

Estimating Environmental Costs

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Outline

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- Economic Input-Out Life-Cycle Assessment Model (EIO-LCA)
- Operational and Production Model

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- Impact on Producers vs. Consumers

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ENVIRONMENTAL COSTS AND THE IT PORTFOLIO



Assessing Future Costs

Future Environmental Costs

- Increased electricity prices (2%-4%)
- Carbon tax per ton (producers and consumers)
 - Projected range: \$10 to \$50 per metric ton

→ *What is the impact of above on TCO of IT products?*

- Purchase Price
- Operational Cost



Assessing Future Costs

Baseline Composition of Enterprise IT Portfolio

- 5,000 Netbooks (e.g. HP Mini)
- 15,000 Handhelds (e.g. HP iPAQ Business Messenger)
- 30,000 Laptops (e.g. HP Compaq Notebook PC)
- 20,000 Desktops (e.g. HP Compaq dc7900 Minitower)
- 1,500 Servers (e.g. HP Proliant DL360)



Three Scenarios

Scenario A: Baseline

- Constant electricity prices
 - Normalized to current (2009) industrial rates
- \$0 carbon tax (e.g. legislation fails to pass or costs absorbed internal to supply chain)



Three Scenarios

Scenario B: Low

- Electricity: 3% increase in prices
 - Normalized to current *industrial* rates
 - Nominal price increase in electricity rates
- \$10 carbon tax



Three Scenarios

Scenario C: High

- Electricity: 3% increase in prices
 - Normalized to current *residential* rates
 - High end price increase
- \$50 carbon tax

OPERATIONAL AND PRODUCTION MODEL

**EIO-LCA Model
and
Power Utilization Model**



Economic Input-Output Model

The economy is divided into n sectors

X_i is the total output (production) of sector i

Y_i is the total final demand for sector i 's product

z_{ij} represents the interindustry sales from sector i to sector j

$$X_i = z_{i1} + z_{i2} + \dots + z_{in} + Y_i$$

Let $a_{ij} = z_{ij}/X_j$:
$$X_i = a_{i1}X_1 + a_{i2}X_2 + \dots + a_{in}X_n + Y_i$$

EIO-LCA Model

Economic Input-Output Model (EIO):

$$X = (I - A)^{-1}Y$$

Decomposition:
$$X = Y + AY + A^2Y + A^3Y + \dots + A^nY$$

EIO-LCA:

$$b_i = R_i x$$

$$b_i = R_i (I - A)^{-1} y$$

b_i is a vector of environmental burdens for each production sector,

R_i is a matrix with diagonal elements representing the impact per dollar output at each stage



Environmental Cost Model

Operational Impact Model:

- Power Utilization

$$P_{sys}^{op} = \sum_{i=1}^n \left(\int_0^T \dot{W}_i X_i(t) \hat{P}_{elec}(t) dt \right)$$

- Environmental Impact

$$\varepsilon_{op} = \hat{\varepsilon}_{elec} (I - A)^{-1} p_{elec}$$

Production Model:

$$b_i = R_i (I - A)^{-1} y$$

i = electricity use and CO2 emissions



RESULTS

**TCO: Product level and
the Enterprise Customer**

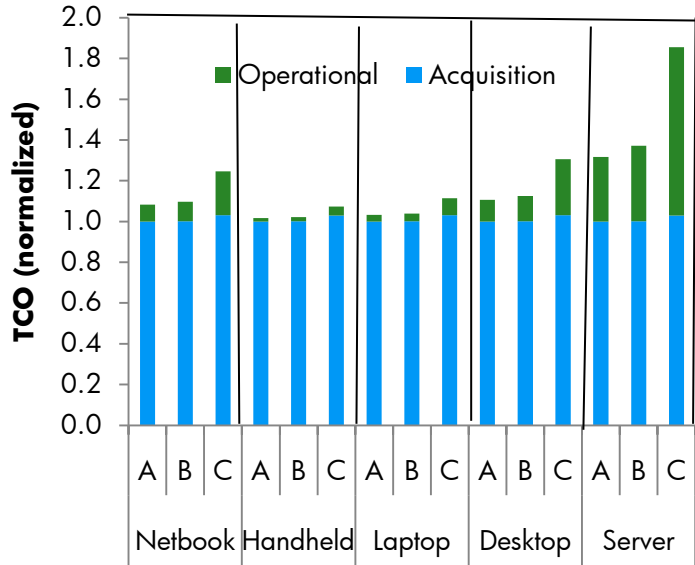
**Distribution of Costs:
Producer vs. Purchaser**



Forecasted Changes in TCO

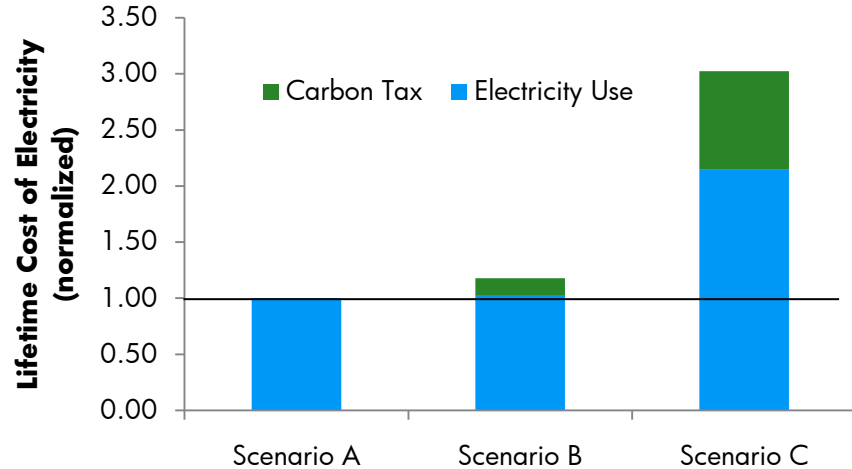
Product-Level

Average increase of 1.3% per device
(range: from 0.3% to 36%)



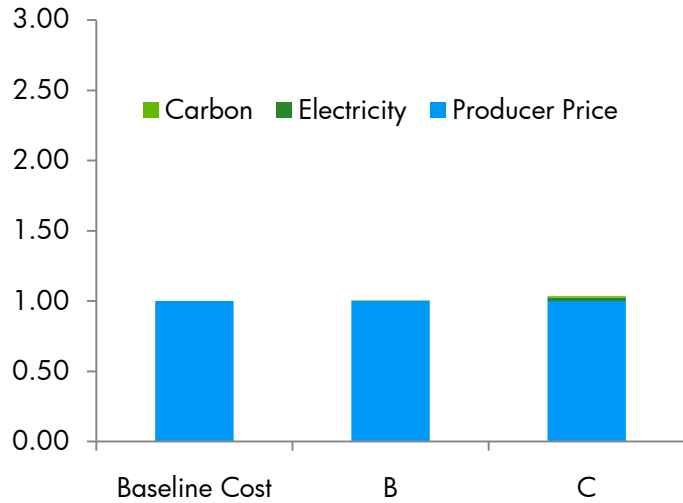
Enterprise-Level Portfolio

1% to 12% potential increase in TCO

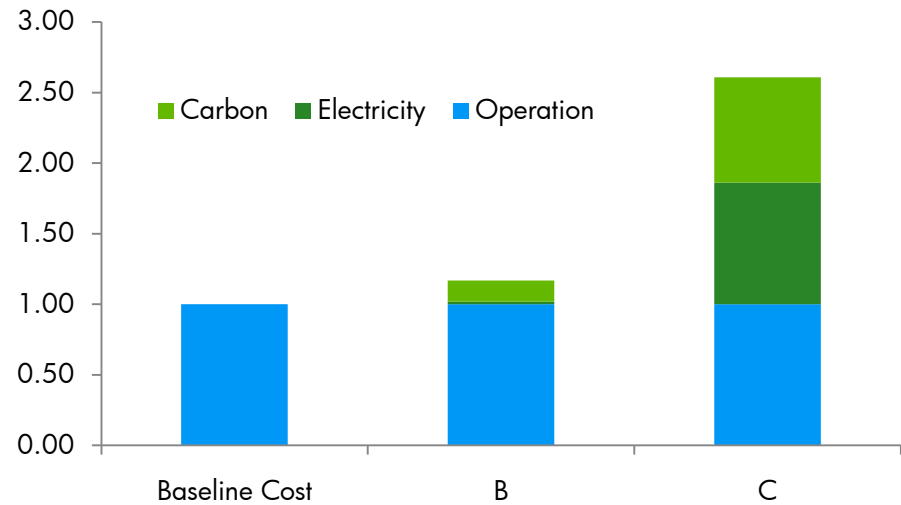


Distribution of Costs

PRODUCER



PURCHASER



CONCLUSIONS



Conclusions and Future Work

Key Contributions

- Constructed a model to evaluate *lifecycle* increase in TCO due to environmental drivers, specifically electricity and carbon costs
 - For the consumer, in terms of acquisition as well as operation
 - For the producer, internally as well as across the supply chain
- Demonstrated model for sample enterprise customer
 - TCO of specific IT product families could increase by up to 36%
 - Increase in TCO of up to \$5.9 million for a representative enterprise customer



Conclusions and Future Work

Future Work

- Elasticity of demand impacts
 - How will consumers respond to increasing cost of IT ownership?
- Demand response mechanisms in the Smart Grid market
 - Time-of-use (TOU) pricing mechanisms

