# Sustainable Value Stream Mapping

Best Management Practice Guide

## Introduction

Value Stream Mapping (VSM) is a tool used in lean manufacturing to identify waste. A value stream is defined as all activities, both value added and non-value added, required to take a product from raw material to the end customer. Value added activities create customer value (i.e. willing to pay for) while non-value added activities (waste) add costs that customers would rather not pay for. As a manufacturing principle, lean's focus is to continuously improve productivity by reducing the use of resources (i.e. time) on activities that do not create value for the end customer.

VSM starts by drawing each major step of the production process along with material inputs/outputs and the time spent associated with each step. The VSM can be used to compare the time spent on non-value added activities with the total time taken to produce the product. The result is a map of the entire manufacturing process for a single batch of production, or a time period (i.e shift or day). Initially created to increase productivity, VSMs can be adapted to also help a company identify the environmental sustainability impacts of production.

## Mapping for Sustainability

While lean manufacturing's focus is reducing non-value added activities, sustainable manufacturing focuses on the three pillars of sustainability: economy, society and the environment. As an approach, sustainable manufacturing manages the products, processes and systems to minimize negative impacts on the environment and improve sustainability performance. The method of capturing sustainability impacts via value stream mapping is called sustainable value stream mapping (Sus-VSM) and allows companies to review their operations from both a lean and sustainable manufacturing perspective.

Create a Sus-VSM to visualize sustainablity impacts of a procees.

Gather data and input from all levels of a company to create a Sus-VSM.

***Need Help...***

- *developing a Sus-VSM,*
- *training a team in Sus-VSM*
- *or educating employees about Sus-VSM?*

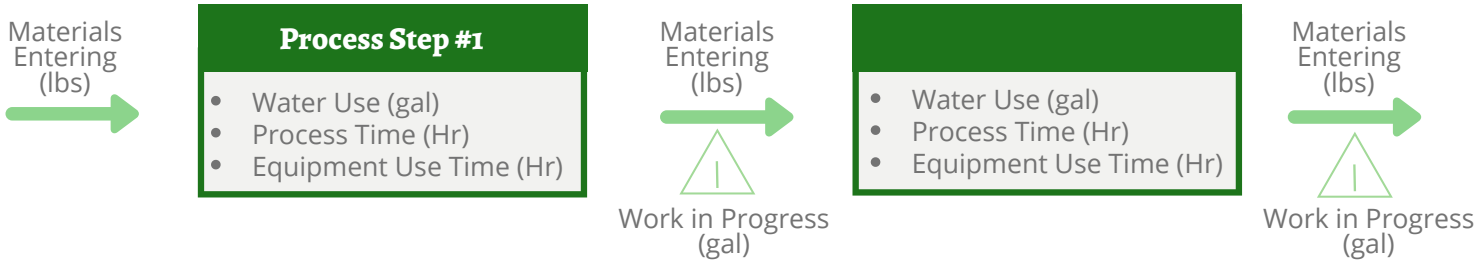
Contact the
**Kentucky Pollution Prevention Center!**

**Website**: www.kppc.org
**Email**: info@kppc.org
**Phone**: 502-852-0965

## Getting Started

To start, one must develop a flow diagram of the existing process from start to finish. Include every major step in the production process, even steps like aging, supply chain and delivery of product to the customer. Arrange each step of production in the order of work. Include all appropriate steps, such as materials entering or leaving, waste creation or removal. Finish by inserting the amount of time required to complete each step (i.e. process time, equipment use time, etc.).

*Example*




## Metrics

Next, establish a set of metrics for each area of interest related to sustainability such as energy use, emissions, waste, etc. After determining the metric set, the required data must be collected. Also consider how to collect all the data efficiently. For example, aid the collection process by establishing clear roles and identifying avenues for data access. Delegating responsibilities may help make data collection more manageable. Sustainability metrics can vary from company to company. Below are a few ideas.

- ***Process Water*** - Measure and track the volume of water that is needed, used, and lost for each process step. Water lost is the amount of water that is not used by another process or reused/recycled within the plant. Water which is treated and then discharged to local waterways or sent to a municipal waste-water treatment plant (WWTP) should be included in the water lost metric. Water lost via spillage or evaporation are other items to include in the lost metric. Note: if water is added to the product, such as juice, this water will be accounted for in the material usage section. Treat oils and coolants in a similar manner.

- ***Raw Material Usage*** - Manufacturing steps related to raw material usage can be divided into two types: subtractive and additive. Subtractive manufacturing are operations that involve material removal, like the machining of a part, while additive steps are processes where material is added to the product, like adding water to create juice. Record the raw material usage for each step within a process line, both additive and subtractive. Why? If the final and initial mass of the product are the only data points on the Sus-VSM, then one cannot identify which process step or steps can be modified to reduce waste and conserve raw materials.

- ***Energy Consumption*** - This metric reflects the amount of energy consumed by a process step, not the energy losses of the machines due to heat, inefficiencies, etc. Along with process energy use, include energy consumption associated with activities occurring in between process steps (i.e. transportation, specialty storage, etc.). Transportation energy includes actions within and outside of the plant. Also include energy required to keep a product at a certain temperature for the next operation in a heating or cooling chamber. However, do not measure or record indirect energy use like lighting, heating and cooling the building, or any other energy consumption which is not dependent on the number of products produced.

## Putting it Together

Add the sustainability metrics either in each process step or below each process step in the flow diagram. This can be done in a variety of ways, however it is to recommended to develop a standardized system for visually representing each metric on the map. A legend could be handy for reference. Below are a few ways to visually representing the company's sustainability metrics on the map.

- ***Process Water Metrics*** - Process water is the water required for the process. Simply determine the quantity of water used for each process step and plot graphically as shown below.

*Example*


*Another Approach*: Place a three-box system below each process step. Insert the amount needed, used and lost respectively in the left, middle, and right hand boxes. Next, sum each box to obtain totals in a similar three-box system box on the right.

*Example*

**Process #1**

| Needed | Used | Lost |
|---|---|---|
| 1 gal | 1 gal | 1 gal |

**Process #2**

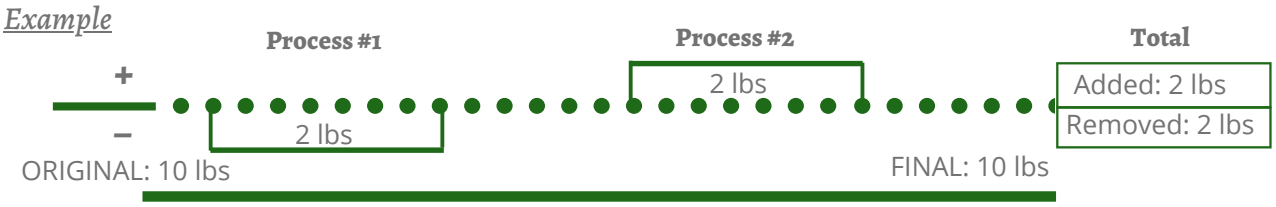
| Needed | Used | Lost |
|---|---|---|
| 1 gal | 1 gal | 1 gal |

**Total**

| Needed | Used | Lost |
|---|---|---|
| 2 gal | 2 gal | 2 gal |

- **Raw Material Usage Metrics** - Illustrate by adding a dotted-line representing the product's mass/volume throughout production. For each process, record the amount removed below the dotted line and record the mass added above the dotted line. Sum the added/removed masses/volumes and then display the totals on the right side of the Sus-VSM. Show the original and final mass/volume of the product by drawing a solid line under the dotted line. Insert the original mass/volume on the left side and final mass on the right side of the solid line.

*Example*




*Another Approach:* As seen on page 2, simply indicate the quantity of materials entering/leaving each process step on the flow diagram. Show material amounts for each step, thus eliminating the need for a separate lines. Waste can be represented in this way as well.

- ***Energy Consumption Metrics*** **-** Draw a solid line to represent energy use. Under each process step, insert an oval on the solid line. Use the ovals and solid line to differentiate between energy consumed during the step and the energy used between each step. Insert energy consumed during the step inside the ovals, and energy consumed between steps on the solid line between the ovals (i.e transport, storage, etc.).

*Example*


Be sure to plot natural gas usage, electric demand and electric consumption separately. Doing so will aid in identifying improvement opportunities.

## Implementing Change

Analyze the freshly created Sus-VSM for areas of improvement by looking for process steps with high sustainability impacts. Make sure to pay attention to the supply chain and product delivery sections of the Sus-VSM. Use these improvement opportunities to develop and implement an action plan.

One way to achieve this is by using a team approach. The team approach can be one green team per facility or a network of teams (e.g. energy, water, materials, etc.). Keep in mind that it is challenging to ask employees to change their way of thinking to focus on the values desired by sustainability. A team approach assists with buy-in from all levels of the organization. Full management support is key for success. If workers feel that management is disrespectful to their efforts, there will be a reluctance to continue which will ultimately derail the objective.

Take time to internally recognize the contributions of teams and individuals. This helps to reinforce the value of sustainability, encourages greater improvement and maintains motivation. External recognition from a third party validates the importance of sustainability endeavors, provides satisfaction to those who earned the award and enhances the company's public image.

***Recognition Opportunity...***

*Kentucky Excellence in Environmental Leadership (KY EXCEL) is a program that recognizes environmental achievements throughout Kentucky.*

*For details, contact **KY EXCEL!***

***Email**: envhelp@ky.gov*
***Phone**: 502-782-6189*

## Summary

The focus of conventional VSM is increasing productivity and eliminating non-value added actions while Sus-VSM is an extra step used to visualize the flow of energy, water and waste through each step of production. The goal of Sus-VSM is to assist an organization with developing more sustainable processes. Sus-VSM achieves this objective by helping an organization analyze their production processes and identify opportunities to reduce energy, materials, and waste. From there, an organization can then use other methods to implement change.

**Basic Sus-VSM Steps:**

1. Develop a process flow diagram.
2. Identify materials/waste entering and leaving each step.
3. Identify time for each process step, equipment use time, water use (if applicable).
4. Collect data for sustainability metrics (e.g. motor hp, natural gas use, water use).
5. Graph sustainability metrics for each process step.

## Additional Resources

**Kentucky Pollution Prevention Center**

- *www.kppc.org*
- *info@kppc.org*
- *502-852-0925*

**Institute for Sustainable Manufacturing**

- *https://www.engr.uky.edu/ism*
- *859-323-3238*

**Visualizing Sustainability Performance of Manufacturing Systems using Sustainable Value Stream Mapping**
*Technical Paper*

- *https://doi.org/10.1016/j.jclepro.2014.05.042*

# Conversion Tables

Tracking performance can require keeping records comprised of a variety of measurements and often converting units. To help out, below is a list of common conversions.

## ENERGY

| From | To | Multiply By |
|---|---|---|
| Btu | J | 1054.2 |
| CCF | MJ | 1.06 |
| hp | kW | 0.74558 |
| J | kWh | 0.0000002778 |
| J/sec | hp | 0.001341 |
| kWh | MJ | 3.6 |
| kWh | hp-hr | 1.341 |
| kWh | Btu | 3,412 |
| thm | MJ | 105 |

## MASS

| From | To | Multiply By |
|---|---|---|
| kg | g | 1000 |
| kg | ton | 0.0011023 |
| kg | M. Ton | 0.001 |
| kg | lb | 2.2046 |
| M. Ton | Ton | 1.1023 |
| oz. | g | 28.350 |
| oz. | lb | 0.0625 |
| Ton | lb | 2000 |

## VOLUME

| From | To | Multiply By |
|---|---|---|
| CC | CF | 0.000035315 |
| CC | Gal. | 0.0002642 |
| CF | Gal. | 7.4805 |
| Gal. | fl. oz. | 128 |
| Gal. | L | 3.7854 |
| L | Gal. | 0.2642 |
| L. Barrel | Gal. | 31.5 |
| L. Barrel | L | 119.24 |
| P. Barrel | Gal. | 42 |
| P. Barrel | L | 158.98 |

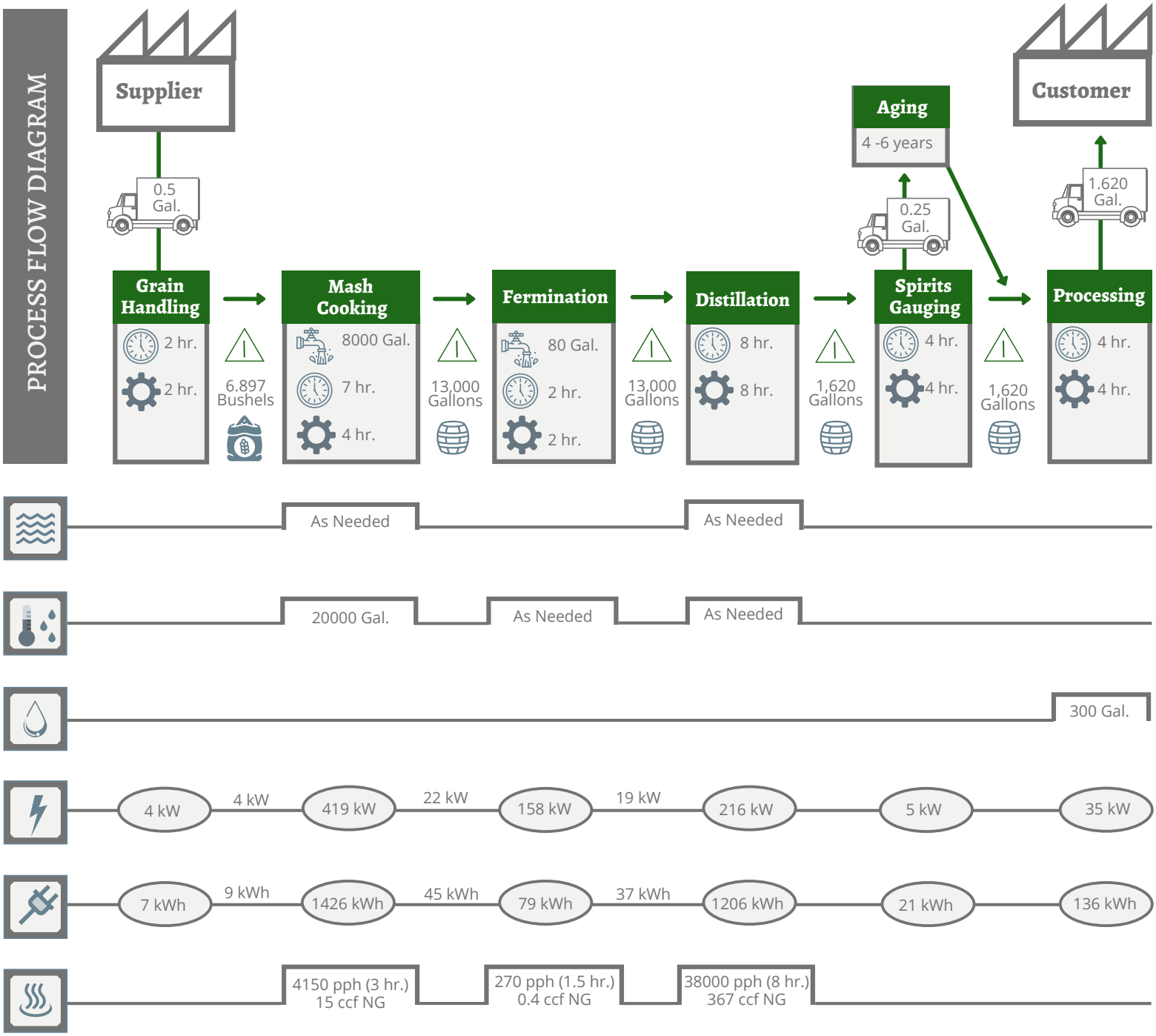
## SYMBOL KEY

| Symbol | Unit |
|---|---|
| Btu | British Thermal Unit |
| J | Joule |
| CCF | 100 Cubic Feet |
| MJ | Megajoule |
| hp | Horsepower (Mechanical) |
| kW | Kilowatt |
| kWh | Kilowatt-hour |
| J/sec | Joule per Second |
| hp-hr | Horsepower-hour |
| thm | 100,000 British Thermal Units |
| kg | Kilogram |
| g | Gram |
| Ton | Short Ton |
| M. Ton | Metric Ton |
| lb | Pound |
| oz. | Ounce |
| CC | Cubic Centimeters |
| CF | Cubic Feet |
| Gal. | U.S. Gallons |
| fl. oz. | Fluid Ounce |
| L | Liter |
| L. Barrel | U.S. Barrel (Liquid) |
| P. Barrel | U.S. Barrel (Petroleum) |

Kentucky Divison of Compliance Assistance
300 Sower Boulevard, 1st Floor, Frankfort, KY 40601
*Assistance Hotline:* envhelp@ky.gov | 502-782-6189

# Mapping for Sustainability

Creating a Sustainable Value Stream Map can help a company identify ways to increase the sustainability of their manufacturing process(es). Below is an example of such a map from a distillery.




## LEGEND

- Gasoline
- Water Consumed
- Process Time
- Equipment Use Time
- Grain
- Product in Process
- Cooling Water
- Chilled Water
- RO Water
- Electric Demand
- Electric Usage
- Steam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