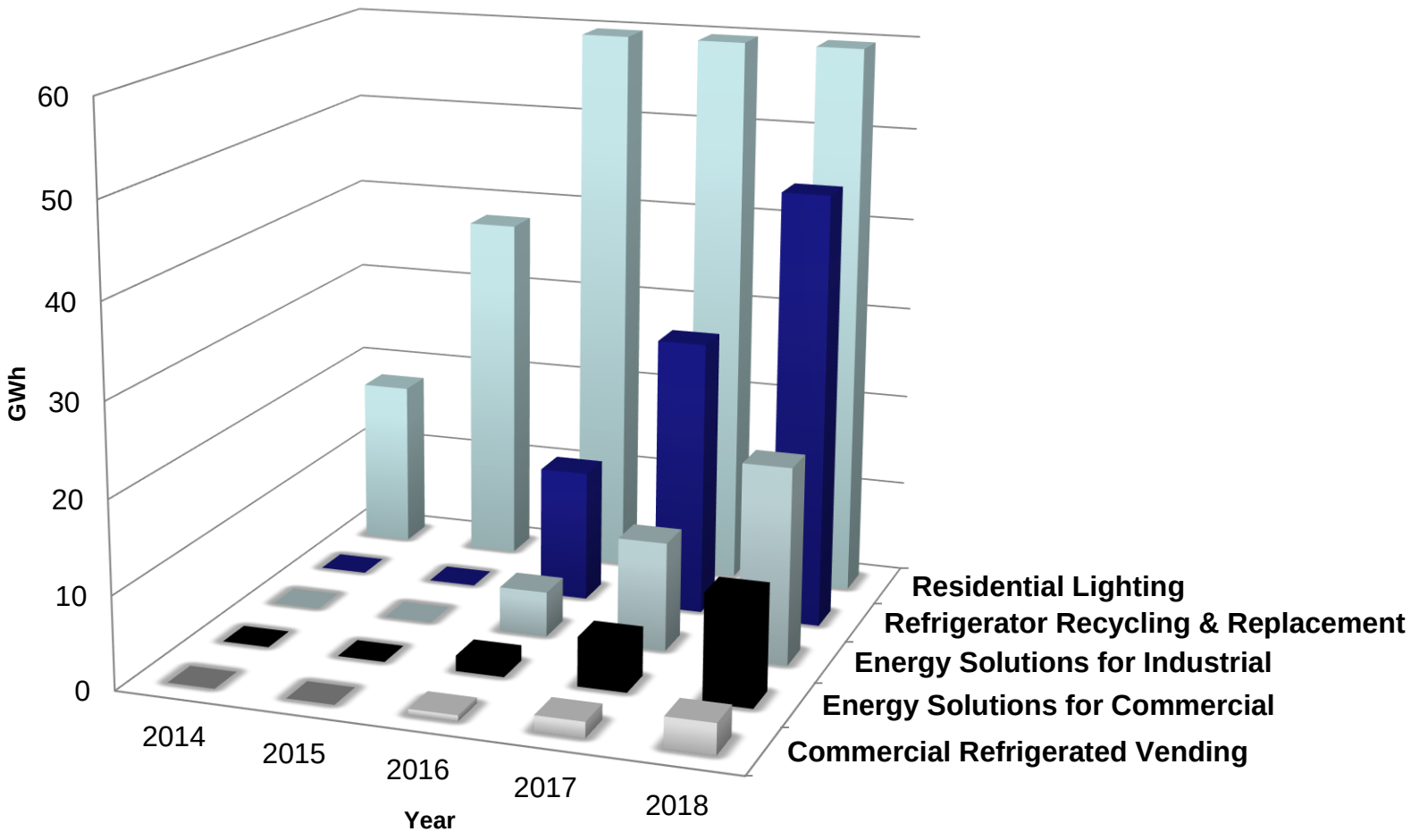
Example: DR can trim about 15% of Tanesco's peak load



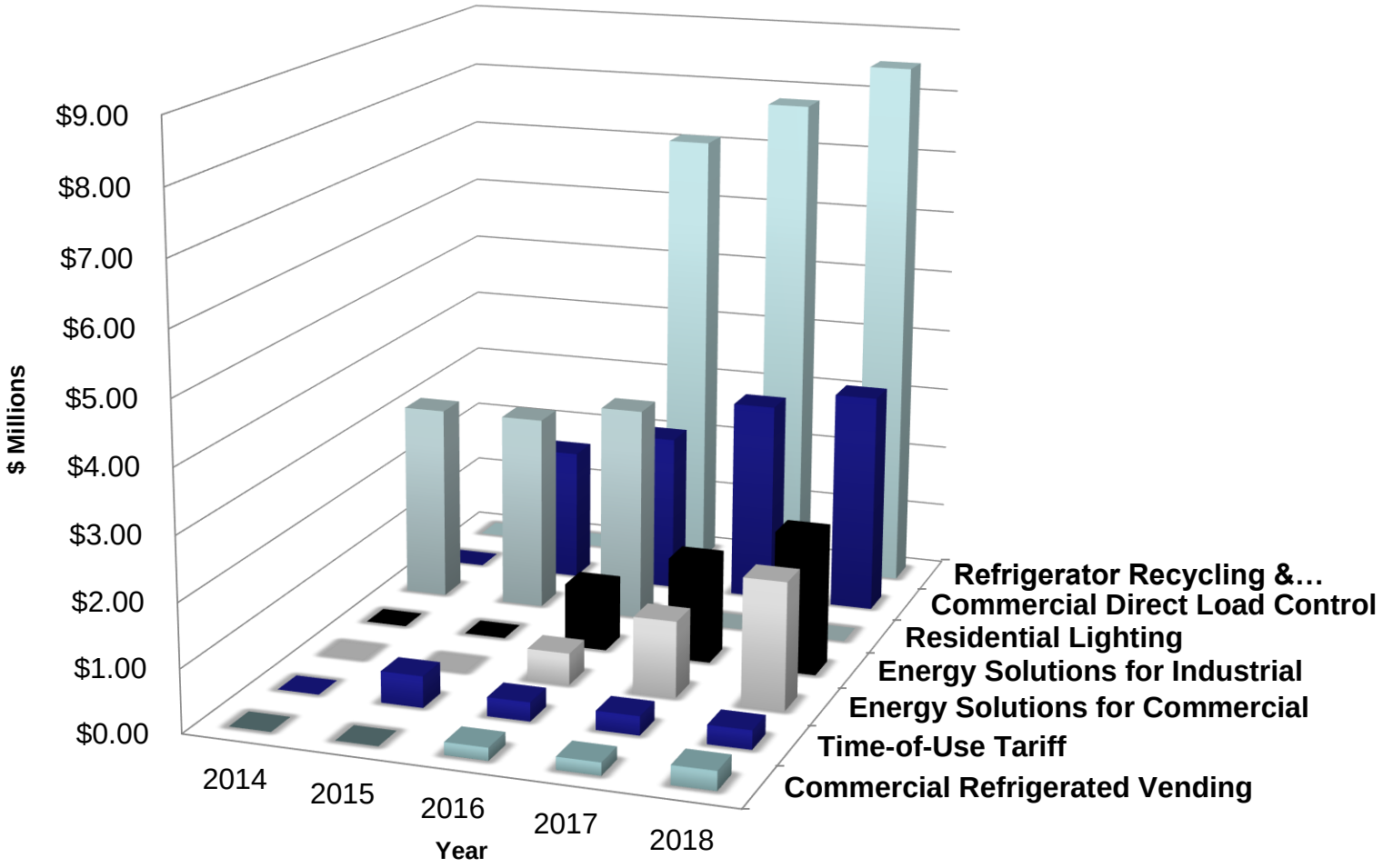
Project Efficiency Potential (Capacity/MW)



Project Efficiency Potential (Energy/GWh)



Project Program Costs ($ Million)



Conduct Cost-Effectiveness Analysis

1. Quantify benefits and costs of each measure from potential estimates
2. Apply a consistent set of economic tests
3. Determine which measures/bundles/programs pass economic tests
4. Assess individual measures vs. bundles and whole programs

Cost-effectiveness Results

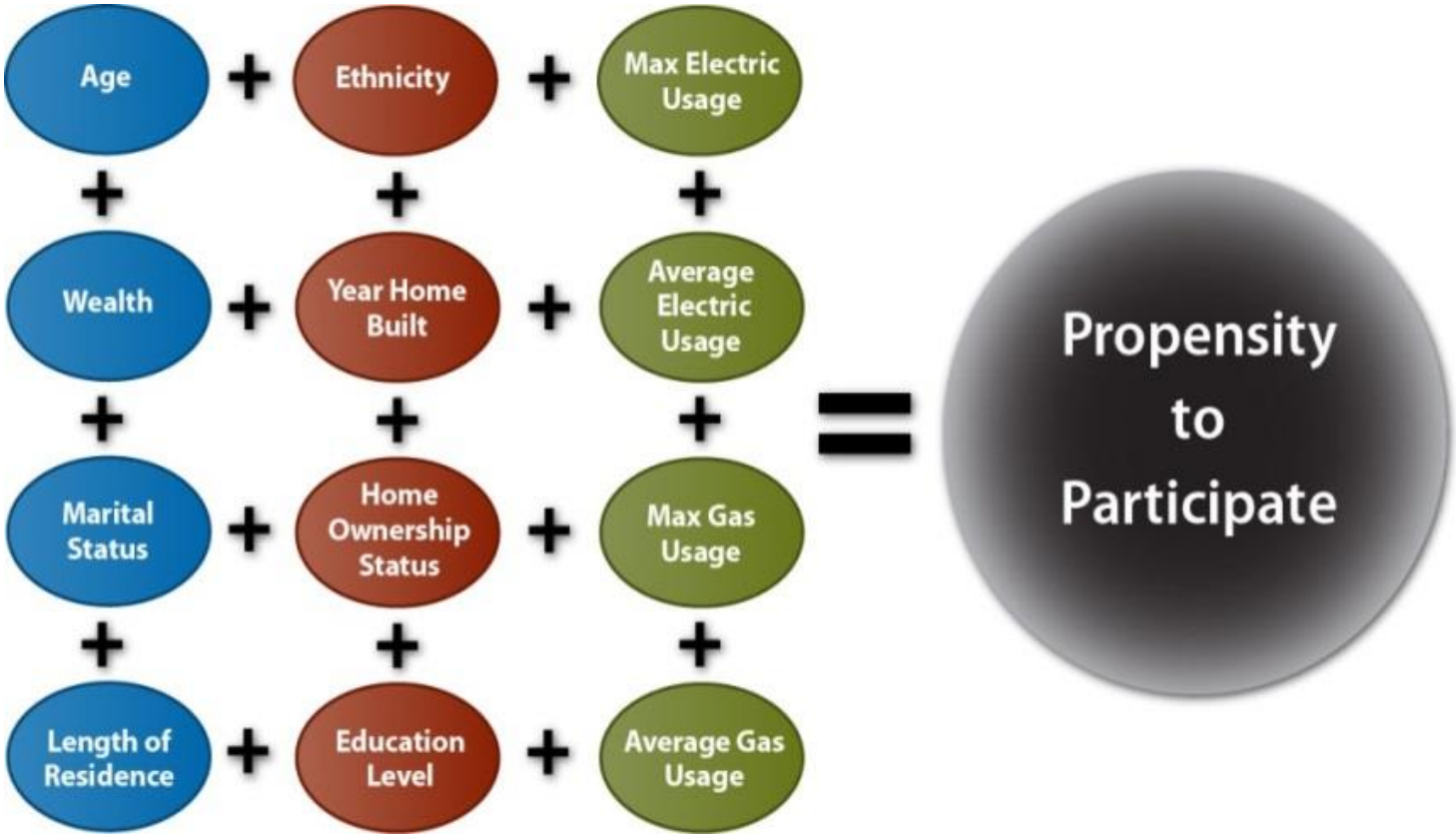
Sector	Program Name	Utility Cost Test (UCT) B/C Ratio	UCT Net Benefits ($ Mil.)	Levelized Cost per kWh ($)	Levelized Cost per kW ($)
Residential	Refrigerator Recycling & Replacement	1.0	$15.4	$0.06	$978
Residential	Residential Lighting	4.8	$37.7	$0.04	$94
Commercial	Energy Solutions for Commercial	1.9	$4.7	$0.07	$140
Commercial	Commercial Refrigerated Vending	3.3	$1.4	$0.03	$89
Commercial	Commercial Direct Load Control	1.0	$8.2	N/A	$108
Industrial	Energy Solutions for Industrial	2.6	$8.5	$0.04	$123
Industrial	Time-of-Use Tariff	19.1	$18.9	N/A	$6
	Total Portfolio	**2.4**	**$94.8**	**$0.06**	**$98**

DSM Program Design/Implementation

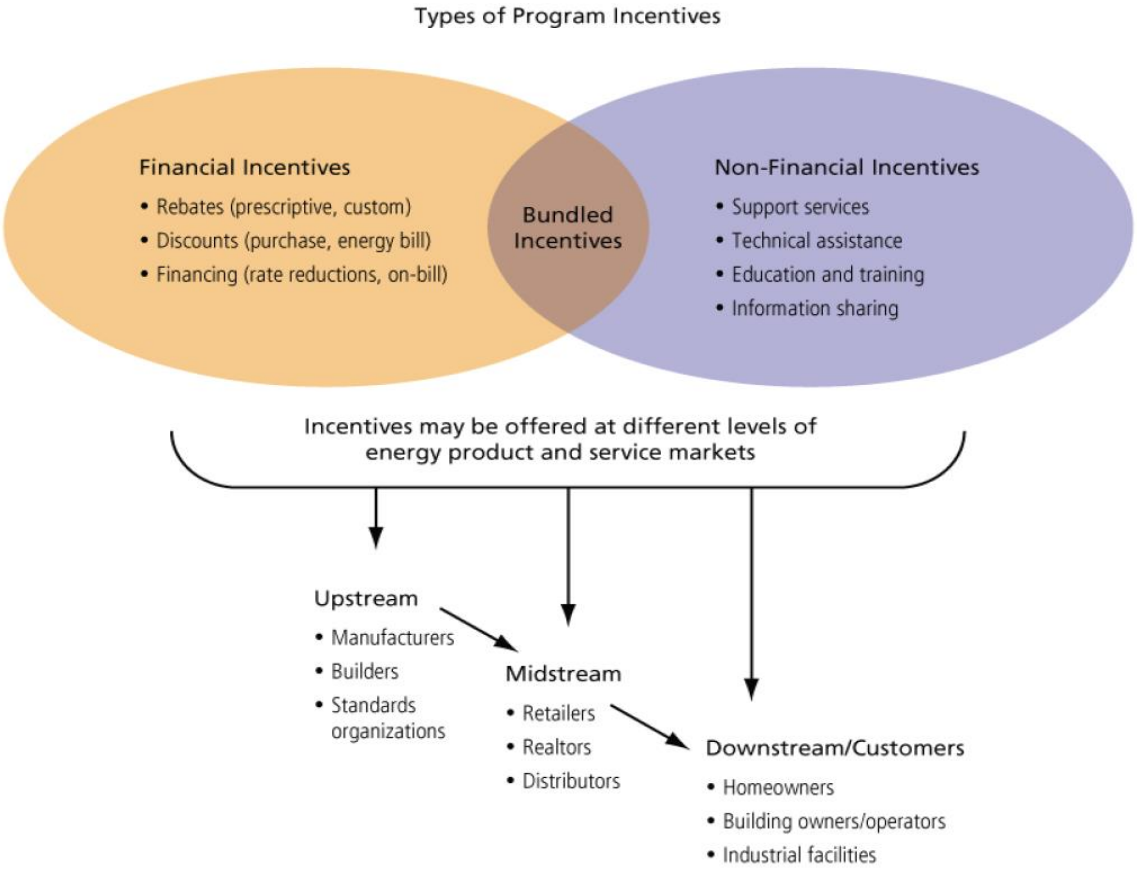
1. Break out program design by sectors—industrial, commercial, residential, etc.
2. Develop key design features—technology, market, incentives, etc.
3. Understand and work with customers and markets—market research, outreach and engagement
4. Develop marketing and implementation plans, systems, and documents

Use “Big Data” to Focus Programs

Use available customer data to identify best prospects

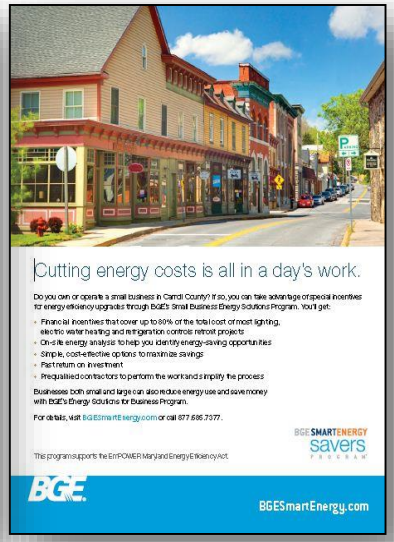


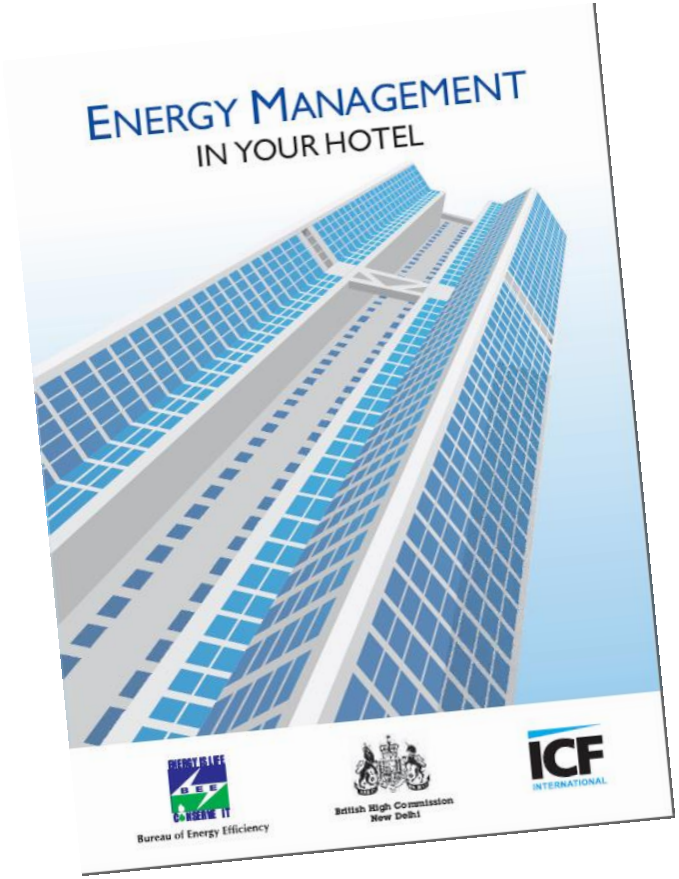
A Map of Program Incentives



National Action Plan for Energy Efficiency (2010). *Customer Incentives for Energy Efficiency Through Program Offerings.* Prepared by William Prindle, ICF International, Inc. <www.epa.gov/eeactionplan>

Market Programs by Sector





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Program evaluation

1. **Evaluation should be designed into the program**—define goals and metrics, collect and report data
2. **Evaluation should be based on:** clear program logic, metrics, and measurement/verification methods
3. **Program design should support evaluation by:** designing management systems and procedures to collect needed data