

Practical Example of

Energy Savings
achieved at Centrale TN

with pre- and post-**Retrofit**
intervention measurements

Definition of Baseline

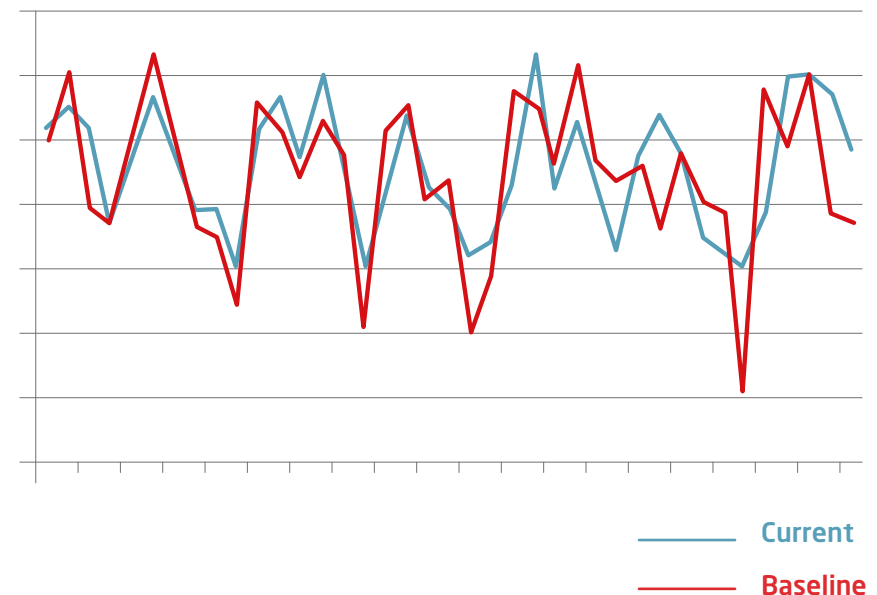
To evaluate the impact of efficiency interventions on consumption, it is first necessary to define an **Energy Baseline** against which the consumption of the point of sale can be compared



IPMVP

International Performance Measurement and Verification Protocol:

An international methodology developed by 15 countries to verify the results of energy efficiency projects and define the calculation methods for energy savings.



IPMVP - What is it

“Why measure and verify? Because you cannot manage what you do not measure.”

– Jack Welch, CEO of General Electric –

What is meant by Baseline

A snapshot of the energy situation before an energy efficiency intervention.

The purpose is to allow for a comparison between the current energy performance and the performance after the energy optimization intervention.

International Performance Measurement and Verification Protocol - IPMVP

An international methodology developed by 15 countries to verify the results of **energy efficiency** projects and define the methods for calculating energy savings.

IPMVP defines a linear dependency of energy consumption based on certain **variables** and uses historical data to determine this relationship.

IPMVP - Linear Regression Method

General formulation of linear regression

Based on the adopted methodology, actual consumption depends on certain **external variables** according to a linear relationship, defined through the **method of linear regression**.

Linear regression is a statistical technique used to analyze the relationship between two variables:

Dependent variable Y:

energy consumption of the point of sale/plant

Independent variables X:

operational/calculated factors

$$y_i = \beta_0 + \beta_1 (x_i) + u_1$$

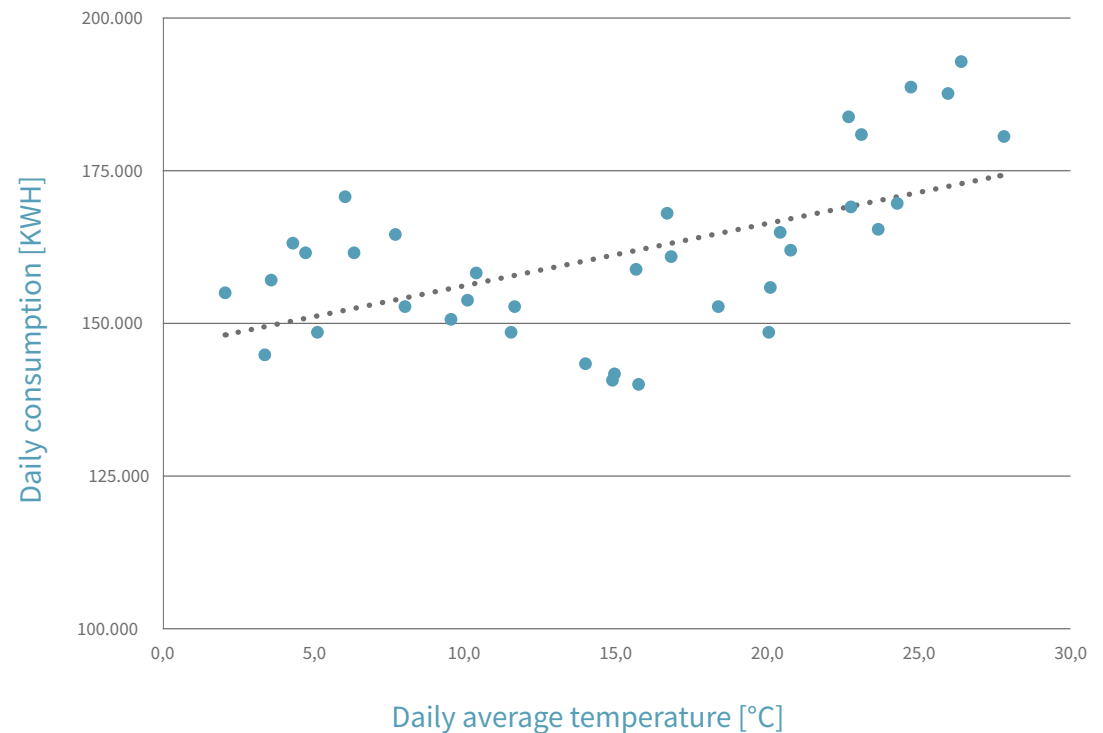
$i = 1, 2, \dots, n \rightarrow$ number of observations

y_i = dependent variable, i.e., the electrical consumption of the point of sale at observation i

β_0 = regression line **intercept**, in this case, the value of the electrical consumption when the independent variable x_i is 0

β_1 = **linear regression coefficient**, indicates the change in electrical consumption as a function of the variables x_i (external temperature, opening/closing days, holidays)

u_1 = statistical error



IPMVP - Statistical Models Used

Combination of linear regressions

The methodology used to describe the baseline consists of defining the electrical consumption of the point of sale through a **combination of linear regression statistical models**. More specifically, the dependent variable (electrical consumption) showed varying relationships with the independent variable **“hourly external temperature”** depending on the observation time.

Moreover, it is possible to identify **different consumption regimes** depending on the hour of analysis.

NIGHTTIME

Hours during which the point of sale is closed, and the electrical consumption from food refrigeration depends on the external temperature, leading to higher consumption in summer and lower in winter.

h = 1,2,3,4,23,24

INTERMEDIATE

Depends on both temperature and weekly periodicity (Saturdays and Sundays) and non-working days.

h = 5,6,7,21,22

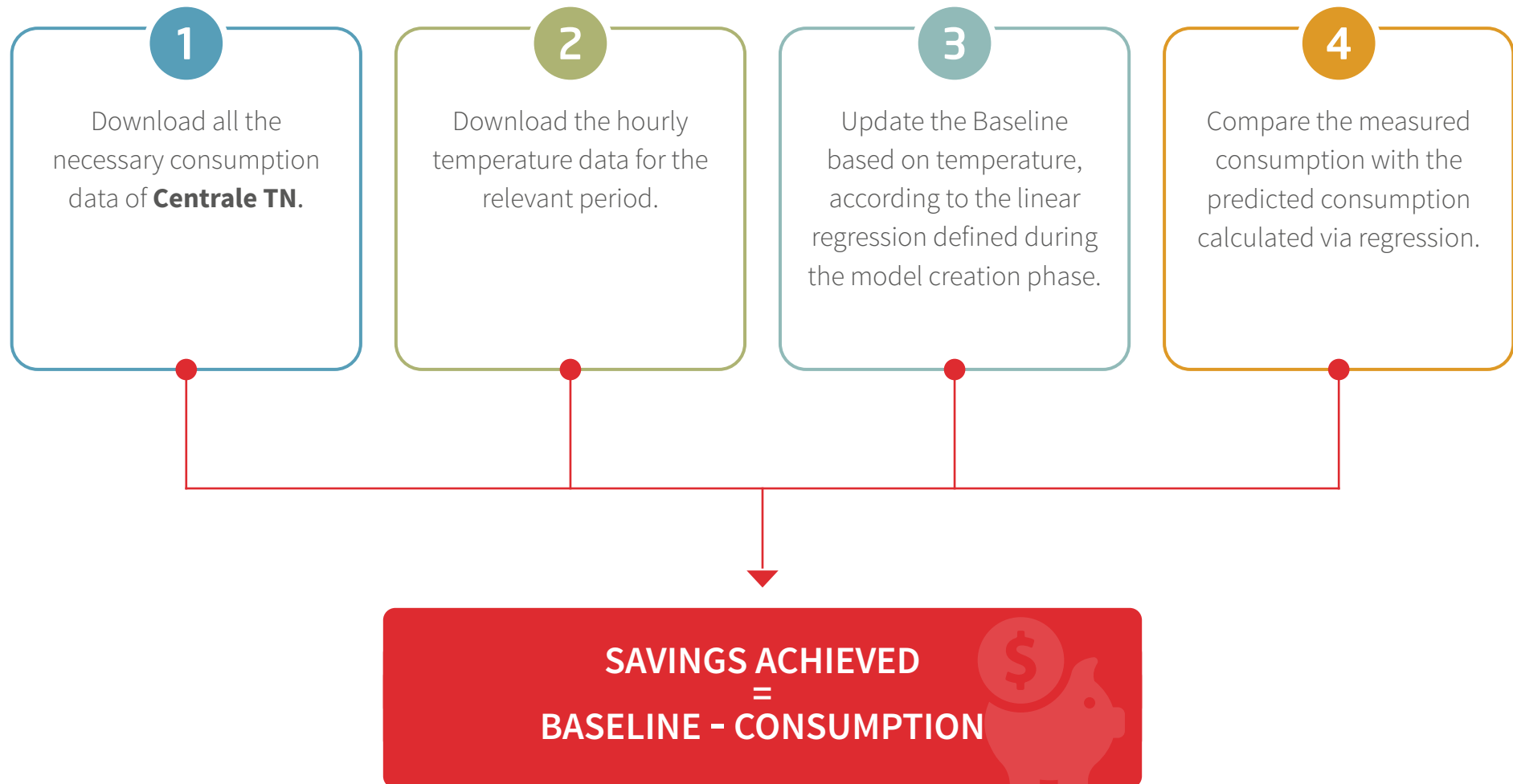
WORKING:

Depends on temperature, weekly periodicity (Saturdays and Sundays), non-working days, and the historical series of electrical consumption.

h = [8, 20]

CALCULATION OF SAVINGS

To calculate the savings achieved, the following steps will be followed:

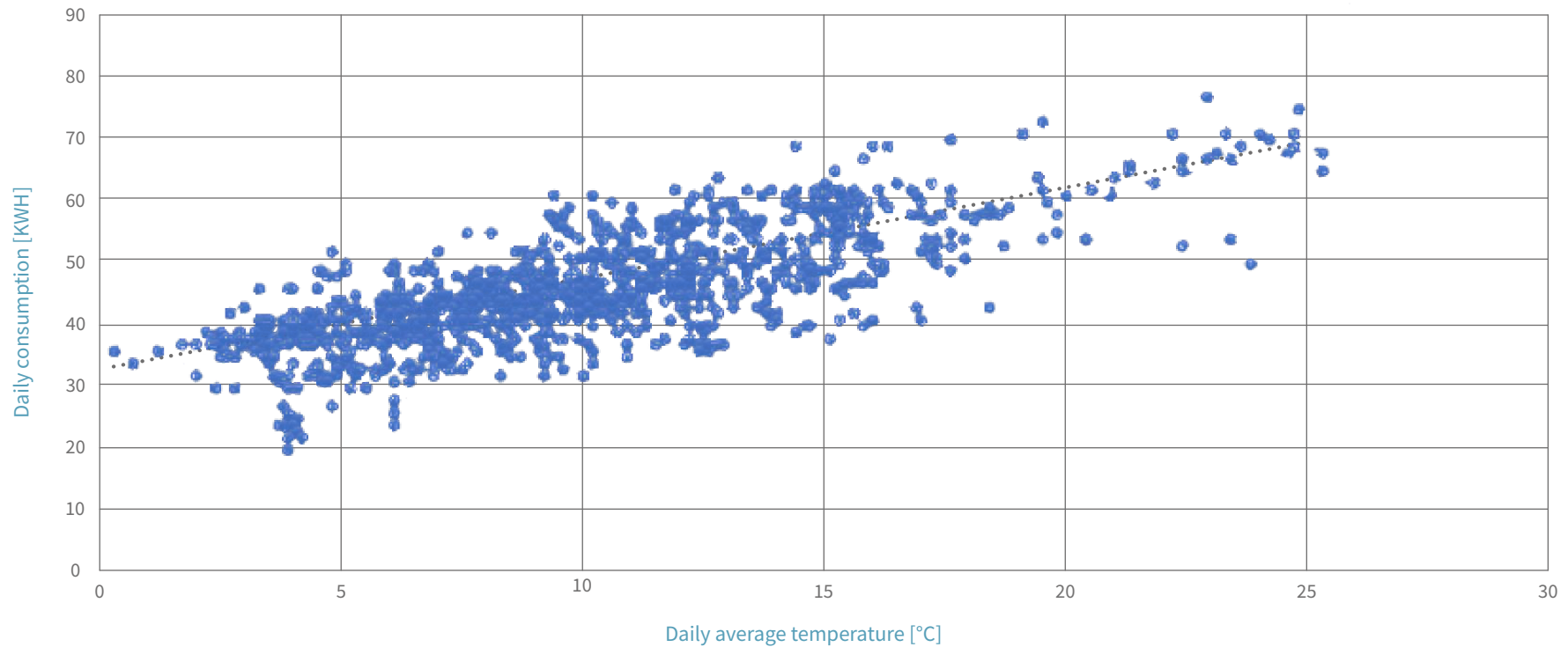


PRACTICAL EXAMPLE OF BASELINE CALCULATION

$$y = 1,4804x + 32,225$$

Linear Regression 07/10 - 08/12 [kWh]

Equation describing the energy consumption of Centrale TN as a function of hourly external temperature:



CENTRALE TN - Example of consumption & savings

Periodo 09/12/2022 - 19/01/2023

Predicted Consumption of Centrale TN (Baseline):

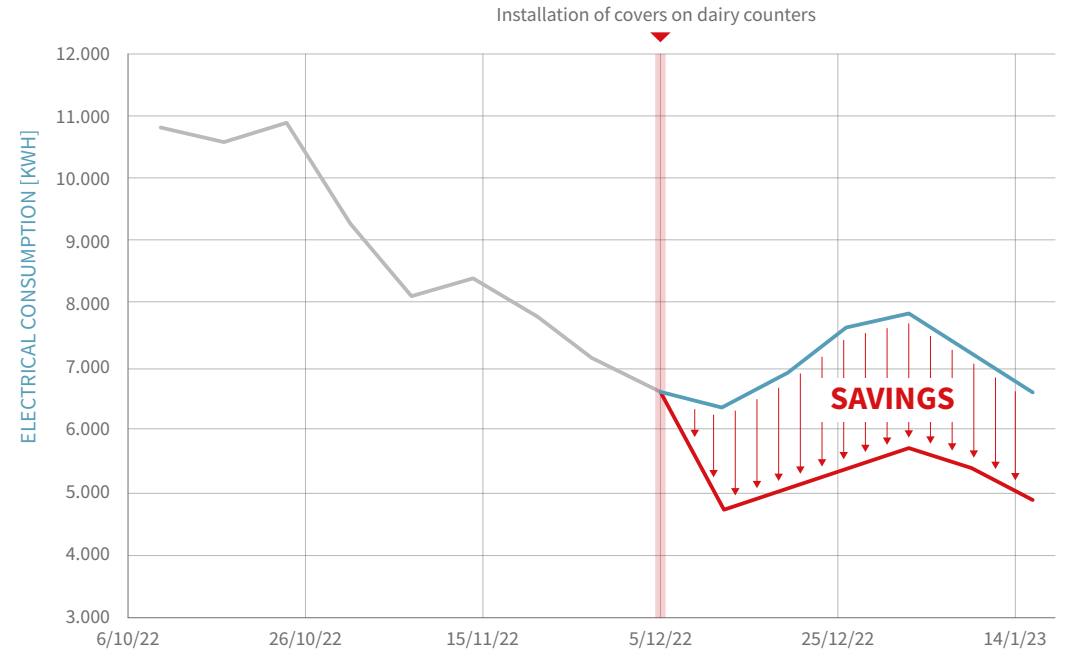
42.952 kWh

Measured Consumption post-intervention:

31.098 kWh

Savings:

-11.494 kWh



SAVINGS IN BILL

-27%
for Centrale TN

-8,5%
for the bill



**EFFICIENCY
IMPROVEMENT
CENTRALE TN**

-42%
for Centrale TN

-12,5%
for the bill

- Baseline
- Measured consumption post-intervention**
- Measured consumption pre-intervention**

RETROFIT INTERVENTION - Aesthetic outcome



RETROFIT INTERVENTION - Aesthetic outcome



