RESOURCE CONSERVATION

OVERVIEW: Resource conservation is the process of selecting and using products, processes, or technologies that minimize the overall use or consumption of resources while effectively achieving a desired function. The Resource Conservation module describes methods for identifying the relative amounts of resources or materials used or consumed by a business as a consequence of changing from a chemical, process, or technology to a substitute. In a CTSA, resource consumption data are usually collected in the Performance Assessment module.

The methods described here focus on direct resource use rates (e.g., the amount of materials consumed to manufacture a product), *not* indirect resource use rates (e.g., the amount of land that is consumed by landfilling waste). Indirect resource consumption is qualitatively evaluated in the Social Benefits/Costs Assessment module.

GOALS:

- Determine the relative amounts of resources consumed by the baseline and the substitutes.
- Evaluate the relative effects on resource conservation of the baseline as compared to the substitutes.
- Provide data on resource consumption rates and relative impacts to the Cost Analysis and Risk, Competitiveness & Conservation Data Summary modules.

PEOPLE SKILLS: The following lists the types of skills or knowledge that are needed to complete this module.

- Familiarity with the types, sources, and supply of resources consumed by the baseline and substitutes.
- Familiarity with the common operating practices employed by the industry that might affect the rate of resources consumption.

Within a business or a DfE project team, the people who might supply these skills include a plant engineer, material scientist, environmental engineer, line operator, or suppliers of the substitutes.

DEFINITION OF TERMS:

Natural Resources: Material or substance which in its basic form is found in nature. For example, water, petroleum, and wood are natural resources in the sense that they do not have to be made in an industrial process.

Renewable Resource: As defined in Society of Environmental Toxicology and Chemistry publications, a renewable resource is one that is being replenished at a rate greater than or equal to its rate of depletion. For example, wood used to make paper can be replaced with wood supplied by the growth of new trees as long as the rate of paper production combined with the rate of wood consumption does not exceed the rate of replenishment.

Resource: Material or substance used as a process raw material or required for process operation (e.g., oil for machine lubrication or a chemical feedstock for a chemical reactor).

APPROACH/METHODOLOGY: The following presents a summary of the technical approach or methodology for evaluating the potential impacts of substitutes on resource conservation. Further methodology details for Steps 1, 3, 6, and 7 follow this section.

Step 1: Review the Chemistry of Use & Process Description module to identify the types of resources consumed and the specific process steps where resources are consumed by the baseline and by the substitutes. It may be useful to categorize resources (e.g., chemical products, water, renewable vs. nonrenewable, etc.) to facilitate the evaluation of the relative impacts of alternatives in Step 7. *(Although energy may be derived from renewable and nonrenewable resources, this module does not focus on energy consumption, which is addressed in the Energy Impacts module.)*

Step 2: Review the Control Technologies Assessment module to identify the control technologies that are recommended or required for the baseline or the substitutes. This can include air pollution control technologies, chemical destruction technologies, and in-plant waste water treatment technologies. Evaluate the control technologies to identify the types of resources they consume (e.g., chemical flocculants used in waste water treatment).

Step 3: Determine the data required to evaluate the rates of consumption of the resources identified in Steps 1 and 2. Provide the data requirements to the Performance Assessment module so that resource consumption data can be collected during the performance demonstration project. Data should be collected on a per unit production basis, or some other basis that allows a comparative evaluation of the resource impacts. If performance data are being collected from existing sources instead of tests performed as part of the CTSA, estimates of resource consumption can be obtained from equipment vendors, industry representatives, or other sources.

Step 4: Obtain data from the Performance Assessment module and calculate the resource requirements of the baseline and of the substitutes. Resource requirements should be calculated using a common basis, such as a per unit production basis or the amount of solvent required to perform a cleaning function one time. This facilitates a comparative evaluation of the substitutes.

Step 5: Provide the resource requirements calculated in Step 4 to the Cost Analysis module, where consumption rates will be converted into monetary values.

Step 6: If up-stream resource conservation impacts are being evaluated in the CTSA, review the Chemical Manufacturing Process & Product Formulation module to evaluate resource requirements during the manufacturing of chemical ingredients or the formulation of chemical products. CTSA pilot projects have qualitatively evaluated up-stream resource conservation impacts.

Step 7: Tabulate resource requirements in Step 4 together with data on up-stream resource consumption from Step 6. Evaluate the relative impacts on resource conservation of the baseline as compared to the substitutes.

Step 8: Report the results of the evaluation to the Cost Analysis and Risk, Competitiveness & Conservation Data Summary modules.

METHODOLOGY DETAILS: This section presents methodology details for completing Steps 1, 3, 6, and 7. If necessary, additional information on this and other steps can be found in the published guidance.

Details: Step 1, Categorizing Resources

To simplify the process for evaluating the relative impact of substitutes on resource conservation, it is useful to develop a means of categorizing similar resources. For example, different chemical products used in one or more process steps could be categorized together, as could water resources, or process materials such as lubricating oils. Table 8-3 gives an example of categorizing the resources consumed during a three-step process to clean manufacturing equipment.

In this example, the equipment is cleaned with a chemical cleaning product; the resources consumed are water, chemicals, and the machine oil necessary to lubricate the cleaning equipment. After cleaning, the cleaned equipment is rinsed with water; process materials are also consumed in this step as the manufacturing equipment degrades incrementally with each cleaning, until it must be replaced. In the final step, some amount of trial processing is required after the cleaning, which results in finished products that do not meet specifications and must be discarded. The two resources consumed in this step are the waste product from the run and the machine oil that is used to lubricate the equipment.

TABLE 8-3: EXAMPLE OF CATEGORIZING SIMILAR RESOURCES				
Process Step	**Resources**			
	Water	**Chemical Products**	**Final Product Materials**	**Process Materials**
Step 1 - Cleaning	Dilute chemical product with water	Chemical cleaning product	None	Machine oil to lubricate cleaning equipment
Step 2 - Rinsing	Water rinse	None	None	Manufacturing equipment depleted after x cleanings
Step 3 - Waste Run	None	None	Trial processing after cleaning to achieve acceptable quality	Machine oil to lubricate manufacturing equipment

Details: Step 3, Collecting Data on Resource Consumption Rates

Data on resource consumption rates can be estimated based on purchase (inventory) records, process operator judgement, vendor data, or measured directly. Whichever technique is used, resource consumption data should be collected or converted into consistent units for the baseline and the substitutes, usually in unit mass (pounds or kilograms) per unit time or unit production. The following are examples of different types of data that can be used to estimate resource consumption rates.

<u>Example, Using Existing Records</u>

For the example of using purchase records to estimate the amount of plastic used in a plastic extrusion operation:

- Records show that 2,500 lbs of plastic pellets are purchased each year.
- It is estimated by the process specialist that 40 percent of this amount is used in the specific process under review.
- (0.40) (2,500 lbs/year) = 1,000 lbs used per year in process.

For the example of using purchasing records to estimate the amount of paint used in a parts painting operation:

- A potential substitute is a technology change where an improved paint spray system with a higher application efficiency will be utilized.
- It is estimated from case study data that a 35 percent reduction in paint use will be achieved since overspray losses will be substantially reduced with the use of the new system.
- From purchasing records it is calculated that 20,000 lbs of paint are currently purchased annually.

- The reduction in raw material (resource) use is estimated as:
  (20,000 lbs per year) - ([1-0.35] x [20,000 lbs per year]) = 7,000 lbs per year.

<u>Example, Using Direct Measurement</u>

For the example of using direct measurement to determine the amount of water utilized per year in a continuous flow rinse tank operation:

- Divert water flow from tank inlet into a container of known volume.
- Collect liquid until 1.5 gallon container is full (determine time interval using a stopwatch).
- Determine amount of time rinse tank is utilized per year.
- If it takes 5 minutes to collect 1.5 gallons, and the tank is used 8 hours/day, 5 days/week, 52 weeks/year:

  Water Consumption Rate = (1.5 gal/5 min) (60 min/hr) (8 hr/day) (5 day/wk) (52 wks/yr) = 37,440 gallons/yr

  Converting to lbs/yr:

  Water Consumption Rate = (37,440 gal/yr) x (8.34 lbs/gal) = 312,249 lbs/yr

Details: Step 6, Evaluating Up-stream Resource Conservation Impacts

The following are examples of the types of questions a DfE project team might consider when qualitatively evaluating up-stream resource conservation impacts:

- Are chemical products made from renewable or nonrenewable resources?
- Are scarce resources consumed to manufacture the chemicals or technologies in the use cluster?
- Are the raw materials used to manufacture the substitutes only found in low concentrations in their natural state (e.g., metals only in low concentrations in their ores)?

Details: Step 7, Evaluating the Impacts on Resource Conservation

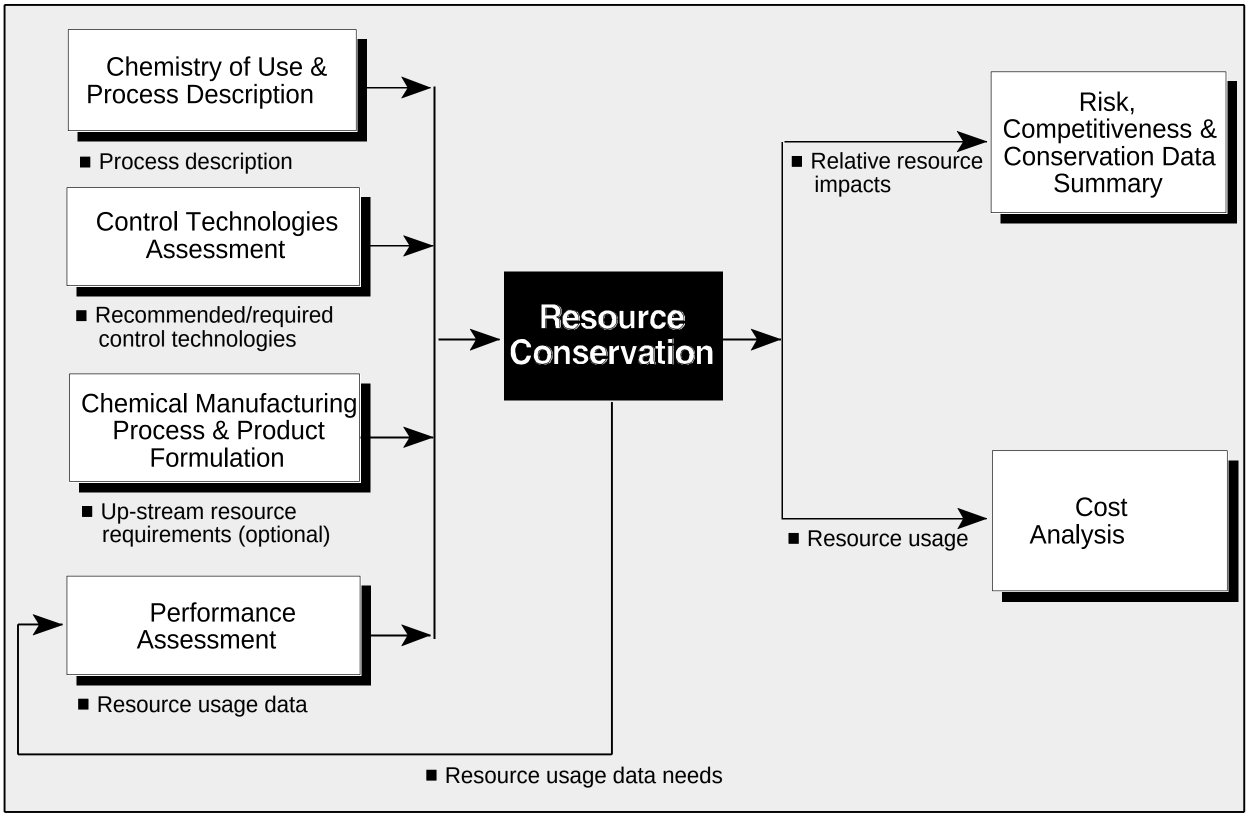
Tabulate the types and quantities of resources consumed by each substitute and baseline technology. Use the tabulation to determine if use of a substitute would result in a relative increase or decrease in overall resource consumption for similar categories of resources. The table may also be used to determine if renewable resources are being substituted for nonrenewable ones or if scarce resources are being substituted for resources in abundant supply. For the example above (see Table 8-3), Table 8-4 gives an example format for tabulating consumption rates.

TABLE 8-4: EXAMPLE OF TABULATED RESOURCE CONSUMPTION DATA FOR ONE SUBSTITUTE							
Process Step	**Resource**						
	Water	**Chemical Product**		**Waste Product**		**Process Materials**	
	Rate (gallons/hr)	**Rate (lb/hr)**	**Renewable**	**Rate (lb/hr)**	**Renewable**	**Rate (amt/time)**	**Renewable**
Step 1 - Cleaning	1	10	yes[a]	N/A	N/A	1 lb/shift	no
Step 2 - Rinsing	100	0	N/A	N/A	N/A	2 sets/yr	no
Step 3 - Waste Run	0	0	N/A	5	no	1 lb/shift	no
TOTAL	101	10	----	5	----	2 lb/shift of oil 2 sets equipment/yr	

N/A: Not applicable.
a) A citrus oil-based cleaner might be an example of a cleaner made from renewable ingredients. (However, petrochemicals are frequently used in the manufacture of chemicals made from vegetable products.)

FLOW OF INFORMATION: Data requirements for the Resource Conservation module are identified based on information from the Chemistry of Use & Process Description, Control Technologies Assessment, and Chemical Manufacturing Process & Product Formulation modules and collected in the Performance Assessment module. (The resource impacts of up-stream processes, such as chemical manufacturing and product formulation, could be collected from suppliers during a performance demonstration project. Up-stream resource conservation impacts have not been quantitatively evaluated in DfE pilot projects, however.) The Resource Conservation module transfers data to the Risk, Competitiveness & Conservation Data Summary and Cost Analysis modules. Example information flows are shown in Figure 8-2.

FIGURE 8-2: RESOURCE CONSERVATION MODULE: EXAMPLE INFORMATION FLOWS



ANALYTICAL MODELS: None cited.

PUBLISHED GUIDANCE: Table 8-5 presents published guidance on estimating the rates of resource consumption.

TABLE 8-5: PUBLISHED GUIDANCE ON ESTIMATING RESOURCE CONSUMPTION

Reference	Type of Guidance
Brown, Lisa, Ed. 1992. *Facility Pollution Prevention Guide.*	General methods for identifying and quantifying process materials consumption.
Dally, James W., et. al. 1984. *Instrumentation for Engineering Measurements.*	Methods for analyzing waste stream and raw material input quantities are discussed in cases where physical measurements are required.
Theodore, Louis and Young C. McGuinn. 1992. *Pollution Prevention.*	General description of process analysis.

Note: References are listed in shortened format, with complete references given in the reference list following Chapter 10.

DATA SOURCES: Table 8-6 lists sources of data which may be useful in calculating resource consumption rates.

TABLE 8-6: SOURCES OF DATA ON RESOURCE CONSUMPTION RATES	
Reference	**Type of Data**
Bolz, Ray E. and G.L. Tuve. 1970. *Handbook of Tables for Applied Engineering Science.*	Contains data which may be useful in analysis, such as material densities.

Note: References are listed in shortened format, with complete references given in the reference list following Chapter 10.