Abstract:

This paper reports industry-wide composite metrics for the US chemical industry and specific comparison metrics for selected other US industries. Calculations are based up on publicly available data.

Design work and preliminary testing of indicators for energy and materials intensity by numerous companies and various organizations has been completed the author and others. That work yielded a good starting point for indicators and metrics of industrial performance. The major themes of those indicators efforts were energy and material use and pollutant dispersion. Metrics for energy efficiency - energy consumed per unit of output – were found to be readily and widely implementable and meaningful for individual large companies. Metrics for material intensity - materials consumed per unit of output – have also been found to be feasible, but are more applicable and relevant in some industry sectors than others. Comparable land use metrics were not developed until recently.

Now, three metrics have been calculated for land use: 1) land required to generate one dollar of annual sales, 2) full-time equivalent jobs generated per acre and 3) pollutants emitted per acre. And composite metrics for entire industries have been developed and calculated. Over 12,000 cases were examined and examples of the data for two land use metrics for job creation and revenue generation have been reported: land area per annual sales dollar and jobs created per unit land area. These are two “benefit metrics” in contrast to the typical “cost metrics”, e.g., material use, energy use, water use and pollutants emitted.

Composite industry-by-industry metrics are reported for use as benchmarks for entire industries (Ref. 1, 4, 6, 7).
Introduction

Issue identification mechanisms, metrics and other indicators must be established before government and industry can make rational judgments regarding industry site selection.

The conventional business model is to evaluate anticipated net revenues and compare that to cost for conducting the business over time. Different companies use various methods, e.g., incorporation of cost of capital, threshold periods for net present value calculations. This is graphically depicted by the following diagram.

Conventional Business Model

Invest when business revenues > business costs

Figure 1. Conventional Business Decision Model

A few companies are incorporating estimated societal costs and societal benefits in the calculation. As estimation methods and their respective databases improve and expand the quality of the decisions improves (Ref. 2).
Governments and civil governing bodies are constantly faced with decisions regarding site selection and business selection. Rhetoric often overcomes reason, with “jobs” and future tax revenues being the factors cited to voters and bond issuers. Tax increment financing is often sought and obtained to provide “preferred employers” with incentives for many projects. Often this leads to leveling existing residential areas, older businesses, agricultural land and undeveloped areas. Little consideration or voice is given to the increase in services required or the widespread exodus of business activity when incentives expire.

Government entities and the public would be well-served to consider the net present value of both costs and benefits for the alternatives they assess and select.
Sustainability Model for Government

Invest when Tax revenues > Services costs
and Total benefits > Total costs

Figure 3. Sustainable Government Decision Model

Earlier design work and preliminary testing of indicators for energy and materials intensity by twenty companies took place under the auspices of the National Roundtable on the Environment and the Economy (Ref. 7) and the Center for Waste Reduction Technologies (Ref. 9, 10). That work yielded a good starting point for indicators and metrics of industrial performance. The major themes of those indicators efforts were energy and material use and pollutant dispersion. Metrics for energy efficiency - energy consumed per unit of output – were found to be readily and widely implementable and meaningful for individual large companies. Metrics for material intensity - materials consumed per unit of output – have also been found to be feasible, but are more applicable and relevant in some industry sectors than others. However, land use metrics were not developed.

Land Use Metrics

Now, three metrics have been calculated for land use: 1) land required to generate one dollar of annual sales, 2) full-time equivalent jobs generated per acre and 3) pollutants emitted per acre. Over 12,000 cases were examined. Examples of the data for two land use metrics for job creation and revenue generation are shown below. The values were calculated from the USDOE Industrial Assessment Center database. While that database was not intended originally for this purpose, the wealth of data and its classification by SIC gives a well-spring of information. In the example shown below for SIC Code 3524, more a dozen sites were characterized. Land area per annual sales dollar and jobs created per unit land area are shown. These are two “benefit metrics” in contrast
to the typical “cost metrics”, e.g., material use, energy use, water use and pollutants emitted.

<table>
<thead>
<tr>
<th>$ Sales</th>
<th>FTE Jobs</th>
<th>Land Area</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>$5.0 M</td>
<td>38</td>
<td>40 k sq. ft</td>
<td>Lawn Vacuum</td>
</tr>
<tr>
<td>19.8 M</td>
<td>65</td>
<td>52 k</td>
<td>Wire</td>
</tr>
<tr>
<td>2.0 M</td>
<td>150</td>
<td>63 k</td>
<td>Mowers, ditchers</td>
</tr>
<tr>
<td>60.0 M</td>
<td>120</td>
<td>78 k</td>
<td>Garden Equipment</td>
</tr>
<tr>
<td>30.0 M</td>
<td>260</td>
<td>100 k</td>
<td>Drive components</td>
</tr>
<tr>
<td>88.0 M</td>
<td>289</td>
<td>128 k</td>
<td>Lawn Mowers</td>
</tr>
<tr>
<td>200.0 M</td>
<td>360</td>
<td>160 k</td>
<td>Lawn Mowers</td>
</tr>
<tr>
<td>220.0 M</td>
<td>800</td>
<td>180 k</td>
<td>Lawn Mowers</td>
</tr>
<tr>
<td>75.0 M</td>
<td>415</td>
<td>210 k</td>
<td>Lawn &amp; Garden Equip.</td>
</tr>
<tr>
<td>200.0 M</td>
<td>137</td>
<td>240 k</td>
<td>Garden Care Equip.</td>
</tr>
<tr>
<td>630.0 M</td>
<td>700</td>
<td>250 k</td>
<td>Weed Eaters &amp; Blowers</td>
</tr>
<tr>
<td>340.0 M</td>
<td>697</td>
<td>375 k</td>
<td>Lawn Mowers</td>
</tr>
<tr>
<td>1750.0 M</td>
<td>750</td>
<td>1740 k</td>
<td>Lawn &amp; Garden Equip.</td>
</tr>
</tbody>
</table>

$274 Average Annual Sales per sq. ft.
57 FTE Jobs per Acre

Table 1. Land Use for Lawn Equipment Production (SIC Class 3524)

If a governing entity or land-owner has a strong interest in area job growth, data from the Industrial Assessment Database can be used to evaluate businesses in various SIC Codes based on the number of jobs likely to be created if a given type of manufacturing facility is developed and located on the property.

Values for more than 100 SIC Codes have been calculated for this study. Decision rules for the study are, in part, dictated by the database itself. Jobs are full-time equivalent positions, but do not include jobs created in the supporting infrastructure including suppliers and contractors. The purpose of the IAC database dictates that at a minimum the land area values include areas that require energy use, e.g., areas under roof or enclosed. Often values for parking, laydown and support infrastructure are also included.

Calculations for SIC Codes with less than five entries were not considered because of possible variability.
Table 2. Job Creation and Sales Revenue per Acre

It appears from the sample above and a broader spectrum examined that some manufacturing industries provide a higher combination of employment benefits and tax revenues than others, e.g., ink, rubber goods and plastic parts versus pipe & tubing.
Based upon earlier work and the Industrial Assessment Center Database, calculations can be made to represent the impact of locating an average chemical plant on a given piece of land.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Emissions per dollar revenue</td>
<td>0.0069 pounds</td>
</tr>
<tr>
<td>Total Emissions per acre per year</td>
<td>24,900 pounds</td>
</tr>
<tr>
<td>Greenhouse Gas equivalents per dollar revenue</td>
<td>2.52 pounds CO₂</td>
</tr>
<tr>
<td>Greenhouse Gas equivalents per acre per year</td>
<td>4558 tons</td>
</tr>
<tr>
<td>Revenue per acre per year</td>
<td>$3.6 M</td>
</tr>
<tr>
<td>FTE jobs per acre</td>
<td>8.7</td>
</tr>
</tbody>
</table>

**Table 4. Emissions metrics for the US Chemical Industry**  
(based on data for 53 product/process combinations – Ref. 1,4)

Calculations for other industries are not complete as of this writing.

**Conclusions**

- A simple set of metrics can be used to make decisions regarding impacts of various types of businesses which might be located on specific pieces of land.
- Useful metrics can be computed from publicly available data such as the Industrial Assessment Center Database.
- There is a wide variation in number of jobs created, revenue generated, emissions and tax base for industries and simple calculations can represent those factors.

**Future Work**

Future work will focus on 1) refining the emissions choices and computing those values for the SIC Codes, 2) calculating service costs, and 3) estimating value-added by various business types.
References


2. Beaver, Earl “Total Cost Assessment and LCA”, Environmental Progress, Summer 2000 (Vol. 19, No.2).


Acknowledgements

I gratefully acknowledge the assistance of James Eggebrecht of Texas A&M University and earlier contributions of Beth R. Beloff and Dickson Tanzil of BRIDGES to Sustainability, and Kimberly Murphy (currently at Five Winds, International). I acknowledge the previous financial support of the United States Department of Energy Office of Industrial Technologies for the underlying work
from two earlier projects and the support of Dow Chemical, Monsanto Company, Owens Corning and GlaxoSmithKline.

These projects would not have been possible without the earlier work by the teams of industrial participants in metrics efforts at the National Roundtable on the Environment and the Economy and those of the Center for Waste Reduction Technologies (Ref. 7, 9,10).