



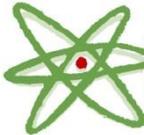
**Vlaanderen**  
is ondernemen

# FROSTINNO

Innovative and energy-efficient frost protection  
in fruit production

MANUAL ECONOMIC CALCULATION TOOL  
FROST PROTECTION MEASURES

**KCE** | KENNISCENTRUM  
ENERGIE  
@THOMAS MORE

 **pcfruit**  
PROEFCENTRUM FRUITTEELT VZW

## 1 – General purpose

For the FROSTinno project, an analysis was carried out to examine the economic feasibility of various frost control measures for different fruit species. This study can be found in the text (in Dutch) '[Economische Haalbaarheidsstudie vorstbestrijdingsmaatregelen](#)' (or Economic feasibility study frost protection measures) on the online (in Dutch) 'Vorstbescherming' (or Frost protection) platform. The principles behind this economic analysis are explained in the accompanying text (in Dutch) '[Achtergrond economische analyse](#)' (or Background economic analysis).

This economic feasibility study was carried out using an '**economic calculation tool**' that was **developed in the framework of this project**. This tool is now also available to fruit growers and suppliers of frost protection measures. They can use it to carry out this economic analysis with their own data. A distinction is made between two functionalities:

- **The 'basic functionality'**: this can be used free of charge and is [available online via the pcfruit website](#) (in Dutch). The **adaptability** of the input parameters is **limited** to the inputs related to the cost of a measure (purchase, range, consumption and labour costs).  
e.g.:
  - A grower/supplier can **purchase/offer a frost control measure more cheaply**.
  - In the analysis the range of a measure was estimated at 8 hectares, but a grower owns a parcel of only 4 hectares (this measure or device can therefore only protect 4 hectares, which is less efficient). The **economic feasibility** of the frost protection measure can then be **recalculated**, taking into account this **additional prerequisite**. (This case is elaborated in the additional annex at the end of the economic feasibility study.)
- **The 'extended functionality'**: this is a **paid version**. In addition to the possibilities of the basic functionality, the user can now adjust all inputs of 'yield values', 'fruit prices' and 'hours in operation'.  
e.g.:
  - The economic analysis of FROSTinno only examined the protection of the Conference pear. Due to the strong tendency towards parthenocarpic fruit set, this cultivar is less sensitive to night frost and control measures will be economically less interesting. The yield values of other crops will be more in line with those of apple than with those of Conference. In the extended functionality, the grower can adjust the yield data and fruit prices of Conference to his/her own crop to examine the economic feasibility of frost protection measures in his/her own crop.

Also the **simulation over 10 years** can be **manipulated**: the **price setting** can be adjusted (only neutral price setting in the basic functionality) and the distribution of the different types of frost year [High impact, Low impact, Near-zero impact frost year] can be selected freely.

Finally, the extended functionality also allows to **screen one's own frost protection technique, which is not discussed in the calculation tool**.

This document is a guide for using the tool. **First, the basic functionality is explained. This explanation remains valid for the extended functionality.** The additional options of the extended functionality are discussed in more detail in the second part of this manual.

## 2 – Manual economic calculation tool

### 2.1 – How to use the calculation tool in basic functionality modus

#### 2.1.1 – The 'Front panel'

Frontpanel

**Frontpanel economic calculation tool**

Select type of fruit	Jonagold (& variants) apple
Select frost sensitivity of orchard	AVERAGE FROST SENSITIVITY
Variable pricing/socio-economic climate	Neutral (mid-price)
	100%
Simulation - future timeline 10 yrs	
3	Years of high impact frost
2	Years of low impact frost
5	Years of near-zero impact frost

KCE | KENNISCENTRUM ENERGIE @THOMAS MORE

pcfruit  
PROEFCENTRUM FRUITTEELT VZW

Selection

FIGURE 1 – 'FRONT PANEL' ECONOMIC CALCULATION TOOL BASIC FUNCTIONALITY.

Select In the front panel of the economic calculation tool:

- The type of fruit:  
**Jonagold apples & varieties – Golden Delicious apples – Conference pears – Cherries – Grapes**
- The frost sensitivity of orchard:  
**High frost sensitivity - Average frost sensitivity - Weak frost sensitivity**
- The pricing:  
**Unfavorable (-20% mid price) – Neutral (mid price) – Favorable (+20% mid price)**
- The **distribution** of the types of the frost years (High impact – Low impact – Near-zero impact) in the **10 yrs simulation is fixed.**

#### 2.1.2 – Yield of an orchard without active frost protection

**Informative section** indicating per frost year [High impact, Low impact Near-zero impact] what the yield would be per hectare under the selected frost sensitivity of the orchard for the selected fruit type and pricing without active frost protection measures.

**Remark:** In contrast to the rest of the analysis, this calculation uses the **corrected mid price** and **not 'the value of a saved fruit'**. In fact, there is no 'rescued fruit', because no frost control was applied.

#### 2.1.3 – General data and prerequisites

General inputs such as cost of propane, diesel and labor costs can be inserted here. These values **apply to all calculations and for all frost protection measures analyzed.**

#### 2.1.4 – The input tabs

At the bottom of the page one can find 3 tabs, namely '**Input data - Yield data**', '**Input data - Fruit prices**' and '**Input data - Running hours**' (Figure 2). The meaning of these datasets is explained in the text (in Dutch) '[Achtergrond economische analyse](#)' (or Background economic analysis).

**Via the selection in the front panel, the right data are retrieved from these tabs.**

The used values 'Yield data', 'Fruit prices' and 'Running hours' can be consulted in the basic functionality, but they **cannot be customized**.

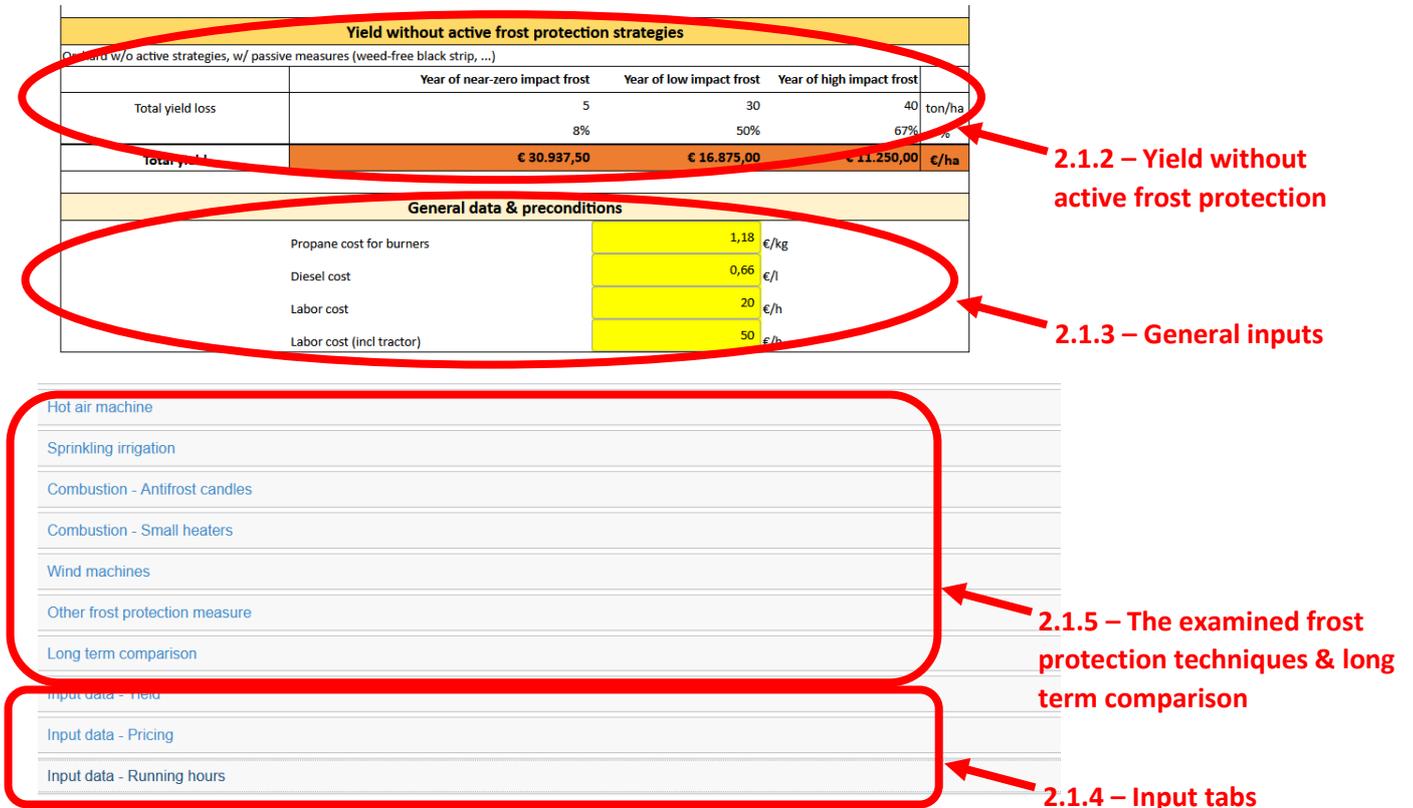


FIGURE 2 – SURVEY ECONOMIC CALCULATION TOOL.

2.1.5 –Active frost protection measures examined

Figure 2 presents 5 tabs: 'Hot air machine', 'Overhead sprinkling', 'Combustion – antifrost candles', 'Combustion – small heaters' and 'Wind machines'. These tabs can be opened individually to show the economic analysis.

These calculations are subdivided into **three sections**:

1. **The costs related to the measure:**

The user enters the requested inputs here in the **yellow cells**. At the bottom of this section the user will find the **total cost per season and per hectare** for a High impact, Low impact and Near-zero impact frost year (**Figure 3**). In the basic functionality and with the data from FROSTInno, these costs will be the same over the different types of frost year. **More explanation** can be found in the **detailed text of the economic analysis**.

Sprinkling irrigation

Costs of frost protection measure				
<b>Investment costs</b>				
Life span	30	yrs		Default 30
Purchase price	25.000,00	€/ha		25000
Annual maintenance cost	500,00	€/(ha*yr)		500
<b>Consumption costs</b>				
Consumption of water and electricity + permit	62,50	€/(ha*night*8h)		62,5
Labour (manual)	1,0	h/night		1
<b>TOTAL cost/year</b>	<b>€ 654,69</b>	<b>€ 654,69</b>	<b>€ 654,69</b>	<b>€/(ha*yr)</b>

**Result: Total costs per season and per hectare**

**Inputs to be entered by the user**

FIGURE 3 – SECTION 1 ANALYSIS FROST PROTECTION MEASURE.

2. **Revenue generated by the measure and calculation of the payback period:**

Based on the specified prices, pricing and yield data, the additional (gross and net) yield generated by the measure for a High impact, Low impact and Near-zero impact frost year is calculated (Figure 4).

These amounts are used to calculate the payback period of the measure assuming this situation occurs year after year. More explanation can be found in the detailed text of the economic analysis.

ADDITIONAL REVENUES & PAYBACK PERIOD OF FROST PROTECTION MEASURE				
	Year of near-zero impact frost	Year of low impact frost	Year of high impact frost	
Gross additional revenue	€ 1.312,50	€ 7.875,00	€ 10.500,00	€/(ha*yr)
Net additional revenue	€ 657,81	€ 7.220,31	€ 9.845,31	€/(ha*yr)
<b>Payback period 'year by year'</b>	<b>38,00</b>	<b>3,46</b>	<b>2,54</b>	<b>Years</b>

**Gross and net additional revenue generated by measure**

**Payback period of the measure for selected conditions**

FIGURE 4 - SECTION 2 ANALYSIS FROST PROTECTION MEASURE.

3. **Results of the simulation in 10 years:**

In this final section, the **timeline** that was **set out in the front panel** is used to calculate:

- The total yield in this period in an orchard **without frost protection**.
- The total (net) additional revenue generated by **the frost protection measure studied** in this period of ten years and the part or weight of each type of frost year in this.
- The **'weighted average payback'** of this measure, considering the relevant distribution of frost years.

These calculations are **always** made **at a neutral price setting** (without correction on the mid price). Hence, the **price setting selected** in the **front panel** is not taken into account (Figure 5).

SIMULATION - 10 YEARS w/ pricing:		Neutral (mid-price)		
Year of near-zero impact frost	Year of low impact frost	Year of high impact frost		
Additional revenue with 5 years of near-zero impact frost	Additional revenue with 2 years of low impact frost	Additional revenue with 3 years of high impact frost		
€ 3.289,06	€ 14.440,63	€ 29.535,94		€/ha
Revenue over 10 yrs w/ respectively 3, 2, 5 high, low and near-zero impact years of frost, w/o any frost protection [€/ha]				€ 222.187,50
Additional revenue over 10 yrs with the same distribution of frost years, with frost protection (w/o depreciation of installation) [€/ha]				€ 47.265,63
Weighted payback period over simulation of 10 yrs				5,29 years

FIGURE 5 - SECTION 3 ANALYSIS FROST PROTECTION MEASURE 10-YR. SIMULATION BASIC FUNCTIONALITY AT NEUTRAL PRICE SETTING.

2.1.5 – ‘Remarks’

- **The tab for 'Hot air machine'** provides the analysis of both the hot air machine type **'Frostguard'** and type **'Frostbuster'**. At the top, the user has to select (**drop-down**) which of the 2 systems is to be further analyzed and has to **provide the correct input values** (yellow cells).
- **For antifrost candles, payback time is not calculated** and only additional revenues are considered.

## 2.2 – How to use the calculation tool with extended functionality

The explanation given in [paragraph 2.1](#) remains valid. However, with the **extended functionality**, the user has the possibility to **make changes in the Input tabs 'Yield data', 'Fruit prices' and 'Hours in operation'**. The results of the economic calculation tool can thus be **'customized'** with your own data, making them **more accurate** and allowing the **economic feasibility** to be **estimated** much more **precisely**.

For a correct interpretation of these input values, please go to **the detailed text of the economic analysis** (in Dutch: **'Achtergrond economische analyse'**). Here, the reader will find a detailed and structured explanation of how these values were obtained and consequently, how the reader can complement these values oneself.

Also, in the Front Panel ([see section 2.1.1](#)), the distribution of the types of frost years in the simulation over 10 years can be changed in the extended functionality (choice of number of High Impact, Low Impact and Near-zero impact frost years: Figure 6).

Frontpanel

**Frontpanel economic calculation tool**

Select type of fruit	Jonagold (& variants) apple
Select frost sensitivity of orchard	AVERAGE FROST SENSITIVITY
Variable pricing/socio-economic climate	Neutral (mid-price)
100%	
Simulation - future timeline 10 yrs	
3	Years of high impact frost
2	Years of low impact frost
5	Years of near-zero impact frost

**Choice of High Impact, Low impact and Near-zero impact frost years in future timeline 10 yrs**

FIGURE 6 - 'FRONT PANEL' ECONOMIC CALCULATION TOOL EXTENDED FUNCTIONALITY.

For the results of the 10-year simulation, the user can chose between simulations with neutral, favourable or unfavourable pricing (Figure 7).

Choice pricing simulation 10 yrs

SIMULATION - 10 YEARS w/ pricing				
	Year of near-zero impact frost	Year of low impact frost	Year of high impact frost	
	Additional revenue with 5 years of near-zero impact frost	Additional revenue with 2 years of low impact frost	Additional revenue with 3 years of high impact frost	
	€ 2.111,50	€ 5.344,60	€ 8.016,90	€/ha
Revenue over 10 yrs w/ respectively 3, 2, 5 high, low and near-zero impact years of frost, w/o any frost protection [€/ha]				<b>€ 177.750,00</b>
Additional revenue over 10 yrs with the same distribution of frost years, with frost protection (w/o depreciation of machine) [€/ha]				<b>€ 15.473,00</b>
Weighted payback period over simulation of 10 yrs				<b>1,70 years</b>

FIGURE 7 - SECTION 3 ANALYSIS VORST PROTECTION MEASURE 10 YR. SIMULATION EXTENDED FUNCTIONALITY.

### 2.2.1 – Analysis of other techniques

- **An additional option has been provided to analyse another frost protection measure or technique that was not dealt with in the basic functionality.**

For this purpose, follow the step-by-step plan:

- Select in the front panel **the type of fruit** to which the frost protection measure applies. (**Jonagold** and **Golden Delicious** simply fall under the **same heading ‘apple’**.)
- Then, in the Input tab 'Yield data', enter the name of the frost protection measure for the relevant fruit type and the cell provided for this purpose. (**see Figure 8**).
- Next, fill in the yield data, which indicate the yield compared to the same plot without active frost protection (lower limit) and compared to the same plot on which there was no night frost (upper limit) (**see Figure 8**).
- In the Input tab, enter the 'Running hours' for this technique. This can be done by filling in these values in the section of the orchard with average frost sensitivity. The values for the orchard with high and weak frost sensitivity are filled in automatically (X2 and /2, respectively) (**See Figure 9**).
- The fruit prices remain applicable as mentioned in the tab 'Fruit prices' unless the reader wants to modify these prices, too.
- In the economic analysis, the costs associated with the other measure or technique can now be completed and the other technique can be analysed.

For the calculation of labor costs, the user can choose to enter year or season data [h/frost year] or data per frost night [h/frost night], so that the 'Rnning hours' can then be taken into account for the further calculation of these labor costs.

Input data - Yield

Fruit	Average yield (ton/ha; NO frost, no other great setbacks)	Active frost protection strategies	Year of high impact frost (ton/ha)	Year of low impact frost (ton/ha)	Year of near-zero impact frost (ton/ha)	Year of near-zero impact frost (ton/ha)
Jonagold (& variants) apple HIGH FROST SENSITIVITY	60	No active frost protection	6,0	20,0	54,0	54,0
		Hot air machine (Frostguard)	NaN	NaN	NaN	NaN
		Hot air machine (Frostbuster)	30,0	48,0	60,0	60,0
		Overhead sprinkling	60,0	60,0	60,0	60,0
		Wind machine	30,0	48,0	60,0	60,0
		Combustion (wax candles, heaters, ...)	NaN	NaN	NaN	NaN
		Other frost protection measure (apple)	0,0	0,0	0,0	0,0

Relevant type of fruit

Cell provided for entry of own frost protection technique or measure for that type of fruit

Input values of yield data

FIGURE 8 – TAB INPUT ‘YIELD DATA’. ENTERING THE DATA FOR THE ANALYSIS OF OTHER FROST PROTECTION TECHNIQUES OR MEASURES (NaN = NO AVAILABLE NUMBER, NOT APPLICABLE).

To fill in yourself (apple and/or pear)

AVERAGE FROST SENSITIVITY	Hot air machine (Frostguard & Frostbuster)	18	18	18
	Overhead sprinkling	15	15	15
	Wind machine	35	35	35
	Combustion (wax candles, heaters, ...)	11	11	11
	Other frost protection measure (apple)			
AVERAGE FROST SENSITIVITY	Hot air machine (Frostguard & Frostbuster)	18	18	18
	Overhead sprinkling	15	15	15
	Wind machine	35	35	35
	Combustion (wax candles, heaters, ...)	11	11	11
	Other frost protection measure (pear)			
AVERAGE FROST SENSITIVITY	Hot air machine (Frostguard & Frostbuster)	20	20	20
	Sprinklers under-canopy*(sprinkling above canopy N/A)	20	20	20
	Wind machine	35	35	35
	Combustion (wax candles, heaters, ...)	15	15	15
	Rain shields (cherries)	0,0	0,0	0,0
AVERAGE FROST SENSITIVITY	Hot air machine (Frostguard & Frostbuster)	8	8	8
	Overhead sprinkling	8	8	8
	Wind machine	20	20	20
	Combustion (wax candles, heaters, ...)	6	6	6
	Electrical tracing (grapes)	8,0	8,0	8,0

FIGURE 9 – TAB INPUT ‘RUNNING HOURS’. ENTERING OF THE DATA FOR THE ANALYSIS OF OTHER FROST PROTECTION TECHNIQUES OR MEASURES FOR THE AVERAGE FROST SENSITIVITY ORCHARD. THE VALUES FOR THE ORCHARD WITH HIGH AND WEAK FROST SENSITIVITY ARE FILLED IN AUTOMATICALLY (X2 AND /2, RESPECTIVELY).