U.S. EPA Experiences Measuring, Reporting, and Verifying Greenhouse Gas Emissions

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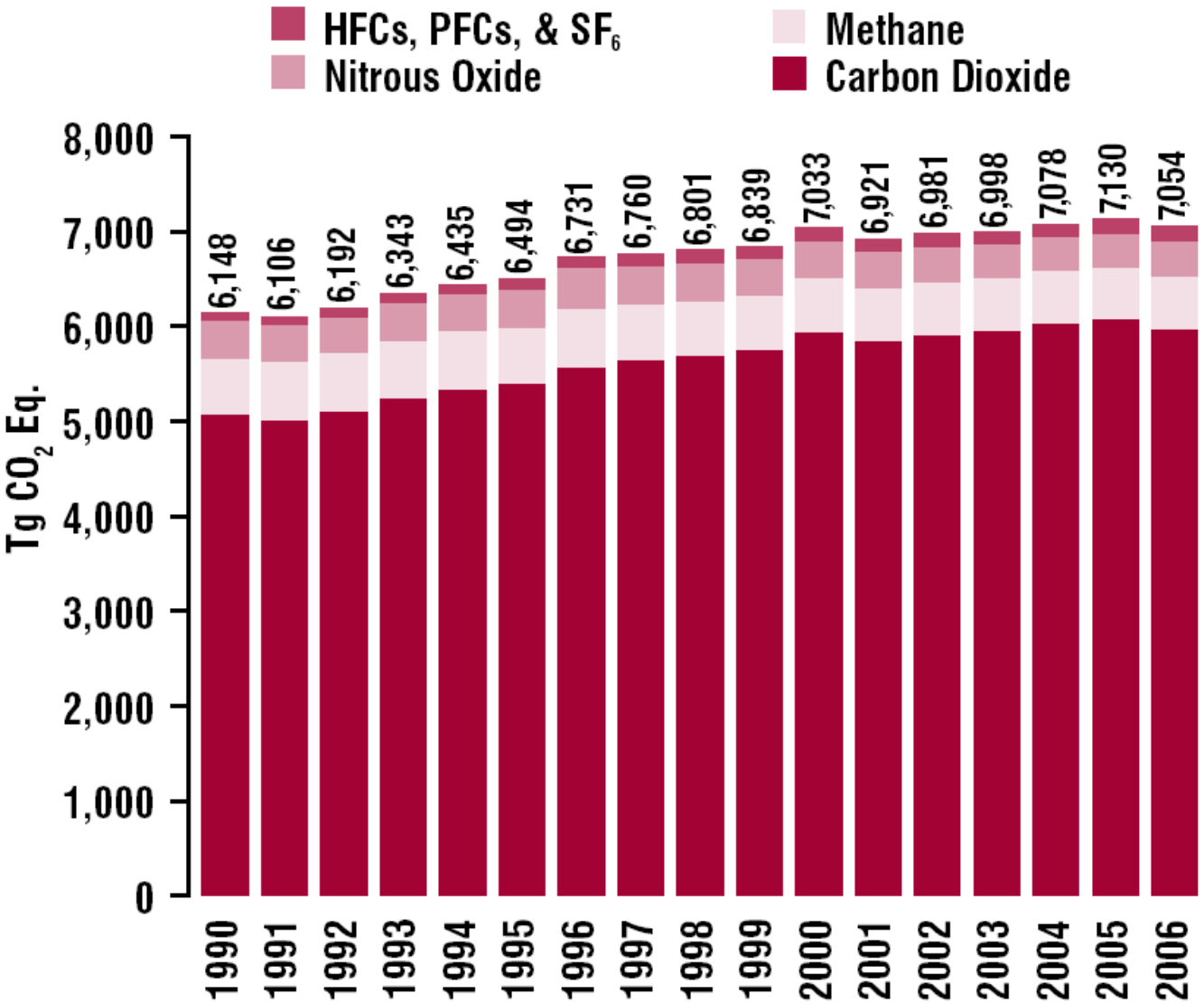
Purpose & Organization

- Purpose
  - Share U.S. experiences measuring, reporting, and verifying greenhouse gas emissions and evaluating program achievements
- Organization
  - U.S. GHG emissions and Office of Atmospheric Programs (OAP) climate protection programs
  - Three examples
    - Indirect emissions – National program (ENERGY STAR Products)
    - Direct emissions – facility level (Semiconductor Manufacturing)
    - Direct emissions – project level (Landfill Gas – CH_4)
  - Conclusion and questions

U.S. GHG Emissions (1990-2006)



Source: *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006* (April 2008)

EPA Climate Protection Programs (partial list)

- 2007 Program Benefits
  - ENERGY STAR Total = 155 $MMTCO_2$ eq.
    - Products & homes
    - Buildings
    - Industry
  - U.S. Fluorinated GHG Programs = 51 $MMTCO_2$
  - U.S. Methane Programs = 64 $MMTCO_2$

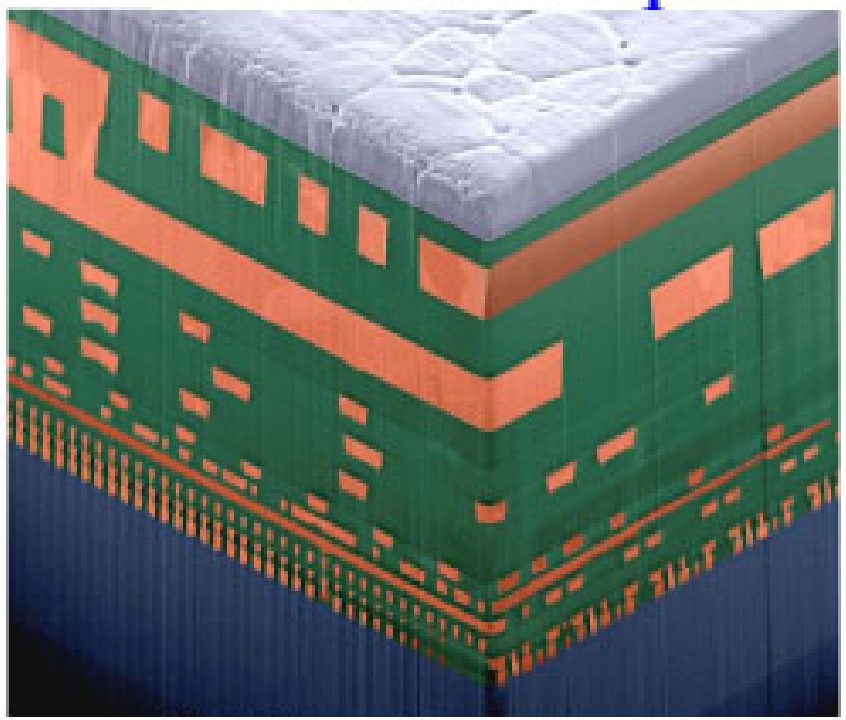
  - 2007 Total = 270 $MMTCO_2$

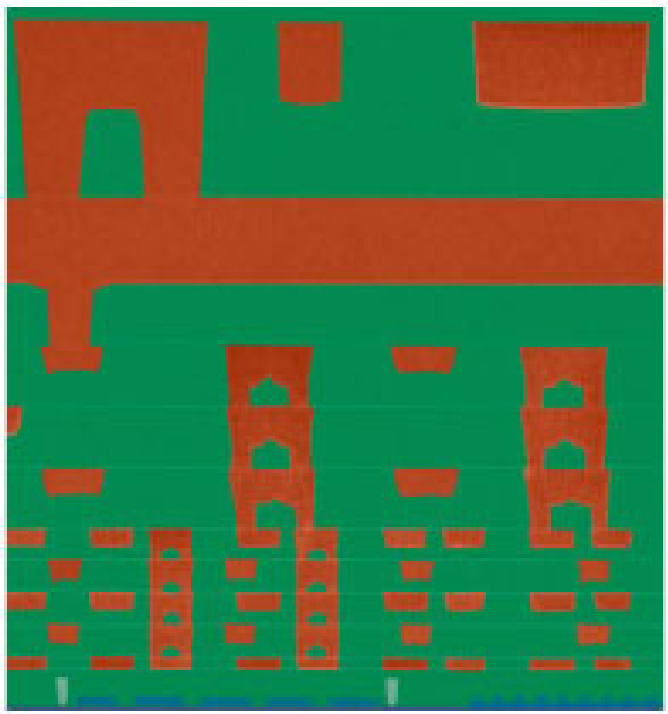
ENERGY STAR Products

- ENERGY STAR label awarded to most energy efficient products by category (e.g., appliances, electronics, office equipment, HVAC)
  - Reduced 65 MMTCO$_2$ eq. in 2007
- Collect total national sales of ENERGY STAR products
- Determine portion of sales above BAU level
  - Accounts for normal adoption of E^2 technology / design
- Multiply unit energy savings/product by units sold over BAU
  - Product specific metrics
  - Assumes every product meets minimum E STAR specification, daily use pattern, etc.
- Calculate emissions reduced by applying marginal carbon emission factor to energy savings
- New specification seeks to capture roughly top 25% most efficient
  - Update specification when E STAR product achieves roughly 50% market penetration
- Program integrity is enhanced by EPA, program partners (manufacturers and NGOs), third parties (Consumer Reports)

Semiconductor Layers

90nm Microprocessor Cross-Sections





Metal levels:

W: 1 local interconnect level plus contact level

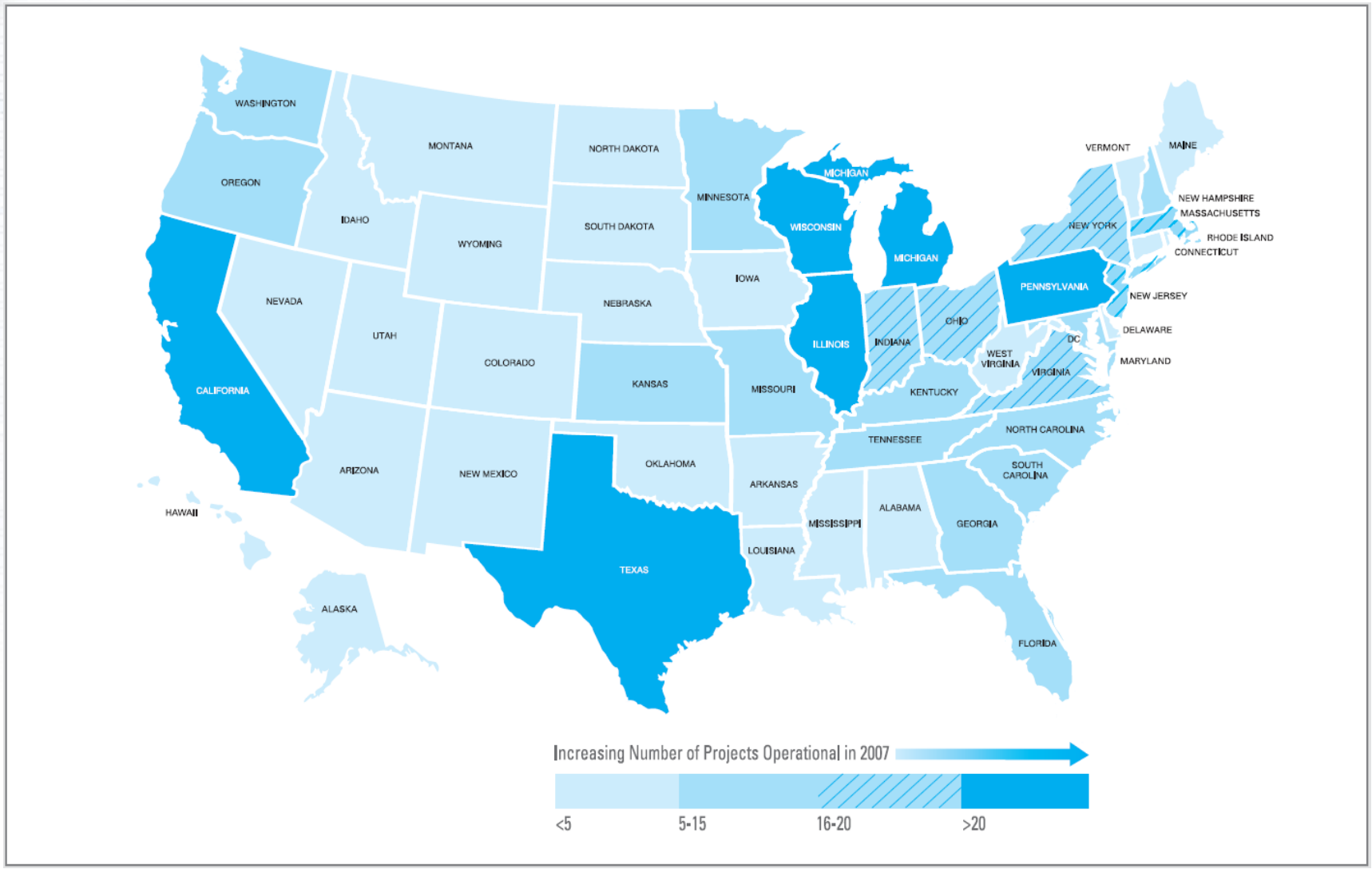
Cu: 10 levels - first 8 levels in low-k, final 2 in SiOF

Al: 1 terminal metal level, used for pads and wiring

Semiconductor Manufacturing

- Advanced electronics manufacturers use and emit very strong fluorinated GHGs
  - Semiconductors, LCDs, MEMS, Photovoltaics
  - PFCs, HFCs, SF_6, NF_3 (plasma etch and CVD clean)
  - EPA U.S. Partners reduced 9 $MMTCO_2$ eq. in 2007
- EPA Partners track and report annual emissions consistent with 2006 IPCC Guidelines – Tiers 2 and 3
  - 80% U.S. industry
- EPA compares actual Partner emissions against "no action" scenario to estimate achievements
  - "No action" scenario uses average 1996 – 1999 vintage emission factor per layer
  - Emission Factor applied to global silicon consumed x layers
  - U.S. Partner share of "uncontrolled" emissions apportioned by production capacity x layers
    - Total Manufactured Layer Area (TMLA)

U.S. Landfill Gas Energy Projects



Landfill Methane Outreach Program

- 19 MMTCO$_2$ eq. in 2007 from both energy and voluntary flaring projects
- Accounts for unregulated sources and tracks landfill gas (LFG) capture and use with flow meters
- 1 million tons U.S. municipal solid waste in a landfill generates 1,783 tons CH_4 / year
  - Average LFG collection system efficiency = 85%
  - Assume average U.S. LFG contains 50% CH_4
  - Electric power generation potential = 0.8 MW
  - LFG energy project reduces 4,258 tons CO_2 eq./year
- Users of LFG for energy assure system integrity – seek to maximize efficiency and profits

Reference LFGE Benefits Calculator at www.epa.gov/lmop/res/calc.htm

State of U.S. LFG-Energy Projects (Dec. '08)

- **469 operational projects currently**
  - **11.5 billion kWh of electricity produced and nearly 80 billion cubic feet of gas delivered in '08**
- **At least 60 projects under construction for '08/09 & more in the advanced planning stages**
- **At least 520 candidate landfills with 1,200 MW of potential capacity *or* 225 billion cubic feet/yr of LFG for direct use AND ~51 MMTCO$_2$ eq. in potential emission reductions!**

Conclusions

- Smart programs begin with measurement and seek continuous improvement
- Screen / measure to identify key sources
- Design appropriate policy or measure
  - Consider cost effective emission measurement and monitoring procedures
- Voluntary programs built upon mutual trust
  - Limited mechanisms for verification
- Sound data support program evaluation, refining policy tools
  - IPCC Inventory Guidelines
  - EPA draft standard method for measuring F-GHG emission control device performance
  - Reporting rule
  - Evolving international MRV approaches

Acknowledgements

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