Exercise 4a.3: Material Flow Analysis of a Coffee Machine

Estimated time requirement: 80 minutes

Introduction

This exercise about Material Flow Analysis (MFA) will provide you with a better understanding about the tool and its application. Upon completion of this exercise, you will be able to describe and illustrate simple techniques of analyzing and documenting material flow, identify sources of waste retrace waste and improvement potentials as well as select appropriate improvement measures, considering lifecycle implications. In addition, you will review and use different modes of visual presentations of MFA for further analysis and identification of improvement potentials.

Table 1: Structure of the exercise

Part	Tasks	Time
1	Analyze the production process described in the case study Quantify the process flows Visualise your findings using a process flow or sankey diagram by populating the Charts A-D with data	30 min
2	Analyse the results; identify and compile at least three measures for improvement by populating table 4 Pitch the results to the “management board” (the group) by writing down your ideas on a flipchart and briefly presenting them (10 min preparation and 5 min presentation per group)	30 min
3	Reflect upon and re-assess the proposed improvement measures in terms of their lifecycle implications by populating table 4	20 min

Background information

Imagine that you have been engaged as a consulting team by a client who loves enjoying hot coffee in the morning, sometimes consuming several cups in course of the day. It is important to the client that the brewed coffee is of a consistent quality. The client wants your support in enhancing the efficiency in their coffee making process. As a first step, you are tasked to analyse and map out the material flows of the process, focusing on water and materials. Upon analysis, you will present your findings to the management board.

Description of process

First coffee is ground in the electrical coffee grinder (using about 400 Watts per hour). To grind one full load of coffee (about 90 g) it takes about 2 minutes. The ground coffee is then transferred to a coffee machine. A portion of left over coffee remains after grinding.

A single-time use paper filter is put into the percolator of the coffee machine and the ground coffee placed in the filter. Cold water is filled into the coffee maker. Once the machine is switched on, the water is pumped to a heating coil. The heated water runs through a small pipe on top of the percolator and drips onto the coffee in the filter paper. The coffee passes through the percolator and drips into the coffee pot beneath. After about 5 minutes, the process is complete.

The energy consumption is about 1000 Watt per hour. The coffee is ready for consumption and can be poured into the coffee cup. One pot of coffee is sufficient for about 2 cups of coffee. After the process the filter paper containing wet spent coffee powder is thrown into a dustbin and replaced with a new paper filter for the preparation of the next pot of coffee.

During the process, some of the water added to the machine evaporates from the open percolator. Not all coffee in the coffee pot is actually served, since the coffee cups used by the client differ in size. Around 10% remains in the pot, each time. Since this unserved coffee gets cold quickly, it is often poured away. Based on some measurements, you have collected following additional data:

Table 2: Data points

Data point	Weight
Coffee beans (used for grinding)	90 grams
Water introduced into the coffee machine	850 grams
Dry paper filter	2 grams
Residues from grinding	2 grams
Coffee made (with concentration of 1% coffee extract)	800 grams
Residual water in coffee machine	4 grams
Evaporated water	13 grams
Coffee grounds (= wet filter **and** wet used coffee)	123 grams

Further analysis of the coffee grounds shows that moisture content of paper filter after use is 50% of its dry mass; the moisture content of the **wet used coffee** is about 50%.

For the purpose of this exercise, the packaging of the coffee and the necessary energy for the process, as well as the waste heat produced are not taken into account. The same applies for the steps of filter production, coffee planting, roasting, storing and purchasing, water treatment, disposal of the filter and drinking.

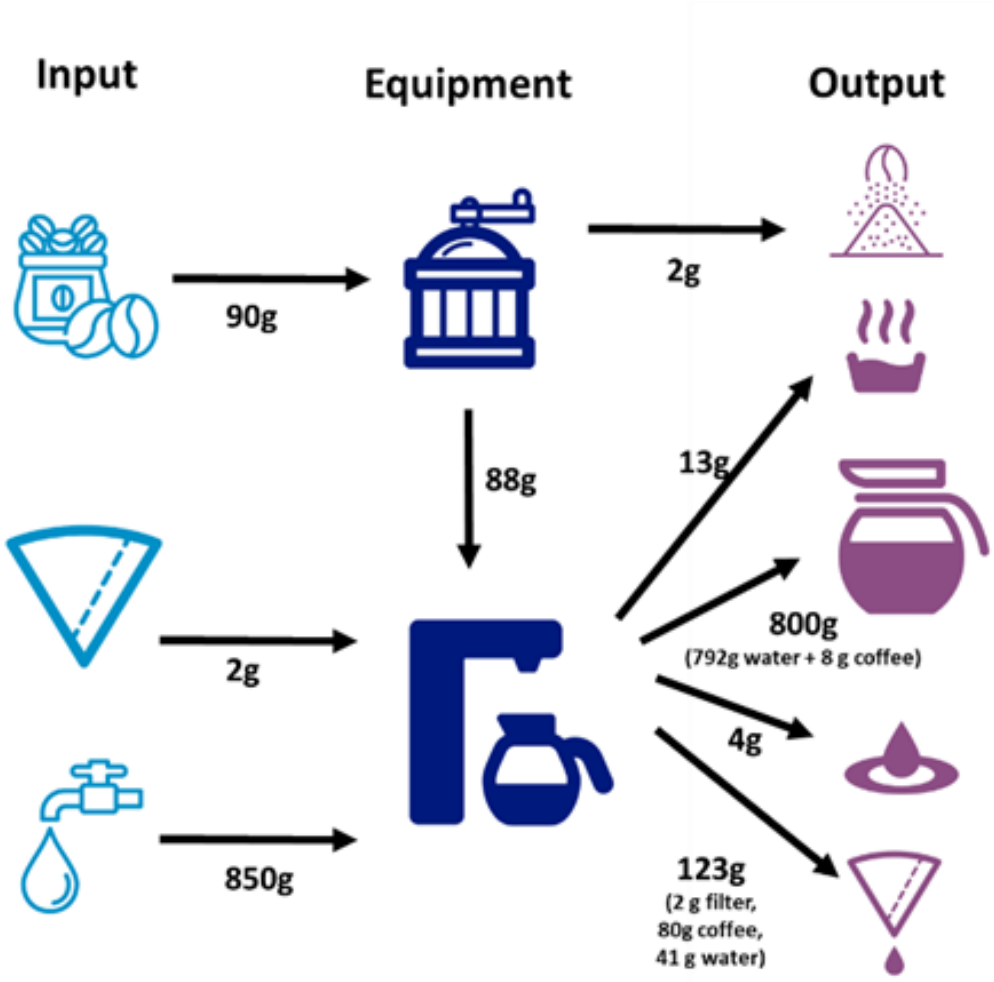
Material flows and stocks

Table 3: Input and output data

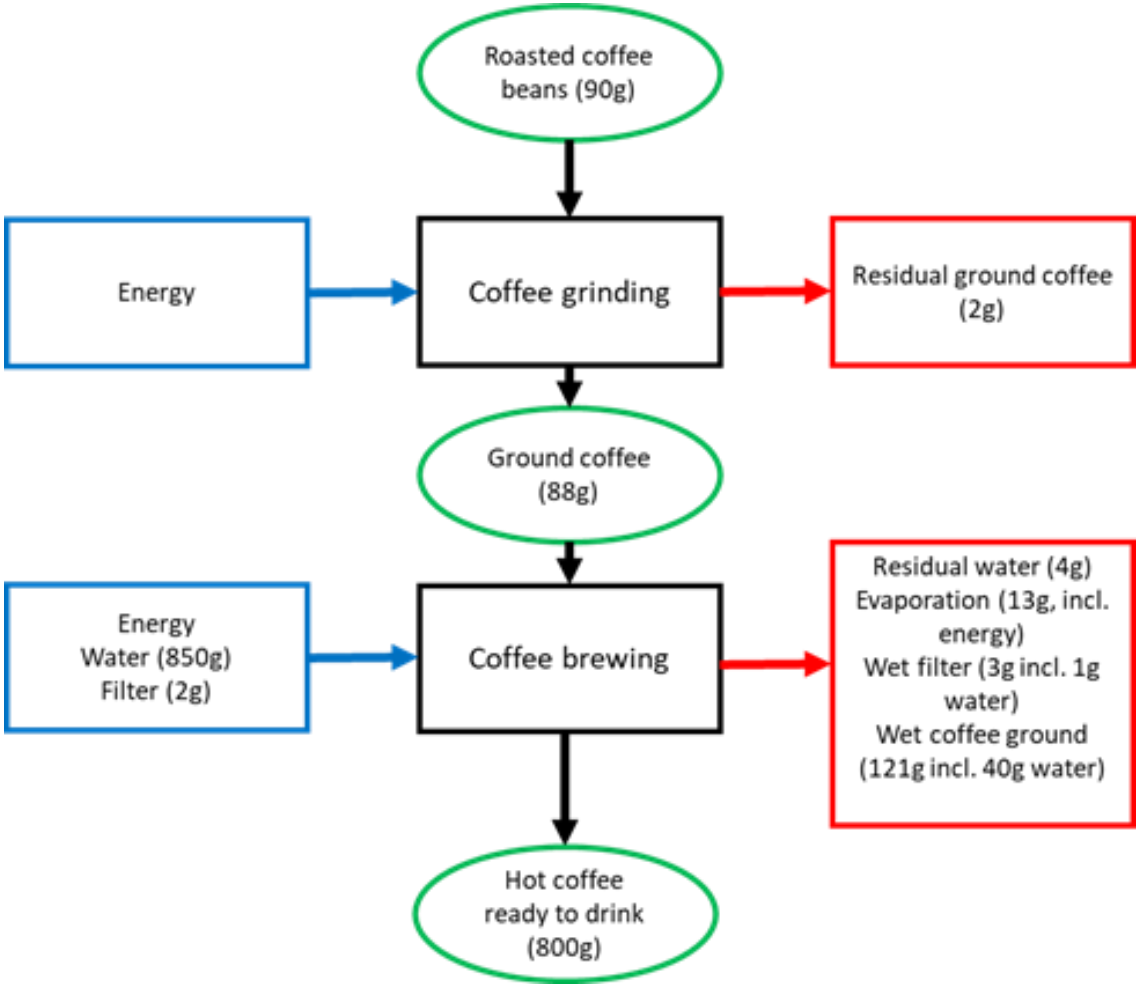
Equipment	Coffee grinder, coffee machine including pot.
Balance period	One brew as representative period comprising all relevant activities and materials in usual amounts.
Process steps	“coffee making”, including coffee grinding, brewing and drinking.
Input	
• Coffee beans	90 grams
• Water	850 grams
• Dry filter	2 grams
Input ∑	942 grams
Product output	
• Water	792 grams
• Coffee extract	8 grams
Product output ∑	800 grams
Non-product output	
Residual coffee powder (grinding)	2 grams
Coffee grounds	
• Filter	2 grams
• Coffee	80 grams
• Water	41 grams
Residual water in coffee machine	4 grams
Evaporated water	13 grams
Non-product output ∑	65 grams
Output ∑	**942 grams**

Process flow

Template chart A: overview (trainer notes)

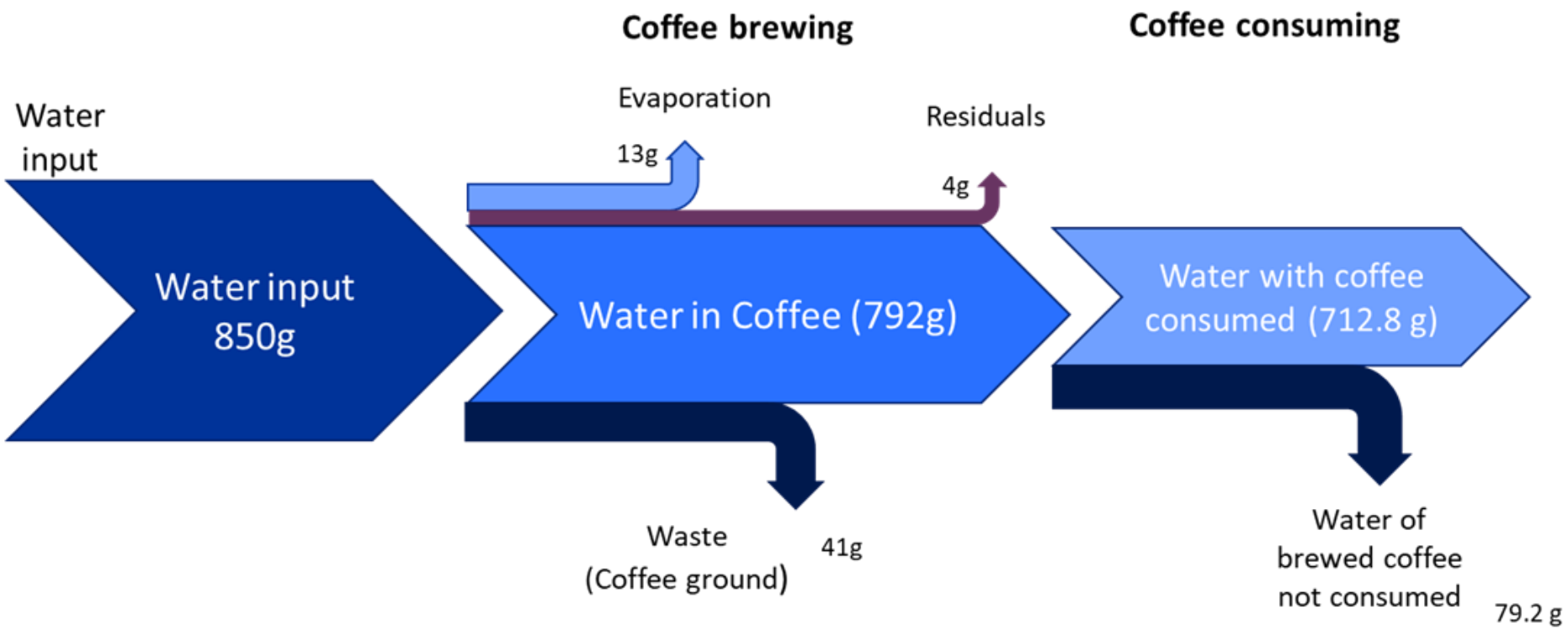


Template Chart B: overview (trainer notes)



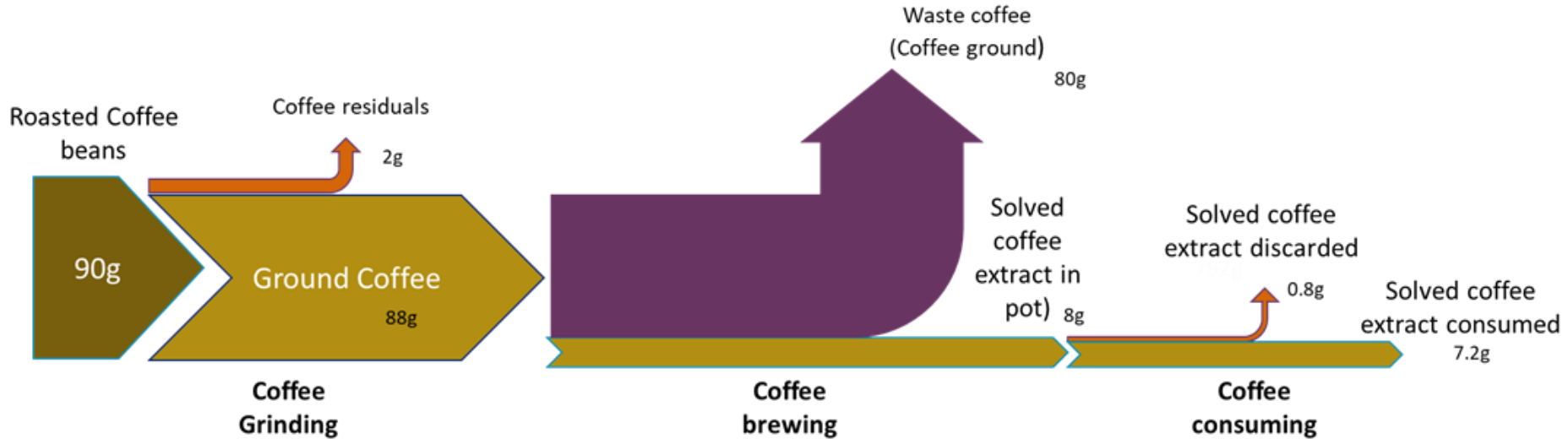
Process flow – Sankey diagram

Template chart C: Water efficiency (trainer notes)



Process flow – Sankey diagram

Template chart D: Material efficiency for coffee (trainer notes)



Measures for process optimization and impacts on lifecycle

Table 4: Exercise template (trainer notes)

Measures	Impacts in lifecycle
Good housekeeping • Improved material utilization; • Grinding of larger quantities; • Define recipes; • Define indicators; • Train operators; • Provide quality control.	Drinking remaining coffee may reduce overall consumption (impact on nervousness/coffee addiction may increase)
Technology modifications • Use a new (closed) coffee machine to reduce losses due to evaporation and waste heat; • Grinder producing less residues (complete emptying); • Finer grinding; • Use bigger filters; • Use espresso machine as completely different technology. • Buy ground coffee	New coffee machine may reduce energy consumption, however, energy required for production of new machine may exceed savings depending on operational life of the same
Substitution of raw and process materials • No paper filter (goldfilter); • Possibility of using pre-ground coffee; • Soluble coffee	Using soluble coffee can eliminate energy consumption at the office almost entirely (only kettle needed) but outsources the same to the production process (i.e. extraction, drying and processing at unknown efficiencies)
Reduce, reuse, recycle • Composting of ground coffee and filters; • Reuse coffee grounds for a low-quality cup of coffee; • Reuse coffee grounds as pesticide (e.g. against potato beetle).	Reuse spent coffee grounds for low-grade coffee can increase overall energy and water consumption as demand for high quality is not fulfilled and additional coffee with fresh grounds will be brewed
Product modifications • Turkish coffee; • Stronger, weaker coffee; • Coffee sweets, coffee pills; • Instant coffee; • Caffeine pills	Turkish coffee may increase private use of toothpaste to remove coffee grounds stuck between teeth
Other organisational measures • Time-travel diagram to optimize coffee quantities.	Can provide indications as to when coffee is consumed (“coffee-rush-hour”) and inform type of technology modifications require (e.g. automatic kill-switch of coffee machine to reduce energy consumption)