

# Chapter 41

## Using Sensor-Based Measurement Technology to Reduce the Environmental Impact of Perishable Goods

**Alexander Ilic**

*ETH Zurich, Switzerland*

**Thorsten Staake**

*ETH Zurich, Switzerland*

**Elgar Fleisch**

*ETH Zurich, Switzerland & University of St. Gallen, Switzerland*

### ABSTRACT

*Perishable goods are still a major challenge for supply chains. Temperature fluctuations and other disruptions can occur at various stages of a distribution network. Without sensor technologies, these disruptions are often not detectable in early stages of the supply chains. As a result, losses accumulate at the end of supply chains where a lot of energy as already invested for delivering these goods up to this point. This chapter shows how sensor technologies can enable a new way of data-driven decision making at the distribution stage of a supply chain. It demonstrates when and how sensors can be used for smart removal and sorting decisions. The results indicate that these decisions can reduce the environmental impact and even increase profits significantly.*

### INTRODUCTION

The literature sends a clear message that loss rates in supply chains of perishable goods are significant. Statistics by the U.S. Department of Agriculture report that average yearly loss rates

at the retail level alone can be as high as 51% for specific commodities. When reviewing the loss figures from a quality management perspective, it is hard to think of any industry that could survive with such high defect rates.

The limited shelf-life of perishable goods and their susceptibility to fluctuations in environmental parameters often force managers to make

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decisions under uncertainty, leading to high loss rates. In order to achieve the same desired output, additional input resources are often required for compensation.

A solution could be low-cost measurement technologies such as Radio Frequency Identification (RFID) tags and sensors. They could provide the necessary information to make the quality deterioration process more predictable and to make problems visible even at earlier stages of supply chains.

This chapter shows when and how sensor information can help increasing efficiency in logistics operations and lowers the environmental footprint for supply chains.

The next section provides background information about sensor-based condition monitoring and product-level carbon footprinting. Sensor-based condition monitoring allows to track information pertaining to individual goods. With this information, each item can be assigned with an individual carbon footprint value. The combination of these two concepts is necessary to quantify the environmental impact of food losses and the potential improvement due to sensor-based decision making.

The main part of this chapter is based on a case study that stems from a research project with a Swiss retailer. We use the example of strawberries in Switzerland to investigate the value of sensor information for profit increase and carbon-footprint reduction on the distribution level. As a primary analysis method, we apply computer simulation. This allows us to explore, evaluate, and analyze parameters of a complex system such as a supply chain in a very cost efficient way. The insights provide also inputs for full-scale roll-outs of sensor technologies and help to determine the economic feasibility. As a starting point for practitioners, we provide a framework to determine the business case for such a scenario.

Finally, this chapter reviews future research directions and trends.

The goal of this chapter is to analyze the impact of sensor based condition monitoring to reduce the chance of food spoilage by making informed sorting and removal decisions at the distribution stage. The hypothesis is that this can lead to significant reductions of greenhouse gas emissions due to waste reduction and better load utilization.

The objectives of this chapter are 1) to provide insights on data-driven decisions for perishable goods at the distribution stage, 2) to show how these decisions can help to reduce the environmental impact at low cost, and 3) to understand the critical factors when and how to apply sensor technologies for managing perishable goods.

## **BACKGROUND**

### **Sensor-Based Condition Monitoring**

The goal of sensor-based condition monitoring is to predict the condition of a good based on the collected temperature information. More accurate temperature measurements lead to the better prediction of shelf-life. A study of Jedermann, Emond, & Lang (2008) indicates that the confidence levels for condition monitoring with current sensor technology is already high enough for supply chain applications. More details on the most suitable implementation for monitoring perishable goods with sensors be found in Jedermann, Ruiz-Garcia, & Lang (2009).

The focus of this section is on applying low cost sensors (such as semi-active RFID tags) to track the temperature of goods. The schematics of such a tag are depicted on Figure 1. The left side of Figure 1 shows the antenna of the tag and the radio frequency front-end. This part is usually powered by the reader in order to conduct a data transfer from the tag memory to the reader. The semi-active tag also contains a battery. The battery enables the microcontroller to continuously measure and store sensor data (e.g., temperature)

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