Klinckenberg consultants

Monitoring Progress towards a Clean Energy Economy

Energy Efficient Residential Appliances

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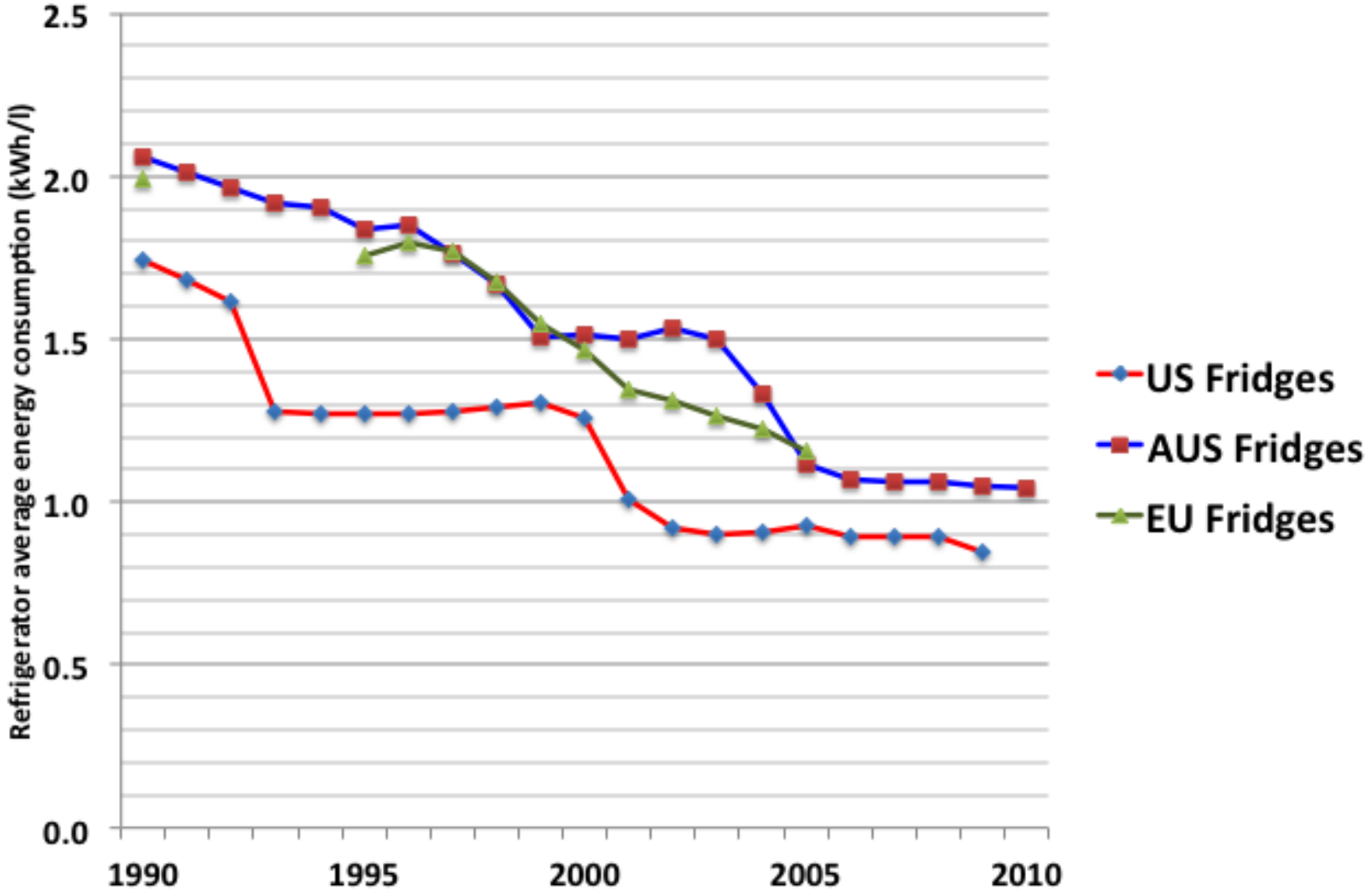
Issues covered

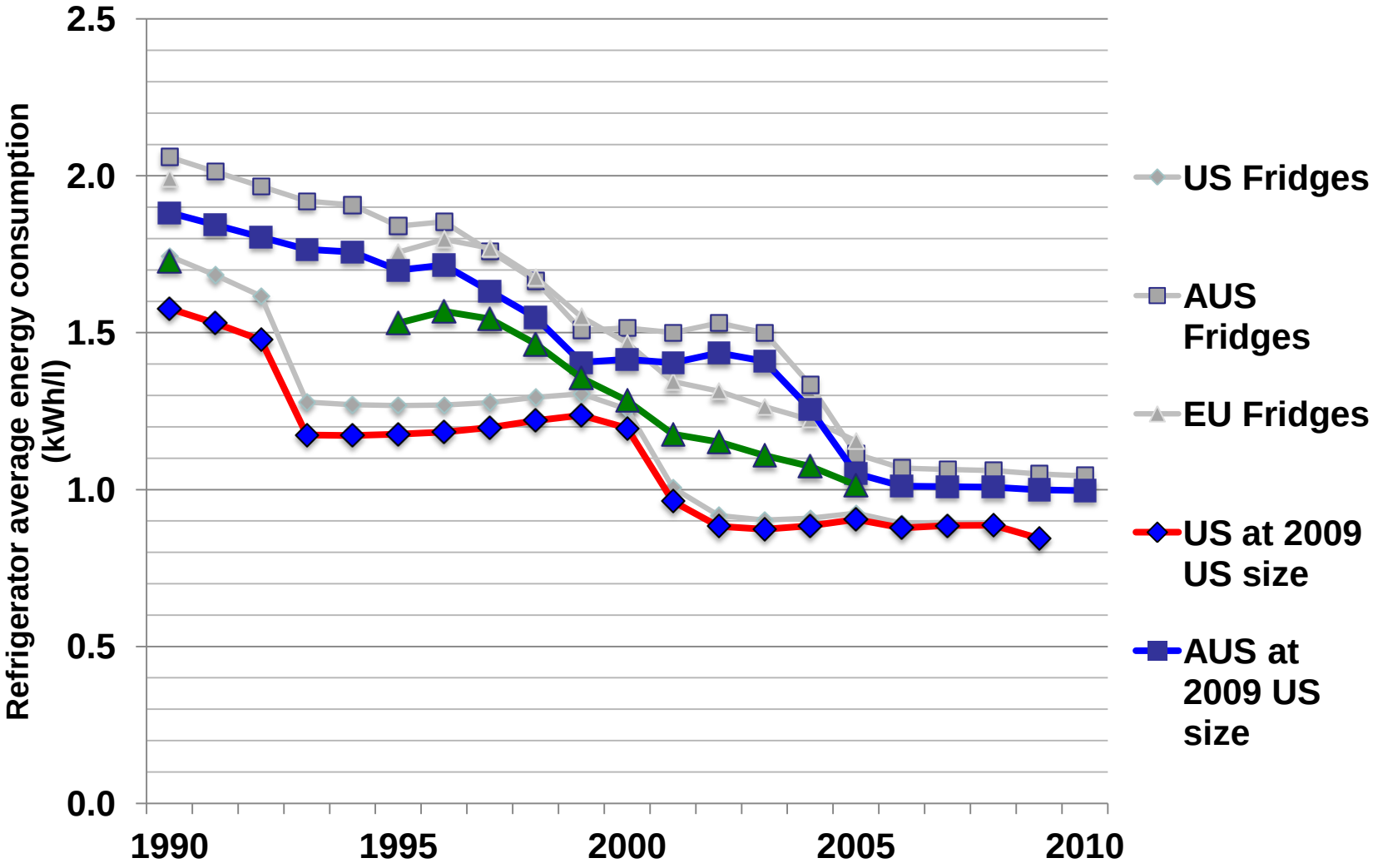
- Energy efficiency progress for a key product
- Technology learning
- Standards and Labels coverage
- Product coverage
- Indicators

Impact of Standards and Labels



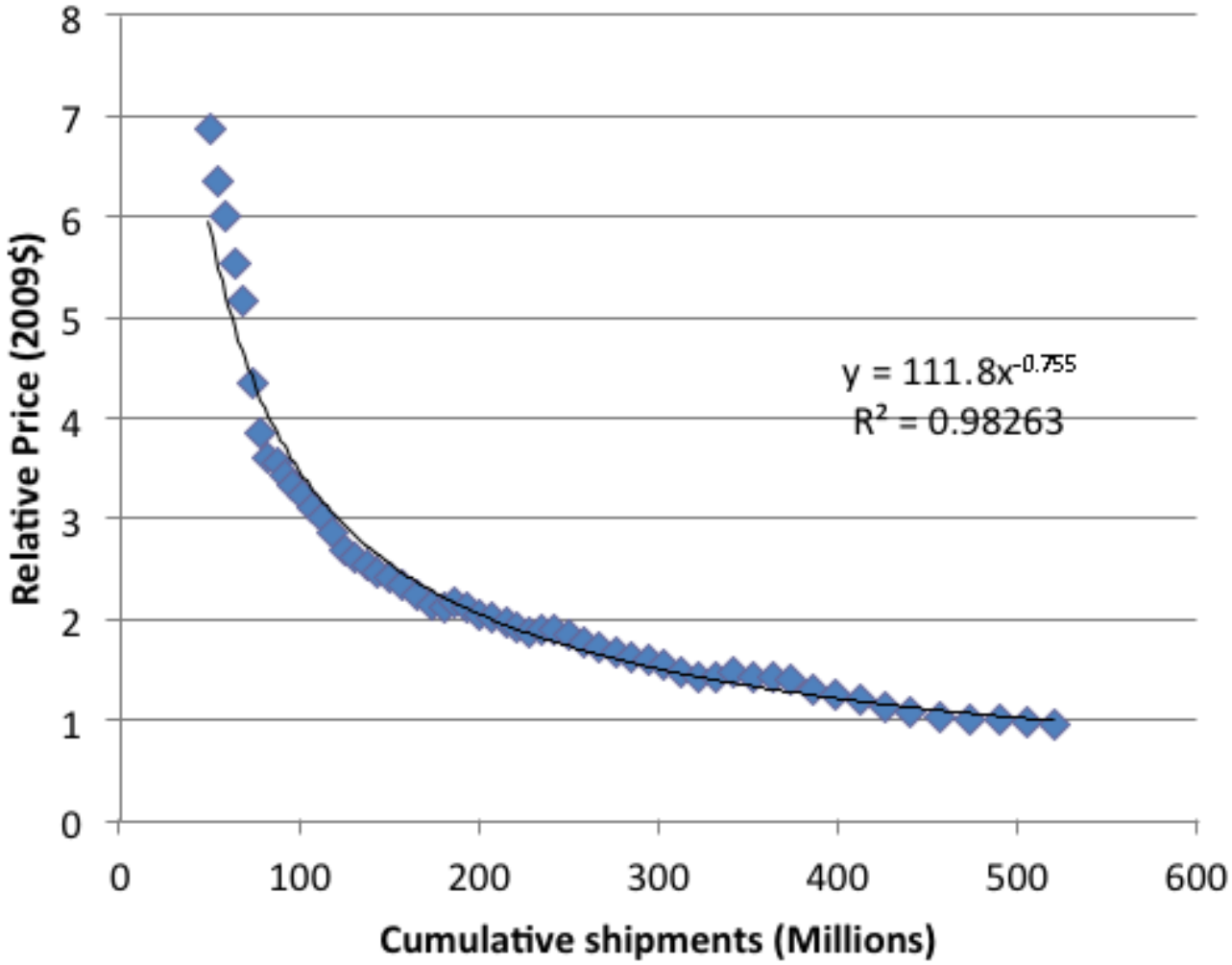
Sources: LBNL (US), Lane et.al (AUS), Ecodesign Lot 13 (EU)

Impact of Standards and Labels - 2



Indicative volume-based efficiency corrections based on IEA 4E M&B report, 2010

Technology Learning - US



Source: TSD Final Rule Refrigerators, DOE, 2011

Refrigerators

Fitting equation:

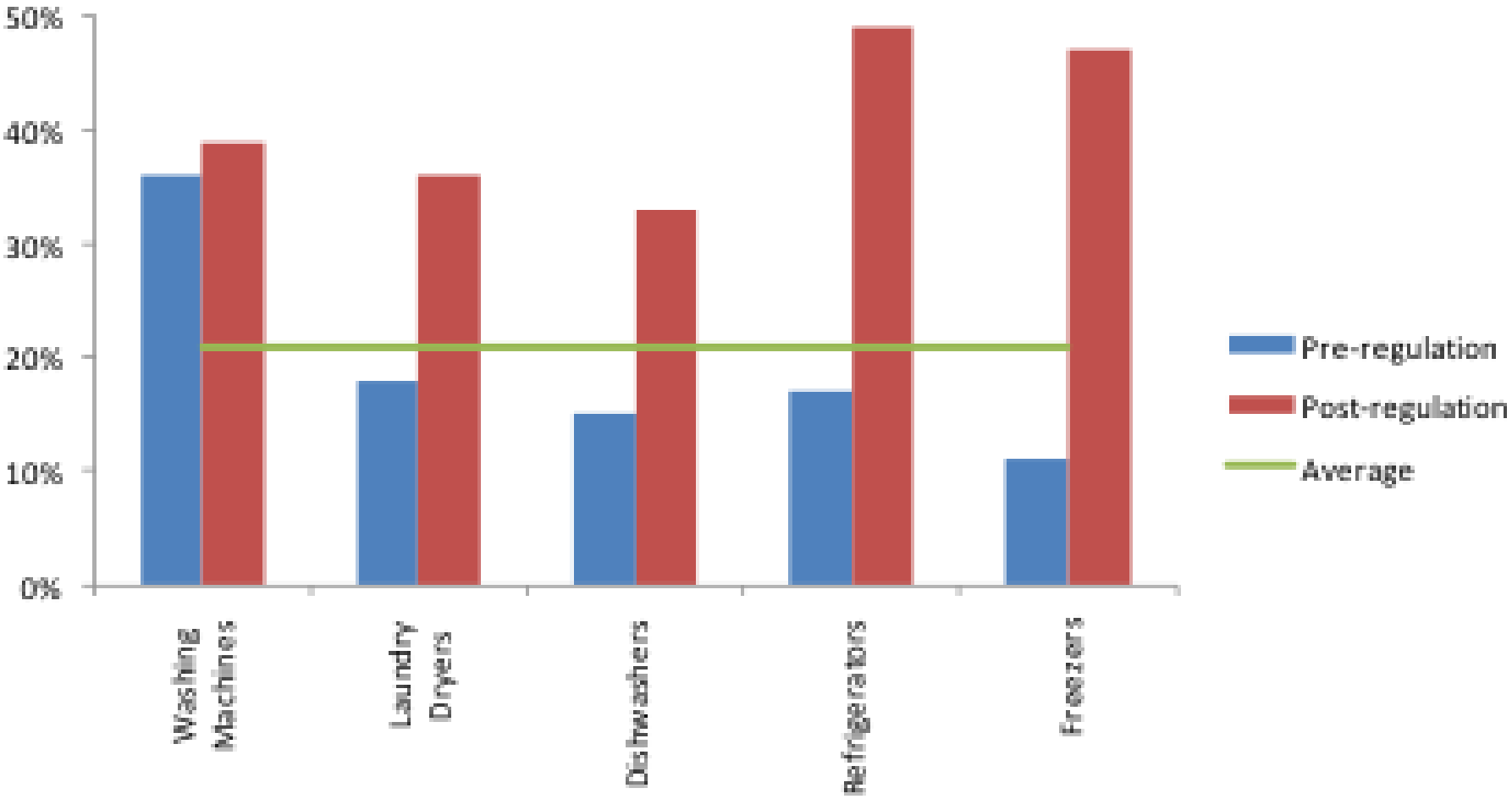
$P(X) = P_o X^{-b}$

$P_o = 112_{-15}^{+17}$

b = 0.755±0.027 (95% confidence)

Learning rate 41%

Technology Learning - EU

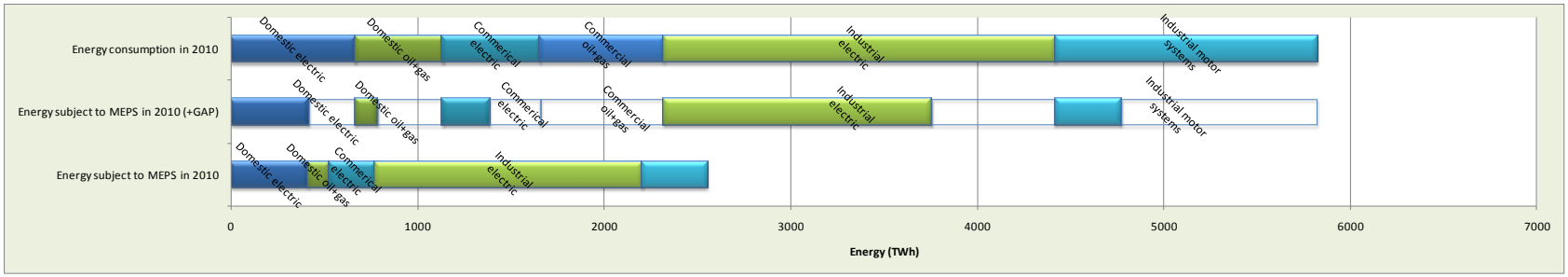


Source: Weiss et al, 2010, reported in PSI for UK Defra, 2011

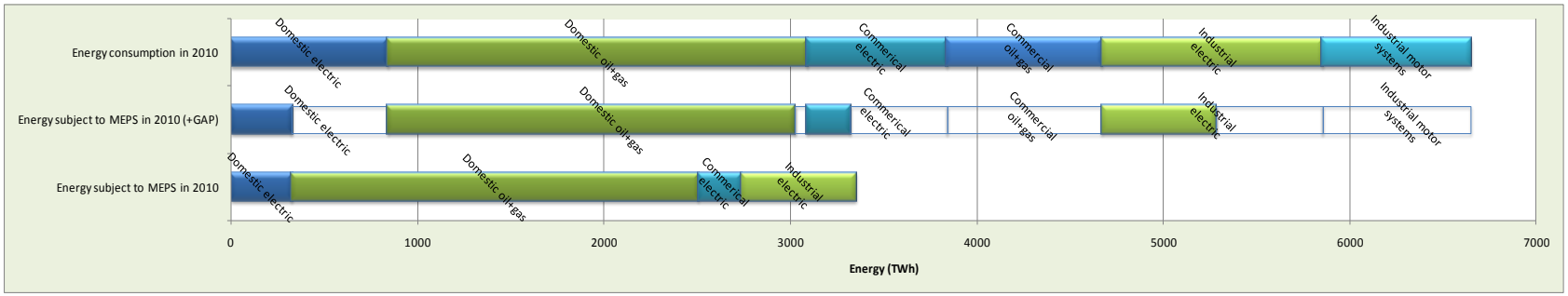
Percentages reflect learning rate: average reduction in cost per doubling of cumulative production

Standards and Labels Coverage

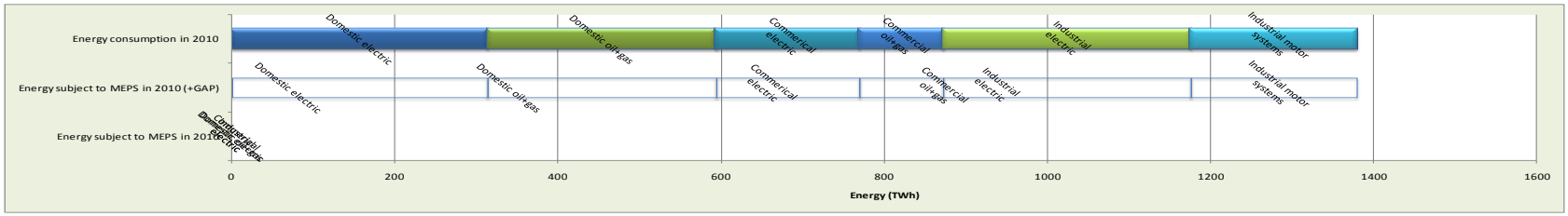
China



EU



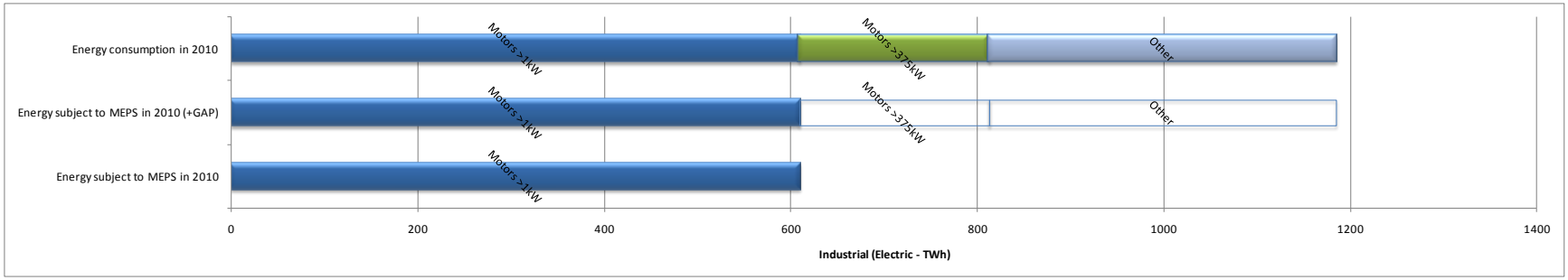
India



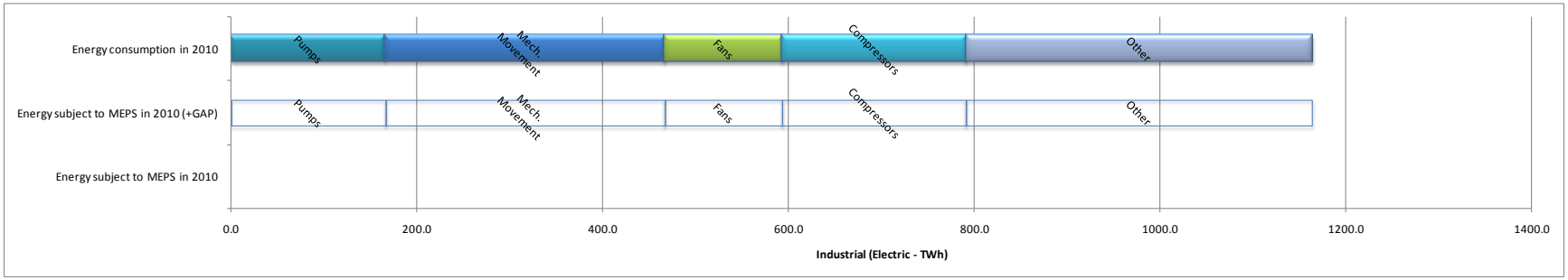
Source: Opportunities for Success and CO2 Savings…, CLASP/Navigant, 2010

S&L Product Coverage

MEPS Coverage in the industrial sector: Electric motors



MEPS Coverage in the industrial sector: Electric motor systems



Source: Opportunities for Success and CO2 Savings…, CLASP/Navigant, 2010

Progress towards a Clean Energy Economy – Key Observations

- Energy Efficiency has been improving, but the obvious measure is not always the best one
- Increases in learning rates are probably a good indicator of sustainable progress
- Coverage of S&L matters more than number of standards and labels:
  - share of energy consumption, and
  - share of energy savings potential
- Ultimate measure is sufficient savings to meet target: % eff. improvement across all demand

Energy Efficient Heating and Cooling Equipment

Sample Metrics for Measuring Progress toward a Global Clean Energy Economy

Resources

- **Public RD&D investment in energy efficient heating & cooling technologies ($/yr) [4]**
- **Private RD&D investment in energy efficient heating & cooling technologies ($/yr) [4]**

Technology Readiness

- **Typical payback period for retrofitting existing heating/cooling system with energy efficient system (yr) [4]**
- Maximum efficiency of a) electric heat pumps, b) gas-engine heat pumps, c) CHP, d) solar thermal, and e) chillers (%) [4]
- Capital cost of a) electric heat pumps, b) gas-engine heat pumps, c) CHP, d) solar thermal, and e) chillers [4]

Market Readiness

- **Percent improvement compared to 2000 of mandatory minimum energy performance standards for heating/cooling equipment sold in G20 countries (%) [1,4]**
- **Number of G20 countries with labeling programs for heating and cooling equipment (#) [1,4]**
- Average value of incentives issued per high efficiency heating and cooling unit ($/unit) [3]

Market Transformation

- **Global sales of new energy efficient heating and cooling equipment (units/yr) [4,5,6]**
- Learning rate: cost reduction associated with cumulative doubling in sales of high efficiency heating and cooling equipment (%) [2]
- Average energy use of new heating and cooling equipment sold (kWh/yr) [1]
- Percent of households with high efficiency heating/cooling system (%) [4]

Impacts

- GHG emissions avoided from use of high efficiency heating/cooling equipment (MtCO2e/yr) [4]
- Number of employees in energy efficient heating and cooling workforce (#)

Energy Efficient Heating and Cooling Equipment – Suggested changes

Sample Metrics for Measuring Progress toward a Global Clean Energy Economy

Resources

- **Public RD&D investment in energy efficient heating & cooling technologies ($/yr) [4]**
- **Private RD&D investment in energy efficient heating & cooling technologies ($/yr) [4]**

Technology Readiness

- **Typical cost for retrofitting existing heating/cooling system with energy efficient system ($/unit) [4]**
- Maximum efficiency of a) electric heat pumps, b) gas-engine heat pumps, c) CHP, d) solar thermal, and e) **AC systems**(%) [4]
- **Average installed efficiency** of a) electric heat pumps, b) gas-engine heat pumps, c) CHP, d) solar thermal, and e) **AC systems**[4]

Market Readiness

- **Percent improvement compared to 2000 of mandatory MEPS multiplied by market coverage for heating/cooling equipment sold in G20 countries (%) [1,4]**
- **Number of G20 countries with labeling programs, split by categorical, endorsement and other for heating and cooling equipment (#, type) [1,4]**
- ~~Average value of incentives issued per high-efficiency heating and cooling unit ($/unit) [3]~~

Market Transformation

- **Global sales of new energy efficient heating and cooling equipment – needs stricter definition (units/yr) [4,5,6]**
- Learning rate: cost reduction associated with cumulative doubling in sales of high efficiency heating and cooling equipment (%) [2]
- Average energy use of new heating and cooling equipment sold (kWh/yr) [1]
- Percent of households with high efficiency heating/cooling system (%) [4]

Impacts

- **End-use energy demand and** GHG emissions avoided from use of high efficiency heating/cooling equipment (**TWh,** $MtCO_2e$/yr) [4]
- ~~Number of employees in energy efficient heating and cooling workforce (#~~)

Energy Efficient Lighting

Sample Metrics for Measuring Progress toward a Global Clean Energy Economy

Resources

- **Public RD&D investment in energy efficient lighting ($/yr) [1]**
- **Private RD&D investment in energy efficient lighting ($/yr) [1]**

Technology Readiness

- **Typical payback period for retrofitting existing lighting systems with energy efficiency lighting in a) residential and b) service applications (yr) [3]**
- Maximum efficacy of a device with lifetime of at least 10,000 hrs (lm/W) [1]
- Ratio of efficacy improvement to lamp cost difference for comparable devices (ratio) [2]

Market Readiness

- **Percent improvement compared to 2000 of mandatory minimum energy performance standards for lamps sold in G20 countries (%) [4]**
- Capacity of manufacturing throughput of high efficacy devices (lm/hr) [2]
- Annual assembly cost reduction for manufacturing high efficacy devices (%) [2]

Market Transformation

- **Global sales of energy efficient lamps (units/yr) [4,5]**
- Average efficacy of annual devices sold (lm/W) [4]
- Learning rate for capital costs: cost reduction associated with cumulative doubling in sales of high efficacy lighting (%) [6]
- Market capitalization of high efficacy lighting companies ($)
- Total electricity consumption from lighting by a) households and b) services [5]
- Percent of lighting devices using high efficacy systems (on a per lumen basis) (%) [5]

Impacts

- GHG emissions avoided ($MtCO_2e$/yr) [4]
- Number of employees in energy efficient lighting workforce (#) [1]

Energy Efficient Lighting – Suggested Changes

Sample Metrics for Measuring Progress toward a Global Clean Energy Economy

Resources

- **Public RD&D investment in energy efficient lighting ($/yr) [1]**
- **Private RD&D investment in energy efficient lighting ($/yr) [1]**

Technology Readiness

- **Typical cost of retrofitting existing lighting systems with energy efficiency lighting in a) residential and b) service applications (yr) [3]**
- Maximum efficacy of (a) a non-directional light source with lifetime of at least 6,000 hrs and (b) a directional light source with lifetime of at least 20,000 hrs (lm/W) [1]
- **Average installed efficacy of lighting in (a) residential and (b) service applications** (lm/W) [2]

Market Readiness

- **Percent improvement compared to 2000 of mandatory minimum energy performance standards multiplied by market coverage for lamps sold in G20 countries (%) [4]**
- **Number of G20 countries with labeling programs, split by categorical, endorsement and other for lamps (#, type) [1,4]**
- Capacity of manufacturing throughput of high efficacy devices (**units/yr**) [2]
- ~~Annual assembly cost reduction for manufacturing high efficacy devices (%) [2]~~

Market Transformation

- **Global sales of energy efficient lamps – needs stricter definition (units/type.yr) [4,5]**
- Learning rate for capital costs: cost reduction associated with cumulative doubling in sales of high efficacy lighting (%) [6]
- Total electricity consumption from lighting by a) households and b) services [5]
- Percent of lighting devices using high efficacy systems (on a per lumen basis) (%) [5]
- ~~Average efficacy of annual devices sold (lm/W)~~
- ~~Market capitalization of high efficacy lighting co~~

Impacts

- **End-use energy demand and** GHG emissions avoided (**TWh,** MtCO2e/yr) [4]
- ~~Number of employees in energy efficient lighting workforce (#) [1]~~

Energy Efficient Appliances

Sample Metrics for Measuring Progress toward a Global Clean Energy Economy

Resources

- **Public RD&D investment in energy efficient appliances ($/yr) [1]**
- **Private RD&D investment in energy efficient appliances ($/yr) [1]**

Technology Readiness

- **Typical payback period for purchasing an advanced appliance (yr) [2]**
- Maximum efficiency achieved in lab for a) refrigerators, b) clothes washers, c) clothes dryers, and d) dishwashers (kW/d/L) [1]
- Ratio of efficiency improvement to appliance cost difference for comparable units (ratio)[2]

Market Readiness

- **Percent improvement compared to 2000 of mandatory minimum energy performance standards for appliances sold in G20 countries (%) [1,5,6]**
- **Number of G20 countries with labeling programs for high efficiency appliances (#) [6]**
- Average value of incentives issued per high efficiency appliance ($/unit) [3,4]

Market Transformation

- **Annual sales of high efficiency appliances (units/yr) [2,8,11]**
- Learning rate for capital costs: cost reduction associated with cumulative doubling in sales of high efficiency appliances (%) [7]
- Average energy consumption for new large appliances including a) refrigerators, b) clothes washers, c) clothes dryers, and d) dishwashers (kWh/yr) [5,10,11]
- Percent of large appliance stock that can be considered high efficiency (%) [1]

Impacts

- GHG emissions avoided from use of energy efficient appliances (MtCO2e/yr)
- Number of employees in high efficiency appliance workforce (#)

Energy Efficient Appliances – Suggested Changes

Sample Metrics for Measuring Progress toward a Global Clean Energy Economy

Resources

- **Public RD&D investment in energy efficient appliances ($/yr) [1]**
- **Private RD&D investment in energy efficient appliances ($/yr) [1]**

Technology Readiness

- **Typical cost of purchasing an advanced appliance (yr) [2]**
- Maximum efficiency achieved in **market** for (a) refrigerators **(kWh/l.yr)**, (b) **televisions (kWh/inch^2.yr)**, **(c) …..**
- ~~c) clothes dryers, and d) dishwashers (kW/d/L)~~ [1]
- **Average installed efficiency of efficient (a) refrigerators, (b) televisions, (c) …..**
- ~~Ratio of efficiency improvement to appliance cost difference for comparable units (ratio)~~[2]

Market Readiness

- **Percent improvement compared to 2000 of mandatory MEPS multiplied by market coverage for appliances sold in G20 countries (%) [1,5,6]**
- **Number of G20 countries with labeling programs, split by categorical, endorsement and other, for high efficiency appliances (#, type) [6]**
- ~~**Average value of incentives issued per high efficiency appliance ($/unit) [3,4]**~~

Market Transformation

- **Annual sales of high efficiency appliances – needs further definition (units/type yr) [2,8,11]**
- Learning rate for capital costs: cost reduction associated with cumulative doubling in sales of high efficiency appliances (%) [7]
- Average energy consumption for new average appliances including (a) refrigerators, (b) televisions, © … (kWh/yr) [5,10,11]
- Percent of installed appliance stock that can be considered high efficiency (% per type) [1]

Impacts

- **End-us energy demand and** GHG emissions avoided from use of energy efficient appliances (**TWh,** MtCO2e/yr)
- ~~Number of employees in high efficiency appliance workforce (#)~~

Thank you

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