HIBIT Manual

Hydrogen Integrated Business Case Impact Tool
Fuel Stations – Vehicles - Buses

version 2.1

Actieplan Duurzame Brandstoffen
Businesscase Toolbox

INFRAM
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HIBIT Manual

Hydrogen Integrated Business Case Impact Tool
Fuel Stations – Vehicles - Buses

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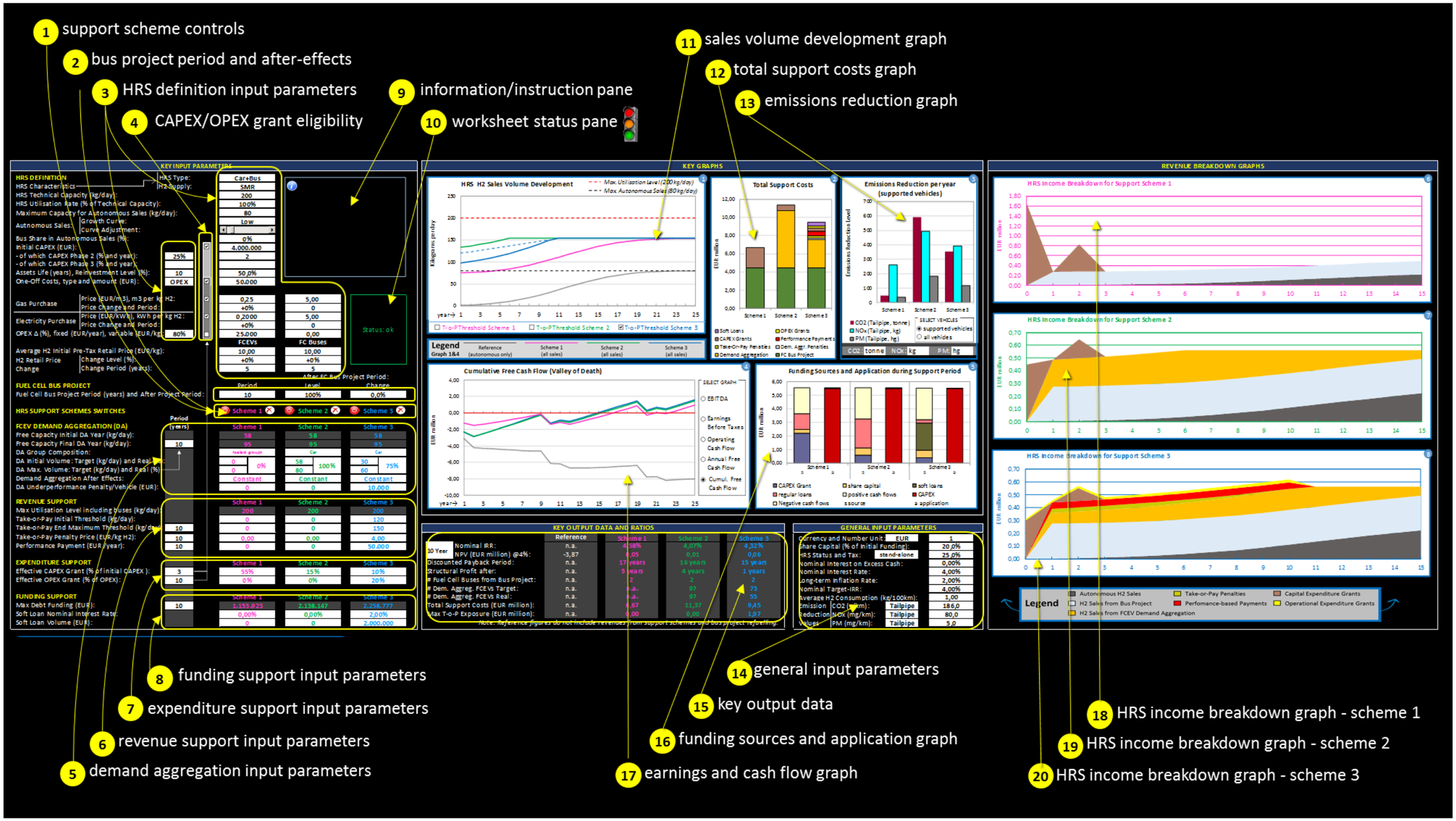
Glossary

CAPEX	Capital Expenditure
CO_2	Carbon Dioxide
EBITDA	Earnings Before Interest, Depreciation and Amortisation
EBT	Earnings Before Tax
FC Buses	Fuel Cell Buses
FCEV	Fuel Cell Electric Vehicle
FCF	Free Cash Flow
H_2	Hydrogen
HIBIT	Hydrogen Integrated Business Case Impact Tool
HRS	Hydrogen Refuelling Station
ICE	Internal Combustion Engine
IRR	Internal Rate of Return
NO_X	Nitrogen Oxides
NPV	Net Present Value
OCF	Operating Cash Flow
OEM	Original Equipment Manufacturer
OPEX	Operational Expenditure
PM	Particulate Matter
ROI	Return on Investment
SMR	Steam Methane Reforming
VAT	Value Added Tax
WACC	Weighted Average Cost of Capital

Dashboard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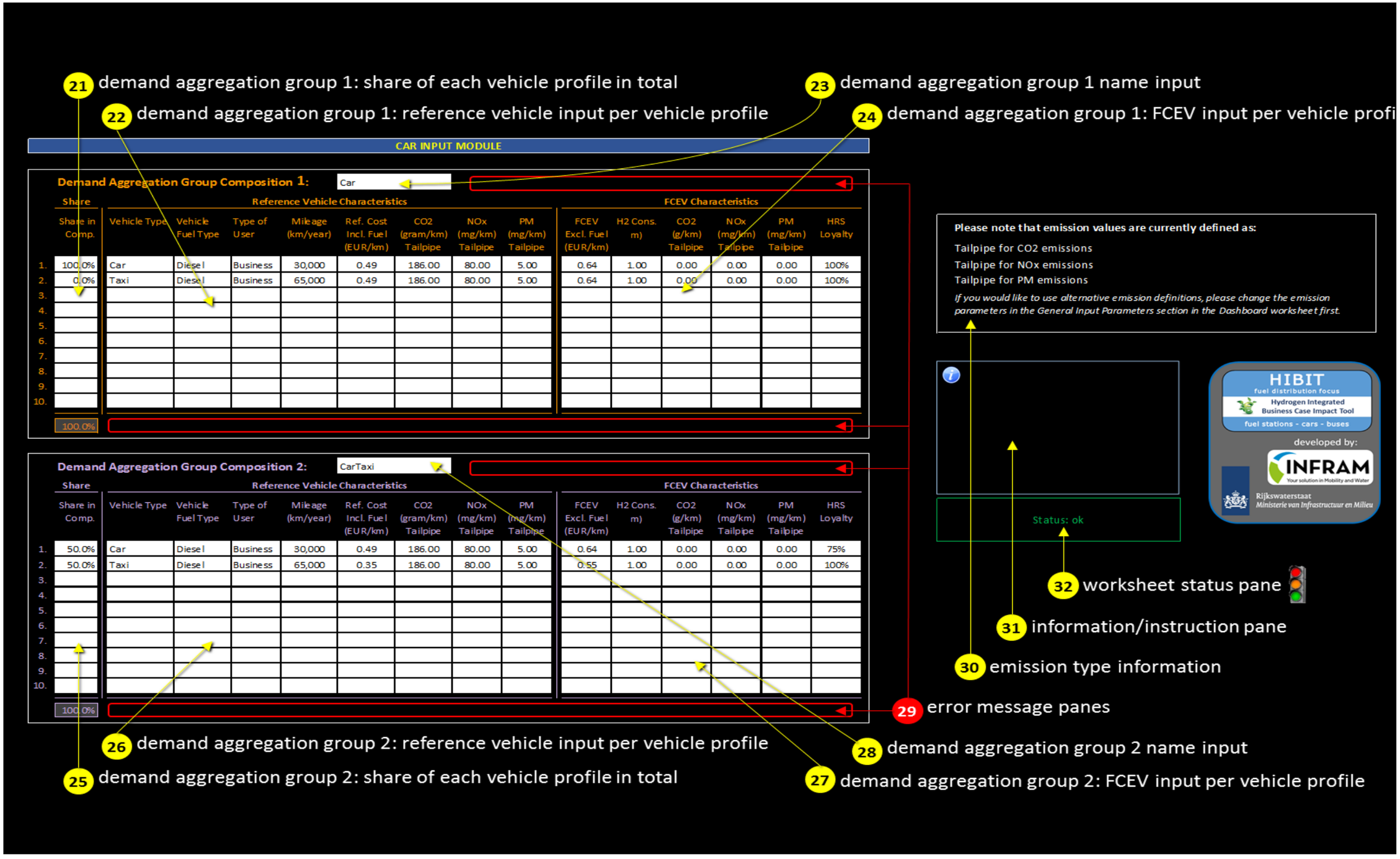
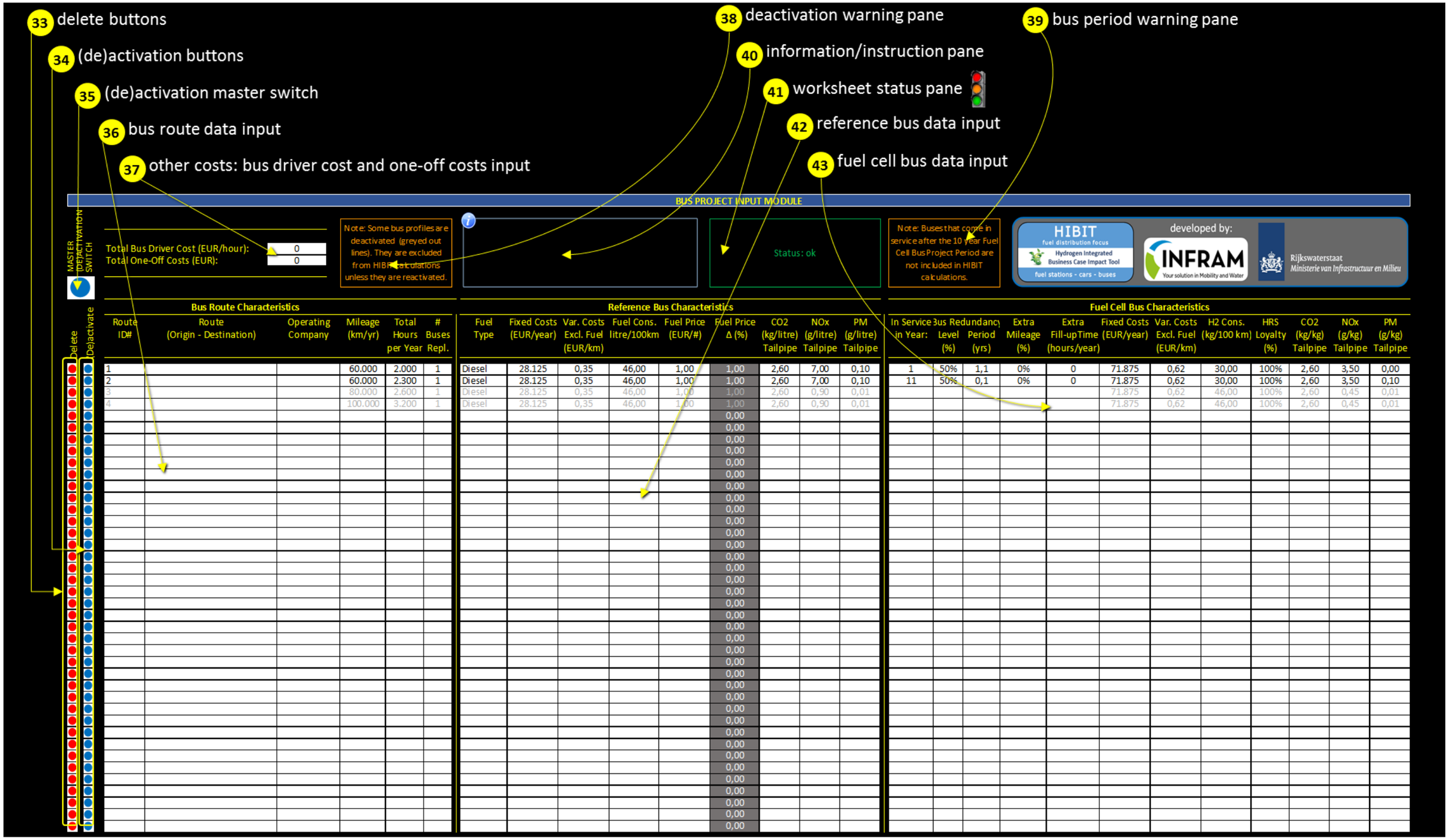


Bus Input Module



Route ID#	Route (Origin - Destination)	Operating Company	Mileage (km/yr)	Total Hours per Year	# Buses Repl.	Fuel Type	Fixed Costs (EUR/year)	Var. Costs Excl. Fuel (EUR/km)	Fuel Cons. litre/100km	Fuel Price (EUR/#)	Fuel Price Δ (%)	CO2 (kg/litre) Tailpipe	NOx (g/litre) Tailpipe	PM (g/litre) Tailpipe	In Service in Year:	Bus Redundancy Level (%)	Redundancy Period (yrs)	Extra Mileage (%)	Extra Fill-up Time (hours/year)	Fixed Costs (EUR/year)	Var. Costs Excl. Fuel (EUR/km)	H2 Cons. (kg/100 km)	HRS Loyalty (%)	CO2 (kg/kg) Tailpipe	NOx (g/kg) Tailpipe	PM (g/kg) Tailpipe
1			60.000	2.000	1	Diesel	28.125	0,35	46,00	1,00	1,00	2,60	7,00	0,10	1	50%	1,1	0%	0	71.875	0,62	30,00	100%	2,60	3,50	0,00
2			60.000	2.300	1	Diesel	28.125	0,35	46,00	1,00	1,00	2,60	7,00	0,10	11	50%	0,1	0%	0	71.875	0,62	30,00	100%	2,60	3,50	0,10
3			80.000	2.600	1	Diesel	28.125	0,35	46,00	1,00	1,00	2,60	0,90	0,01						71.875	0,62	46,00	100%	2,60	0,45	0,01
4			100.000	3.200	1	Diesel	28.125	0,35	46,00	1,00	1,00	2,60	0,90	0,01						71.875	0,62	46,00	100%	2,60	0,45	0,01
											0,00															

1 About HIBIT

1.1 HIBIT Functionality

HIBIT is a Hydrogen Refuelling Station (HRS) business case simulation model. HIBIT supports the individual and joint financial decision-making process of HRS operators and public authorities.

Early HRS investments are generally considered high risk as hydrogen sales growth rates are low and the transition to hydrogen-fuelled mobility is still uncertain. HIBIT provides insight into all HRS financial aspects and offers a variety of financial instruments to improve HRS business case performance. HIBIT includes both cost reduction and revenues increase instruments.

HIBIT has two modules for arranged fuel-cell vehicles: a fuel cell car demand aggregation module and a fuel cell bus module. These modules are dynamically linked to the HRS business case module. These modules allow for the simulation of the impact of arranged fuel cell vehicles in addition to expected autonomous developments. This helps administering agencies to evaluate the effects of investing in fuel cell vehicles (leading to accelerated HRS hydrogen sales) as an alternative to providing direct HRS support.

HIBIT also shows the expected environmental impact of the transition from fossil to hydrogen fuelled vehicles: reduction of carbon dioxide (CO_2), nitrogen oxides (NO_X) and particulate matter (PM).

HIBIT is set up as a dashboard model with a what-you-see-is-what-you-get layout. If input data are modified, all financial and environmental impact figures are automatically adjusted accordingly. This makes HIBIT particularly well-suited as a negotiation support tool.

HIBIT is designed for use by both experienced and less-experienced staff and comes with a dynamic fill assistant feature and an extensive input error checking mechanism. However, if HIBIT is used in a decision-making process, we strongly advise consulting a financial expert.

1.2 System Requirements and Settings

HIBIT is a Microsoft Excel model. The following systems and settings are required:

- Microsoft Excel 2007 or higher;
- Visual Basic for Applications (VBA) enabled.

VBA scripts are only used to enhance user experience. VBA is not used to perform calculations. **Warning: HIBIT contains VBA (Visual Basic for Applications) scripts to enhance user experience. VBA-scripts from unknown or unreliable sources can potentially harm your computer(network). It is recommended to download HIBIT only from the Rijkswaterstaat or Infram website.**

1.3 General Screen Controls

HIBIT screen layout can be adjusted by using built-in Microsoft Excel controls as indicated in figure 1.

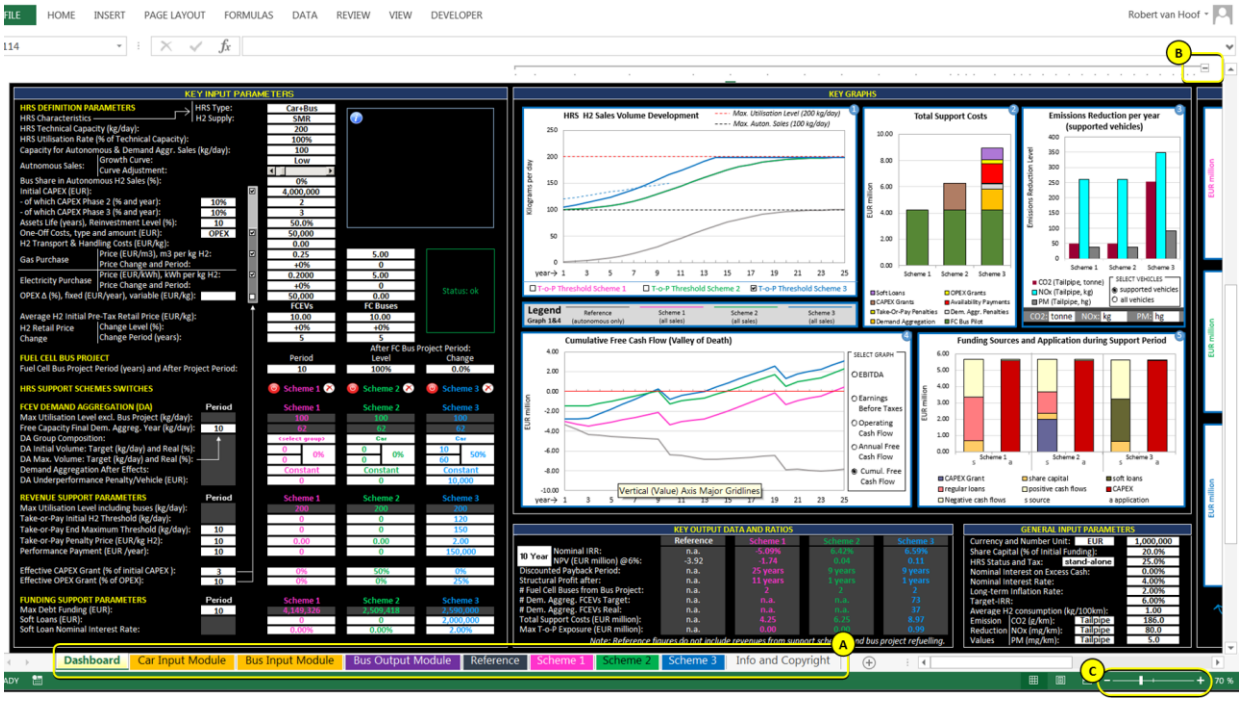


Figure 1: HIBIT general screen controls

Worksheets

HIBIT information is organised over nine visible worksheets and one hidden worksheet (refer to paragraph 4.3). You can easily switch worksheets by clicking on the relevant worksheet tab. Worksheet tabs can be found in the lower left corner of the HIBIT screen, indicated by (A) in figure 1. Worksheet tabs include:

- Dashboard. This is the HIBIT main screen and includes all HRS input parameters, support scheme parameters and summarised business case results, both in numbers and graphs.
- Car Input Module. This is the input screen for FCEV demand aggregation data.
- Bus Input Module. This is the bus data input screen.
- Bus Output Module. This worksheet contains all financial and environmental data with respect to buses in the bus project. The bus project refers to arranged buses that refuel at a specific HRS.

- Reference. This worksheet contains a detailed financial overview of the HRS reference situation (autonomous developments only, no external support and no sales from FCEV demand aggregation or fuel cell bus refuelling).
- Scheme 1. This worksheet contains a detailed financial overview of the HRS support scheme 1 situation (including support scheme 1 effects).
- Scheme 2. This worksheet contains a detailed financial overview of the HRS support scheme 2 situation (including support scheme 2 effects).
- Scheme 3. This worksheet contains a detailed financial overview of the HRS support scheme 3 situation (including support scheme 3 effects).
- Info and Copyright. This worksheet contains HIBIT version and contact details as well as copyright information.

Collapse and Expand Data

Information can be collapsed or expanded for ease of understanding by clicking the '+' or '–' icons as marked by (B) in figure 1. All output worksheets also have expand and collapse icons which can be used to show or hide detailed information.

Zoom

If the items appear too small or too large on the screen, a zoom function can be applied by using the Excel zoom slider, marked by (C) in figure 1. Alternatively, zoom options are available under the Microsoft Excel 'View' ribbon tab.

1.4 Information and Instruction Panes

Most of the HIBIT information and instructions are provided real time in the information and instruction panes, available in the Dashboard and Demand Aggregation Input worksheets.

- The information and instruction pane on the Dashboard worksheet is marked by (9) in the Dashboard Overview on page 6.
- The information and instruction pane on the Car Input Module worksheet is marked by (31) in the Car Input Module Overview on page 7.
- The information and instruction pane on the Bus Input Module worksheet is marked by (40) in the Bus Input Module Overview on page 8.

Information panes provide information on the selected input or output cell.

1.5 Error Checking

HIBIT includes an extensive mechanism of real time warnings and error checking to ensure data accuracy. This mechanism includes the following items:

- Drop-down Lists. If possible, input options are presented as drop-down list items, allowing easy selection of one of the presented options.
- Error Checking as You Type. If the provided input is not correct, an error alert appears and provides further information.
- Ex-post Error Checking. Sometimes information that was correct when originally provided may become inaccurate when other input parameters are adjusted. This leads to an ex-post error notification. Error notifications and warnings appear in the HIBIT status panes, appearing in green if no errors were found, appearing in red if one or more errors were found and appearing in orange in case of missing or possibly incorrect data. In case of errors or warning notifications, HIBIT also highlights the specific cells that may hold incorrect or incomplete data.
    - The worksheet status pane on the Dashboard worksheet is marked by (10) in the Dashboard Overview on page 6.
    - The worksheet status pane on the Car Input Module worksheet is marked by (32) in the Car Input Module Overview on page 7.
    - The worksheet status pane on the Bus Input Module worksheet is marked by (41) in the Bus Input Module Overview on page 8.

2 Business Case Input

2.1 Getting Started

How it works

HIBIT simulates a HRS business case. This simulation starts in the Dashboard worksheet with a HRS expenditure specification and a hydrogen sales development prediction. HIBIT calculates all financial and environmental results automatically.

If the financial results are not satisfactory, the user can compose up to three tailor-made schemes of support instruments to enhance HRS financial performance. The support measures menu includes grants, performance payments, guarantees and the creation of additional hydrogen demand by stimulating FCEV sales. The HIBIT Dashboard shows the key financial results of all schemes so that support schemes can be compared to the base case and to one another on the basis of costs, efficiency and effectiveness. HIBIT also includes detailed financial statements of each support scheme.

In case HRS revenues are (partly) derived from arranged fuel cell vehicles, additional vehicle information can be provided to determine the costs involved in setting up these arrangements. This is for example the case if funds are spent on:

- demand aggregation: investment in FCEV sales acceleration in order to propel hydrogen sales volume.
- fuel cell bus projects: investment in the deployment of fuel cell buses leading to HRS income from bus refuelling.

All input parameters can be adapted at any time; HIBIT presents the according effects immediately.

Input Worksheets

The Dashboard worksheet is the core of the financial model. It contains all HRS input parameters, support scheme parameters and key financial output data and graphs. Refer to paragraph 2.2 for instructions how to fill this worksheet.

If one or more support schemes include demand aggregation activities, the Car Input Module worksheet needs to be completed with car data. Refer to paragraph 2.3 for instructions how to fill this worksheet.

If (a part of) the HRS sales is from bus refuelling, the Bus Input Module worksheet needs to be completed with bus data. Refer to paragraph 2.4 for instructions how to fill this worksheet.

Input/Output Cells and Worksheet Protection

Input cells always have a white background. Most cells with a grey background can be selected to activate the explanatory text in the information/instruction pane, but they cannot be edited. All other cells cannot be selected.

All worksheets are protected without passwords. It is recommended to keep worksheet protection enabled to prevent formulas from being overwritten.

2.2 Dashboard Input Modules

Note: All numbers in brackets refer to the Dashboard Overview on page 6. All data supplied in this overview are just general dummy figures which have to be replaced by project-specific input values.

The HIBIT Dashboard is HIBIT's main module. This is the worksheet where general financial parameters, HRS-specific data and support scheme data are defined. The Dashboard also presents key financial information both in numbers and graphs.

2.2.1 General Input Parameters

In order to perform business case analysis, HIBIT requires general financial data input, marked by (14) on the Dashboard Overview on page 6. This is usually a one-off thing as these parameters are not likely to change frequently.

They include the following items:

Currency and Number Unit

Select the currency of your choice. Changing the currency will only change the currency labels in HIBIT, data will not be converted.

Select the number unit of your choice. The selected number unit is only applied to the detailed output worksheets 'Reference', 'Scheme 1', 'Scheme 2' and 'Scheme 3'.

Share Capital (% of Initial Funding)

As explained in chapter 4, HIBIT simulates HRS business case performance under the pro forma assumption that the HRS is an independent externally funded entity. In order to calculate the required level of debt funding, HIBIT requires information about the level of equity-funding. The equity share is determined by assumed HRS development risk and usually ranges between 10% (low risk) and 60% (high risk).

HRS Status and Tax

As chapter 4 explains, HIBIT simulates HRS business case performance under the pro forma assumption that the HRS is an independent externally funded entity. In order to process tax payments correctly, HIBIT requires information about the HRS legal status: it can either be an incorporated or a stand-alone entity.

- In most cases a HRS is an incorporated entity. This means that it is a sub-unit within the HRS operator's company. If 'incorporated' is selected, HIBIT assumes a vertical offset of losses: pre-tax losses are offset against assumed parent company profits.
- If a HRS is treated as a stand-alone company, HIBIT assumes a horizontal offset of losses: pre-tax losses are offset against future HRS profits, if any. 'Stand-alone' may also be selected in case of an incorporated HRS in combination with the absence of parent company profits.

'Tax' refers to the applicable corporate tax rate. HIBIT allows for only one flat tax rate.

Nominal Interest on Excess Cash

In case cash piles up in the HRS entity, this cash may generate interest income. The applicable nominal interest percentage can be provided here.

Nominal Interest Rate

The nominal interest rate is the cost of capital related to all senior debt.

Long-term Inflation Rate

The long-term inflation rate is used to calculate real interest rates. HIBIT calculates in constant prices, without the effects of inflation. The long-term inflation rate is used to calculate interest rates net of inflation. Usually a consumer price index is a good reference.

Nominal Target-IRR

HIBIT calculates the HRS Net Present Value (NPV). The Target-Internal Rate of Return (IRR) represents the HRS capital cost and is used as the discount rate to calculate the NPV.

Assumed capital costs can be determined by calculating the Weighted Average Cost of Capital (WACC) as follows (example):

	Total	Debt	Equity
a. Share in Funding	100%	80%	20%
b. Required Return (after Tax)		4.00%	15.00%
c. WACC (=a*b)	**6.20%**	3.20%	3.00%

a. Determine the share of debt and equity funding - refer to the 'Share Capital' section in this paragraph.
b. Determine the required return on debt (equal to the nominal market interest rate you provided in the HRS definition section – refer to the 'Nominal Interest Rate' section in this paragraph).
c. Multiply the shares of debt and equity with the required returns. The WACC is the sum of the two.

Average H_2 Consumption and Emission Reduction Values

HIBIT offers the option to calculate CO_2, NO_X and PM emissions reduction volumes from fuel cell vehicles refuelling at the involved HRS, assuming that these fuel cell vehicles replace Internal Combustion Engine (ICE) vehicles. Enter the average hydrogen consumption of a fuel cell vehicle and the expected average CO_2, NO_X and PM emissions reduction compared to their ICE counterparts. Define the emission type:

- tailpipe emissions: emissions directly from the vehicle's tailpipe,
- tank-to-wheel emissions: tailpipe emissions plus emissions from the vehicle's tires and brakes,
- well-to-wheel emissions: tank-to-wheel emissions plus emissions from fuel production and transport.

Note that fuel consumption and emissions reduction values in this section only apply to autonomous development refuelling, meaning that bus project or demand aggregation initiatives. are excluded. Specific fuel consumption and emission data bus project and demand aggregation vehicles are provided in the Car Input Module and Bus Input Module.

2.2.2 HRS Definition

HRS characteristics and expenditure can be provided in the HRS Definition Parameters section, marked by (3) on the Dashboard Overview on page 6

HRS Characteristics

Select the HRS type (car, bus or car and bus) and H_2 supply method (delivered, steam methane reforming or electrolysis). HIBIT uses this information to tailor the dashboard layout to the specific HRS configuration. Superfluous fields are hidden and required fields are shown.

HRS Technical Capacity

The HRS technical capacity is expressed as the maximum output in kilograms per day.

HRS Utilisation Rate

The HRS Utilisation Rate is the average hydrogen throughput as a percentage of the technical capacity. The maximum HRS utilisation (when the HRS is fully up and running) equals HRS technical capacity multiplied by its utilisation rate.

Maximum Capacity for Autonomous Sales

Autonomous sales are the result of demand arising from the general transition to FCEV mobility. The maximum capacity for autonomous sales is HRS capacity available to service this autonomous demand as well as demand from demand aggregation initiatives. However, required capacity for bus project refuelling is not included in capacity for autonomous sales.

The gap between the maximum HRS utilisation level and the autonomous sales maximum is either reserved capacity for bus refuelling or regarded as idle capacity in case of HRS underperformance.

Autonomous Sales

The exact development of the HRS revenue curve is hard to predict as it depends on many uncertain variables. Following the principle 'it is better to be roughly right than precisely wrong', HIBIT offers a 'look and feel' option to sculpt a tailor-made market growth curve. Growth curve design is best done as follows:

1. Make sure support schemes 1, 2 and 3 are deactivated (refer to paragraph 2.2.4 for instructions).
2. Choose a growth curve from the dropdown list (zero, very low, low, medium, high, very high) with a slope that best suits the expectations of HRS sales development from autonomous refuelling. Key graph 1 (HRS H2 Sales Volume Development, marked by (11) on the Dashboard Overview on page 6) shows the resulting growth curve.
3. Use the slider  to move the curve left or right. There may be a small delay before you actually see the curve move.

Bus Share in Autonomous Sales[1]

In case of a Car+Bus HRS type, HIBIT requires information about the bus share in autonomous sales. This is especially important if hydrogen for bus and car refuelling sells at a different prices.

[1] This input field is only available if the HRS Type is set as "Car+Bus".

Initial CAPEX

Enter the total expected HRS Capital Expenditure. In case of a phased investment, phase 2 and phase 3 investments can be provided as a percentage of the total investment and the number of years after project start these phase 2 and 3 investment are done.

Assets Life and Reinvestment Level

Enter the expected lifetime of the HRS assets. Assets life is the period after which assets are replaced. HIBIT assumes linear depreciation. After the indicated HRS asset life period, HIBIT assumes asset replacement. The Reinvestment Level is set as a percentage of initial CAPEX. For example, an 80% Reinvestment Level means that HIBIT assumes a reinvestment level equal to 80% of initial CAPEX. This reinvestment level applies to all future assets reinvestments.

One-Off Costs

One-Off Costs are typically non-CAPEX start-up costs paid once and not repeated, such as planning costs and costs of building permits. One-Off Costs can be treated as CAPEX or OPEX. If treated as CAPEX, these costs are treated the same way as other CAPEX and written off over the assets depreciation period. If treated as OPEX, these costs are fully accounted for in the HRS profit and loss statement in the first development year.

Transport & Handling Costs[2]

In case of delivered hydrogen (instead of onsite production) transport and handling costs apply. These costs are expressed as an amount per kilogram.

H2 Purchase Price[2]

In case of delivered hydrogen HIBIT requires pre-tax purchase price input. If the hydrogen purchase price is expected to change (other than inflation effects), a change level and period can be provided as well. HIBIT assumes a linear pattern. If for example a 10% decline (to be entered as '-10%') over a 10 year period is expected, an annual decline of 1% is assumed.

Gas Purchase Price and Quantity[3]

In case of onsite Steam Methane Reforming, HIBIT requires gas purchase price and required gas volume input. If the gas price is expected to change (other than because of inflation effects), a

[2] This input field is only available if the H2 Supply is set as "Delivered".

[3] This input field is only available if the H2 Supply is set as "SMR".

change level and period can be provided as well. HIBIT assumes a linear pattern. If for example a 10% increase over a 10 year period is expected, an annual increase of 1% is assumed.

Electricity Purchase Price and Quantity

HIBIT requires electricity purchase price and required electricity volume input. If the gas electricity is expected to change (other than inflation effects), a change level and period can be provided as well. HIBIT assumes a linear pattern. If for example a 5% decline (to be provided as '-5%') over a 10 year period is expected, an annual decline of 0.5% is assumed.

OPEX

Enter the expected fixed HRS OPEX as an amount per year and variable OPEX as an amount per kilogram produced hydrogen. HIBIT also offers the option to process semi-fixed OPEX. This only has an effect in case of a phased investment. The semi-fixed OPEX-portion can be provided as a percentage of total fixed OPEX. Example: Total investment is 400 of which 300 is invested in year 1 and 100 in year 2. Total fixed OPEX is 25, with an 80% semi-fixed OPEX portion. Total Fixed OPEX is as follows:

	Year 1	Year 2
OPEX Fully-Fixed	=20% × 25 = **5**	=20% × 25 = **5**
100% OPEX Semi-Fixed	=80% × 25 = 20	=80% × 25 = 20
Investment level	= 300/400 =75%	=400/400 = 100%
OPEX Semi-Fixed	= 75% × 20 = **15**	=100% × 20 = **20**
Total Fixed OPEX	= 5 + 15 =**20**	= 5 + 20 = **25**

Fully-Fixed OPEX equals 20% of 25 =5. Total semi-fixed OPEX is 80% of 25 = 20. The investment level in year 1 is 75%. This means that semi-fixed OPEX in year 1 equals 75% of 20 = 15. Total investment level in year 2 is 100%. This means that semi-fixed OPEX as from year 2 equals 100% of 20 = 20.

Average H_2 Initial Pre-Tax Retail Price

This is the hydrogen (pre-tax) pump price. The following information can be provided for either or both FCEVs and buses (depending on the HRS Type):

- Average Initial H_2 Retail Price exclusive of taxes and duties. Currently, hydrogen pre-tax retail prices are around EUR 10 per kilogram.
- H_2 Retail Price Change Level and Period. If a future retail price change is expected, the change level (as a percentage of the initial H_2 retail price) and a change period can be provided. HIBIT assumes a linear change pattern. For example, if a 15% price reduction (provided as '-15%') is assumed over a period of 15 years, HIBIT assumes an average pre-tax retail price reduction of 1% per year.

2.2.3 Fuel Cell Bus Project[4]

The Fuel Cell Bus Project refers to initiatives involving the deployment of fuel cell buses (usually in scheduled service) refuelling at the involved HRS. Most bus-related financial details can be provided in the Bus Input Module (explained in paragraph 2.4).

The following bus-related project details are provided in the Dashboard worksheet, marked by (2) on the Dashboard Overview on page 6:

- Bus Project Period: the total number of years buses will be refuelling at the involved HRS;
- After FC Bus Project Period: This is an indication of the expected H_2 sales volume level after bus project expiration. The sales volume level is indicated as a percentage of sales volume in the final bus project year. The sales volume change indicates the annual growth (or decline) of sales volume starting from the indicated sales volume level at bus project expiration.

2.2.4 HRS Support Schemes Switches

In order to enhance HRS business case performance, HIBIT offers options to compose tailor-made support packages from a variety of support instruments, described in paragraphs 2.2.5. to 2.2.8. HIBIT allows for a maximum of three support schemes. Each support scheme can be switched on/off or can be completely deleted by using the controls marked by (1) on the Dashboard Overview on page 6.

- Click to activate or deactivate a support scheme. Deactivation will not lead to data removal, it will only exclude the support scheme from HIBIT calculations and output. After deactivation, data remain visible, though greyed out.
- Click to clear a support scheme. This will lead to support scheme data removal. After clicking this button, HIBIT asks for data removal confirmation.

2.2.5 FCEV Demand Aggregation

Demand Aggregation is the creation of hydrogen demand from FCEV refuelling in addition to autonomous market developments. This results in additional hydrogen demand leading to additional HRS revenues. All Demand Aggregation parameters are marked by (5) on the Dashboard Overview on page 6.

[4] This input field is only available if the HRS Type is set as "Bus" or "Car+Bus".

Free Capacity Initial and Final Demand Aggregation year

You can specify the period during which the demand aggregation applies in the column 'Period'. HIBIT shows free refuelling capacity for both the initial year (first year) and the final year of demand aggregation support. This information can be used as a reference for demand aggregation volumes. Demand aggregation volumes are not allowed to exceed free capacity.

Free Capacity for the Initial Demand Aggregation year is calculated as follows:

- maximum HRS Utilisation Level × Percentage of CAPEX realised in Phase 1 (year 1);
- minus the autonomous refuelling volume in year 1;
- in case of bus refuelling: minus total capacity reservation for bus refuelling × Percentage of CAPEX realised in Phase 1 (year 1).

Free Capacity for the Final Demand Aggregation year is calculated as follows:

- maximum HRS Utilisation Level;
- minus autonomous refuelling volume in final demand aggregation year;
- in case of bus refuelling: minus forecasted bus refuelling volume in final demand aggregation year.

Demand Aggregation Group Composition

Select the name of the applicable demand aggregation group. Refer to paragraph 2.3 for further details about demand aggregation group definition.

Demand Aggregation Initial and Maximum Volumes, Target and Real

Enter the target initial volume and maximum (to be reached in the final demand aggregation year) target hydrogen sales volume from demand aggregation, in kilograms per day. Enter 100% in the right adjacent cell if these targets are expected to be fully met. Enter a lower percentage to simulate scenario's with real demand aggregation volumes lower than their target values. HIBIT assumes a linear relationship between initial and maximum demand aggregation volumes.

The Key Output Data and Ratios table, marked by (15) on the Dashboard Overview on page 6, provides information about the number of demand aggregation vehicles resulting from demand aggregation volumes and the applicable demand aggregation group compositions. Refer to paragraph 3.1).

Demand After Effects

HIBIT requires information as to what happens when demand aggregation support ends. The following options are available:

- Zero. This option assumes that when demand aggregation initiatives end, all users switch (back) to a vehicle type other than an FCEV. Additional demand aggregation sales fall back to zero. This is a worst case scenario. Figure 2 illustrates this effect.

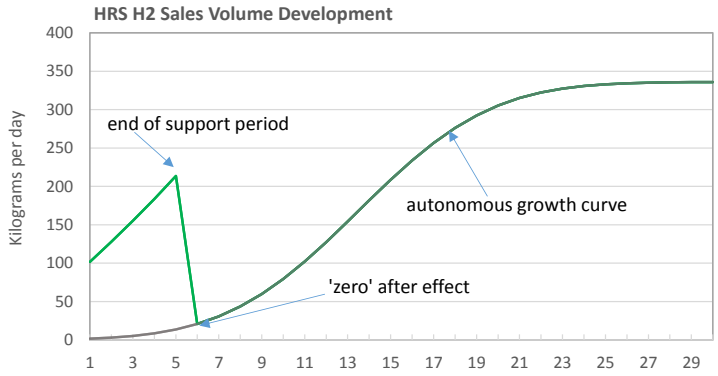


Figure 2: Illustration of 'zero' demand aggregation effect after support period. The green line indicates total sales volume including demand aggregation (after) effects.

- Decrease. This option assumes that the hydrogen volume from refuelling FCEVs originating from demand aggregation slowly decreases. Some users may switch to other vehicle types and others may increasingly fill up at other HRS. HIBIT processes such development by keeping the total hydrogen sales volume level constant from the end of the support period until the autonomous growth curve exceeds this constant volume level. Figure 3 illustrates this.

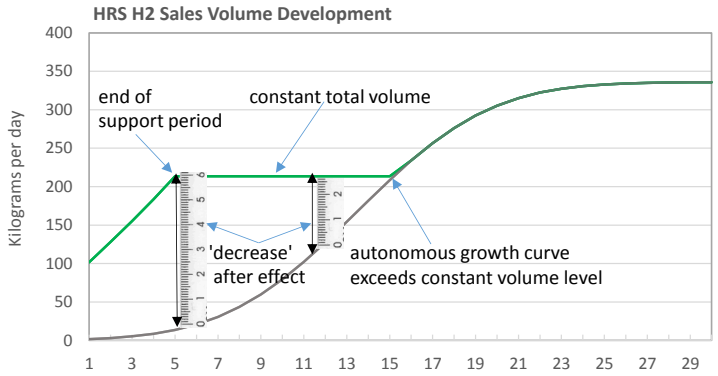


Figure 3: Illustration of 'decrease' demand aggregation effect after support period. The green line indicates total sales volume including demand aggregation (after) effects.

- Constant. This option assumes that the hydrogen volume from refuelling FCEVs originating from demand aggregation remains at a constant level after the support period. In this case, HIBIT will take total hydrogen volume at the end of the support

period as a reference, adding autonomous sales growth to this total volume. Figure 4 illustrates this effect.

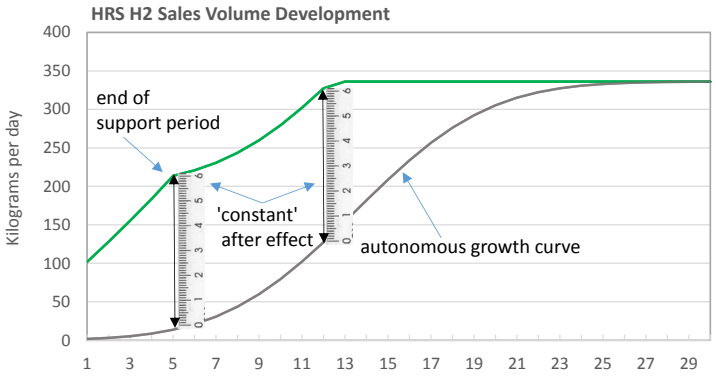


Figure 4: : Illustration of 'constant' demand aggregation effect after support period. The green line indicates total sales volume including demand aggregation (after) effects.

- S-curve. This option ceases to identify demand aggregation participants as a separate group. It simply takes the total sales volume at the end of the support period as a reference and assumes a growth pattern similar to the autonomous growth curve (S-curve). This is done in the following four steps:
    - Step 1. HIBIT considers the total hydrogen sales volume at the end of the support period.
    - Step 2. HIBIT calculates when the total hydrogen sales as referred to in step 1 would have been reached in the autonomous growth curve (S-curve).
    - Step 3. HIBIT identifies the S-curve growth pattern starting from the point referred to in step 2.
    - Step 4. For the period starting at the expiration of the demand aggregation support period, HIBIT assumes a growth pattern similar to the pattern identified in step 3.

  This is a best case after effect scenario. Figure 5 illustrates this.

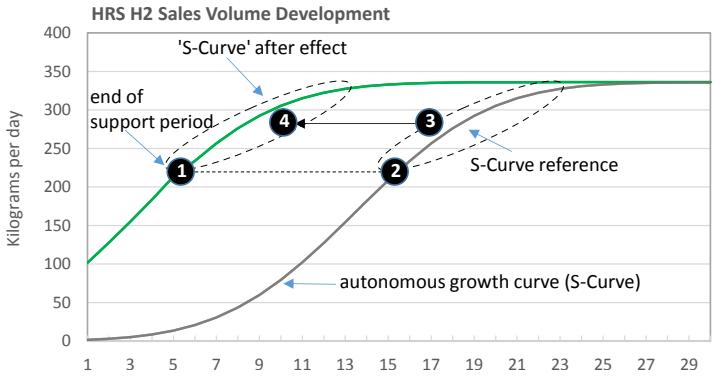


Figure 5: Illustration of 'S-curve' demand aggregation effect after support period. The green line indicates total sales volume including demand aggregation (after) effects. Numbers indicate steps 1 to 4.

Demand Aggregation Underperformance Penalty

HIBIT offers the option to apply a penalty in case real demand aggregation levels fall below target levels. This penalty is for example paid by the party responsible for demand aggregation. The total penalty level is equal to the target number of demand aggregation FCEVs minus the real number of demand aggregation FCEVs multiplied by the penalty per vehicle. The Key Output Data and Ratios table, marked by (15) on the Dashboard Overview on page 6, provides information about the target and real number of vehicles from demand aggregation.

It is recommended to check compliance with EU regulations in case such penalty payment obligation is assumed by a public sector party.

2.2.6 Revenue Support Parameters

Revenue support is focused on enhancing HRS revenues, by providing performance-related payments or guarantees. All Revenue Support parameters are marked by (6) on the Dashboard Overview on page 6.

Maximum Utilisation Level

The Maximum Utilisation Level is equal to the HRS technical capacity multiplied by its utilisation rate. Take-or-pay volumes are not allowed to exceed the maximum utilisation level.

Take-or-Pay Initial H_2 Threshold

Take-or-pay contracting is described in Appendix A. Enter the initial volume (at the beginning of the support period) to be guaranteed by take-or-pay provisions.

Take-or-Pay End Maximum Threshold

Enter the period during which the take-or-pay support applies, followed by the volume to be guaranteed by take-or-pay provisions at the end of the take-or-pay support period. HIBIT assumes a linear relationship between initial and end volumes.

Take-or-Pay Penalty Price

Enter the period during which the take-or-pay penalty payments apply, followed by the penalty price per kilogram underperformance. This is the price the counterparty pays for not 'taking' the agreed take-or-pay volume levels. Usually the penalty price is lower than the sales price as it only covers unavoidable HRS costs. For example: In a given year the take-or-pay guarantee level is 100 kg/day with a EUR 3/kg penalty price. If total sales level is 90 kg/day, the due take-or-pay penalty payments in that year are (100 kg/day – 90 kg/day) × EUR 3 × 365 days = EUR 10,950. Check compliance with EU regulations in case such penalty payment obligation is assumed by a public sector party.

Performance-based Payment

Performance-based payments are described in Appendix A. Enter the amount the HRS operator will receive annually during the support period if the HRS performance meets the agreed performance level. It is recommended to check compliance with EU regulations in case such performance-based payment obligation is assumed by a public sector party.

2.2.7 HRS Expenditure Support Parameters

Expenditure support is focused on decreasing HRS expenditure, by providing grants. All Expenditure Support parameters are marked by (7) on the Dashboard Overview on page 6.

Capital Expenditure Grant

1. Enter the period during which the CAPEX grant applies.
2. Tick the CAPEX-items eligible for CAPEX grant support in the CAPEX/OPEX grant eligibility box marked by (4) on the Dashboard Overview on page 6.
3. Enter the effective CAPEX grant as a percentage of total HRS capital expenditure. For example: If 90% of CAPEX qualifies for CAPEX support and the CAPEX grant is 50%, the effective CAPEX grant is 90% × 50% = 45%.

Operational Expenditure Grant

1. Enter the period during which the OPEX grant applies;
2. Tick the OPEX-items eligible for OPEX grant support by ticking these items in the CAPEX/OPEX grant eligibility box marked by (4) on the Dashboard Overview on page 6.

3. Enter the effective OPEX grant as a percentage of total HRS operational expenditure. For example: If 90% of OPEX qualifies for OPEX support and the OPEX grant is 50%, the effective OPEX grant is 90% × 50% = 45%.

2.2.8 HRS Funding Support Parameters

Expenditure support is focused on enhancing HRS funding, by providing soft loans. All Funding Support parameters are marked by (8) on the Dashboard Overview on page 6.

Maximum Debt Funding

Enter the period during which the funding support applies. The Maximum Debt Funding' cell shows the total level of debt funding required during this period. This output can be used as a reference to determine soft loan volume levels. HIBIT assumes that the part of the required initial debt funding not provided by soft loans, is provided by commercial senior debt.

Soft Loan Nominal Interest Rate

Soft loans are described in Appendix A. The soft loan interest rate can be lower than, equal to or higher than the senior debt interest rate. A lower percentage can be regarded as direct financial support. Soft loans sometimes have a higher interest rate than senior debt. Because of their junior position, soft loans are considered higher risk than senior debt. Soft loans provide a financial buffer for providers of debt in case of default. Higher risk usually means a higher price. However, by providing soft loans below market rates, HRS operators receive a double advantage: cheap money serving as buffer for senior debt providers leading to lower senior debt costs. It is important to check if the provision of soft loans is compliant with EU regulations.

Soft Loan Volume

The soft loan volume is the maximum amount invested in the provision of soft loans. Obviously soft loans volume cannot be higher than the required maximum debt funding volume. However, an error message may appear if a lower value than the maximum debt funding volume is provided. This is because there is some correlation between the maximum debt funding volume and the soft loan volume. Such errors can be resolved by starting with a significantly lower soft loan volume and then gradually increasing it until the maximum level has been reached.

2.2.9 Common Warnings and Errors

All dashboard warning and errors are shown in the worksheet status pane, marked by (10) on the Dashboard Overview on page 6

Interest versus inflation warnings

As explained in paragraph 2.2.1 under 'Long-term Inflation Rate', inflation is removed from all interest rates. If the assumed inflation percentage is higher than the nominal interest rate, this leads to a negative real interest rate. Negative real interest rates do exist in times of very low nominal interest rates and relatively high inflation, but are generally regarded as undesirable.

Required hydrogen volumes versus available capacity errors

These errors occur if HIBIT ascertains a discrepancy between the required and available refuelling capacity. Such errors may occur because of the following reasons:

- HRS Technical Capacity; and/or
- HRS Utilisation Rate; and/or
- HRS Maximum Capacity for Autonomous Sales; and/or
- CAPEX Phase 2/Phase 3 data

are changed after the key input parameters were set.

In these cases the worksheet status pane shows an error notification and cells with possible inaccurate content are marked. Such errors can be resolved by:

- increasing HRS Technical Capacity or HRS Utilisation Rate;
- decreasing the percentage of phase 2 or phase 3 investments;
- advancing phase 2 or phase 3 investments;
- decreasing demand aggregation volumes;
- decreasing take-or-pay volumes;
- decreasing required volumes for bus refuelling.

Demand aggregation group composition errors

These errors generally occur for one of the following reasons:

- You have assumed a demand aggregation sales volume without having selected a demand aggregation group. HIBIT therefore cannot process demand aggregation effects. You can resolve this error by selecting a (valid) demand aggregation group.
- You have selected an invalid demand aggregation group. Paragraph 2.3 describes how to define valid demand aggregation groups. Groups can be invalid for one of the following reasons:
    - The demand aggregation group name is not unique. In this case, HIBIT cannot identify the correct demand aggregation group.
    - The sum of shares in a composition group does not equal 100%, leading to incorrect demand aggregation calculations.

You can resolve these errors in the Demand Aggregation Input worksheet.

Demand Aggregation Effect after Support Period Errors

This error occurs if you have assumed a demand aggregation sales volume without selecting an after effect option. You can resolve this error by selecting one of the after effects described in paragraph 2.2.5 under 'Demand Aggregation Effects after Support Period'.

Take-or-Pay Penalty Price Errors

Take-or-pay penalty prices should be lower than the hydrogen pre-tax retail price. An error occurs if you change the hydrogen retail price to a level below the provided take-or-pay penalty price. You can resolve this error by either changing the hydrogen retail price or the take-or-pay penalty price.

Soft Loan Errors

These errors occur if the total soft loan volume exceeds the total required initial debt funding volume. You can resolve this error by adjusting the soft loan volume.

2.3 Car Input Module

Note: all numbers in brackets refer to the Car Input Module Overview on page 7. *All data supplied in this overview are just general dummy figures which have to be replaced by project-specific input values.*

The Car Input Module is the module with reference and fuel cell vehicle information. This information is used to process vehicle demand aggregation data.

HIBIT allows for a maximum of two demand aggregation groups. Each demand aggregation group can consist of up to ten vehicle profiles.

HIBIT uses demand aggregation group information to calculate the number of vehicles involved, given the target demand aggregation hydrogen sales volume, and to calculate additional total costs of ownership of fuel cell vehicles and demand aggregation CO_2, NO_X and PM reduction effects.

2.3.1 Group Composition

Demand Aggregation Group Composition Name

You can enter a name for each demand aggregation group. These names can be provided in the fields indicated by (23) and (28). Make sure every name is unique, otherwise HIBIT will not be able to identify the correct demand aggregation group.

Share in Composition

Each demand aggregation group consists of up to ten vehicle profiles. Each vehicle profile consists of reference vehicle and FCEV characteristics. Enter the share of each vehicle profile in the sections indicated by (21) and (25). Make sure that the sum of all shares equals 100%.

2.3.2 Reference Vehicle Input

It is assumed that demand aggregation group participants swap their current ICE vehicle for an FCEV. In order to calculate the demand aggregation's financial and environmental effects, HIBIT needs information on both current reference vehicles and the fuel cell replacement vehicle. Reference vehicle input can be provided in the sections marked by (22) and (26).

Vehicle Type

Enter the current ICE vehicle type for each vehicle profile, such as car, bus or van. You may also enter a concrete reference vehicle type such as 'Volvo V40' or more general 'A-segment' or 'D segment', whichever is the clearest and most convenient. The information provided here will only be used for explaining vehicle details in demand aggregation summaries.

Vehicle Fuel Type

Enter the current ICE vehicle fuel type for each vehicle profile, such as petrol or diesel. The information provided here will only be used for explaining vehicle details in demand aggregation summaries.

Type of User

Enter the type of user for each vehicle profile, such as business, private or taxi. The information provided here will only be used for explaining vehicle details in demand aggregation summaries.

Mileage

Enter the average annual mileage for each vehicle profile. HIBIT uses this information to calculate demand aggregation effects.

Reference Cost

Enter the reference (ICE) vehicle's total cost per kilometre. HIBIT uses this information to calculate cost differences between the reference vehicle and its FCEV replacement. Total cost of ownership provides the most complete information but may be difficult to obtain. Alternatively you can include only those categories with different cost levels for the reference vehicle and the FCEV. HIBIT calculates on the basis of cost differences, not absolute cost levels. Reference costs can be roughly estimated using a simple calculation framework, as demonstrated in figure 6.

		per 5 years	per year	per kilometre
Mileage			20,000	
Depreciation	Retail Price	50,000		
	Second-Hand Value after 5 Years	25,000		
	Depreciation	25,000	5,000	0.25
Insurance			0	0.00
Road tax			0	0.00
Maintenance			0	0.00
		l/100km	price/l	
Fuel		5.00	1.40	0.07
Total Costs per Kilometre				0.32

Figure 6: Example of a simple total cost per kilometre calculation.

This example assumes cost difference between ICE vehicles and FCEVs in terms of depreciation and fuel costs. As insurance, road tax and maintenance are assumed to be equal for both vehicle types, in this example these costs are left out. An important factor to be included in such calculations is value added tax (VAT) deductibility. Generally private persons have to assume VAT as a cost. Corporate users may be able to deduct VAT, so in these cases cost calculations should be made exclusive of VAT.

CO_2, NO_X and PM

Enter the reference vehicle's CO_2, NO_X and PM emissions per kilometre. There are several sources available providing such emission data per vehicle, for example *http://www.nextgreencar.com/tools/emissions-calculator*. Verify that emission values are in line with the selected emission type (refer to paragraph 2.2.1).

2.3.3 FCEV Replacement Vehicle Input

FCEV Cost

Enter the FCEVs total cost per kilometre excluding fuel costs (these costs will be calculated using the hydrogen fuel retail price provided in de Dashboard worksheet).

H_2 Consumption

Enter the FCEVs fuel consumption in kilograms per 100 kilometres. This information is available from most OEMs' websites. This information is used to calculate how many vehicles are required to match the required additional hydrogen sales from demand aggregation.

CO_2, NO_X and PM

Enter the reference FCEVs CO_2, NO_X and PM emissions per kilometre. There are several sources available providing such emission data per vehicle, for example *http://www.nextgreencar.com/tools/emissions-calculator*. Verify that emission values are in line with the selected emission type (refer to paragraph 2.2.1).

HRS Loyalty

HRS loyalty answers the question 'Which percentage of all refuelling is done at this specific HRS?'. This percentage represents the share of this HRS in all refuellings per vehicle profile. As the number of HRS is very limited in early market phases, the HRS loyalty percentage is expected to be close to 100%.

2.3.4 Common Warnings and Errors

All warning and errors are shown in the worksheet status pane, indicated by (32).

Demand Aggregation Group Composition Name Errors

This error occurs if a demand aggregation group name is not unique. In this case, HIBIT cannot identify the correct demand aggregation group. You can correct this error by changing one of the duplicate names.

'Total Share' Errors

This error occurs if the sum of shares in a composition group does not equal 100%, leading to incorrect demand aggregation calculations. You can correct this error by changing one or more vehicle profile shares.

2.4 Bus Input Module

Note: all numbers in brackets refer to the Bus Input Module Overview on page 8. *All data supplied in this overview are just general dummy figures which have to be replaced by project-specific input values.*

The Bus Input Module is the module with reference and fuel cell bus information. HIBIT uses bus-related data to calculate business case effects from bus refuelling, including effects on HRS hydrogen sales, total costs of ownership effects and CO_2, NO_X and PM reduction effects.

HIBIT allows for a maximum of 40 bus routes. Bus routes can easily be switched on or off by clicking the blue (de)activation buttons marked by (34). Deactivation means that bus route data are excluded from HIBIT calculations but remain available. These data can easily be included in

HIBIT calculation, simply by reactivating them. It is also possible to (de)activate all bus data by clicking the large blue (de)activation master switch (35).

Particular bus route data can easily be deleted by clicking the corresponding red delete button marked by (33).

Bus Route Characteristics

HIBIT allows for a maximum of 40 bus routes and an infinite number of buses per route. Bus route characteristics are provided in the fields marked by (36) and include:

- Bus route identification number, origination, destination and operating company. These input fields are not used in any calculation. They are only intended to make it easier to identify particular bus routes.
- Mileage. This is the number of kilometres per bus route.
- Total Hours per Year. This is the amount of time the bus is operational per year. This information is relevant in case of bus redundancy requirements (refer to the Fuel Cell Bus Characteristics section below) leading to additional driver wages costs.
- Number of Buses Replaced. Most bus routes are operated by multiple buses. This cell indicates the number of buses being replaced with fuel cell buses.

Reference Bus Characteristics

HIBIT determines the extra costs of fuel cell bus operation by comparing total costs and emissions of operating fuel cell buses to reference buses (in most cases: diesel). This is why reference bus information is required. Reference bus characteristics are provided in the fields marked by (42) and include:

- Fuel type. This is diesel in most cases.
- Fixed Costs. Total fixed costs (such as depreciation, insurance, fixed maintenance) per reference bus per year.
- Variable Costs. All variable costs per kilometre but excluding fuel (fuel costs are calculated separately).
- Fuel Consumption. This is reference bus fuel consumption in litres per 100 kilometres.
- Fuel Price. This is the reference fuel price.
- Fuel Price Δ. You can test business case sensitivity to reference fuel price levels, simply by entering a fuel price Δ percentage. For example: if the reference fuel price is EUR 1.00/l and Fuel Price Δ is -10%, HIBIT calculates with a EUR 0.90/l reference fuel price.
- CO_2, NO_X and PM. Enter the reference bus CO_2, NO_X and PM emissions per kilometre. Verify that emission values are in line with the selected emission type (refer to paragraph 2.2.1).

Fuel Cell Bus Characteristics

Fuel cell bus characteristics are provided in the fields marked by (43) and include:

- In Service in Year. Enter how many years from the bus project start reference buses operating a specific route will be replaced by fuel cell buses. It may be the case that not every bus operating a specific route is replaced at the same time. In that case all bus data in a given row can be copied into one or more new rows after which the bus replacement year can be adjusted.
- Bus Redundancy Level and Period. Bus redundancy refers to the period where reference buses serve as an instant backup in case the fuel cell bus fails, for example because of technical issues. Instant backup service means that a reference bus operates the same route, right behind the fuel cell bus. The Bus Redundancy Level is best defined as the total bus redundancy time as a percentage of total bus operation time. For example: if five buses operate a specific route and one bus has diesel backup service for 50% of its operating time, the total Bus Redundancy Level is 50% / (5 × 100%) = 10%. Bus Redundancy Period refers to the total period during which bus redundancy applies;.
- Extra Mileage. Refuelling facilities may not always be available at the best location (bus depot or near to the bus route). If fuel cell buses have to make detours (compared to reference buses) to reach refuelling facilities, the extra mileage can be provided here (as a percentage of total route mileage).
- Extra Fill-Up Time. Fuel cell bus refuelling may take longer than diesel bus refuelling. Extra fill-up time can be provided in hours per year.
- Fixed Costs. Total fixed costs (such as depreciation, insurance, fixed maintenance) per fuel cell bus per year.
- Variable Costs. All variable costs per kilometre but excluding fuel (fuel costs are calculated separately).
- H_2 Consumption. This is the fuel cell bus hydrogen consumption in kilograms per 100 kilometres.
- HRS loyalty answers the question 'Which percentage of all refuelling is done at this specific HRS?'. This percentage represents the share of this HRS in all refuellings per vehicle profile. This is 100% in most cases as (scheduled service) bus refuelling will mostly be done at refuelling stations owned or contracted by the bus operating company.
- CO_2, NO_X and PM. Enter the fuel bus CO_2, NO_X and PM emissions per kilometre. Verify that emission values are in line with the selected emission type (refer to paragraph 2.2.1).

Other Costs

The other costs category, marked by (37), contains two remaining cost items required to calculate the extra costs of fuel cell bus operations:

- Total Bus Driver Costs. Bus driver cost per hour is required to calculate bus redundancy costs.
- One-Off Costs. This is where non-recurring costs not yet covered by other input fields can be provided. For example: the costs of possible required infrastructural adjustments with respect to fuel cell bus operations.

Warnings and Error Panes

The Bus Input Module has three areas with information about its status:

- The Deactivation Warning Pane, marked by (38). If certain bus routes are deactivated this pane shows the notification that deactivated bus routes are not included in HIBIT calculations.
- The Bus Period Warning Pane, marked by (39). This pain shows a notification if some buses come in service after bus project expiration.
- The Worksheet Status Pane, marked by (41). The most common error reported in the status pane is related to capacity issues. For example, if the HRS maximum utilisation level is 100 kg/day and the maximum capacity for autonomous sales is 40 kg/day (refer to paragraph 2.2.2), HRS capacity for bus refuelling is 60 kg/day. If 80 kg/day capacity is required (based on data provided in the Bus Input Module), a capacity-related error notification appears. This error notification is also shown on the Dashboard worksheet.

3 Business Case Results

3.1 Key Output Data and Graphs

3.1.1 Key Output Data

The key output data section is marked by (15) on the Dashboard Overview on page 6.

Note: Reference figures are based on autonomous hydrogen sales only and do not include business case effects from bus project refuelling nor effects from FCEV demand aggregation.

Nominal IRR

First, select a period to which IRR and NPV calculations apply. The Internal Rate of Return (IRR) is the interest rate at which the net present value of all the HRS after tax cash flows (both positive and negative) equals zero. HIBIT calculates the after-tax IRR. IRR should ideally be equal to or higher than HRS capital costs. An IRR lower than the assumed capital costs means that the project does not produce enough cash to cover all costs, including capital costs. An IRR higher than the assumed capital costs means that the project produces (more than) enough cash to cover all costs, including capital costs. An IRR higher than the HRS capital costs alone does not necessarily mean that a project is bankable (refer to paragraph 3.4). The IRR cannot always be determined. For example, the IRR cannot be calculated if all cash flows are positive or negative or if cash flows are intermittently positive-negative. Please note that this simple IRR calculation is based on the following assumptions:

- future positive cash flows are reinvested against the same return as generated by the HRS operations;
- future negative cash flow are funded against a rate equal to the return generated by the HRS operations and not against the cost of capital.

Net Present Value (NPV)

NPV shows the present value of the HRS investment for the selected period, based on the expected revenues from that investment in future years minus project expenditure. The nominal target-IRR (refer to paragraph 2.2.1) is used as the NPV calculation discount factor.

A positive NPV indicates that the HRS Return on Investment (ROI) exceeds the HRS capital costs. A negative NPV means that HRS ROI is not enough to cover its capital costs. A positive NPV usually means that the project gets through to the next round of decision making. A positive NPV alone does not necessarily mean that a project is bankable (refer to paragraph 3.4).

Discounted Payback Period

The discounted payback period indicates the number of years it takes to break even in cash flow terms (including borrowing costs). For the following cases, the discounted payback period is not applicable ('n.a.'):

- The discounted payback period is longer than 30 years, or
- The discounted payback period cannot be calculated. This is the case for example if you have defined a support scheme including a 100% capital expenditure grant. In such cases the initial expenditure is zero and obviously a payback time cannot be determined.

Structural Profit After

This figure shows the number of years it takes the HRS operator to reach a level of structural profitability, meaning that HRS profits remain positive.

Fuel Cell Buses from Bus Project

This figure shows the number of fuel cell buses included in HIBIT calculations. This information is based on data provided in the Bus Input Module.

Demand Aggregation FCEVs, Target and Real

This figures show the target and real number of FCEVs, based on data provided in the FCEV Demand Aggregation Section (refer to paragraph 2.2.5) and in the Car Input Module (refer to paragraph 2.3).

Total Support Costs

This figure shows the total cost of the support schemes based on data provided in the support scheme input section and fuel cell bus project data. The 'Total Support Costs' graph, marked by (12), shows a breakdown of these support costs.

Maximum T-o-P Exposure

Total support costs include actual take-or-pay *payments* in case of HRS underperformance. This cell shows total take-or-pay *exposure*: the total sum of payments due in case the full take-or-pay guarantee becomes effective.

3.1.2 Key Graphs

HRS H2 Sales Volume Development

This graph is marked by (11) on the Dashboard Overview on page 6. It shows the sales volume development in kilograms per day. The grey curve is the autonomous reference curve, which is input provided in the Growth Curve Pattern section (refer to paragraph 2.2.2). The support

scheme 1 (pink), support scheme 2 (green) and support scheme 2 (blue) lines show the sales volume development including additional sales from bus project refuelling and demand aggregation.

Take-or-Pay Threshold volumes can be made visible for any support scheme when the corresponding 'T-o-P Threshold' box is ticked.

Total Support Costs

This graph is marked by (12) on the Dashboard Overview on page 6. It shows total support costs per support scheme and provides a cost breakdown in the following categories:

- Fuel Cell Bus Project. This is the total additional cost of fuel cell bus operations compared to reference bus operations (based on data provided in the Bus Input Module) during the fuel cell bus project period.
- Demand Aggregation. This is the total additional cost of FCEV deployment compared to reference vehicle deployment. The calculation is based on data provided in the FCEV Demand Aggregation section on the Dashboard worksheet and data provided in the Car Input Module.
- Demand Aggregation Penalties. If the number of real demand aggregation FCEVs is lower than the target number of FCEVs and if a demand aggregation underperformance penalties applies, this part of the graph shows the total applicable penalty volume. The key output data and ratios section, marked by (15) shows the underlying number of vehicles.
- Take-or-Pay Penalties. If the actual hydrogen sales volume falls below the agreed take-or-pay threshold, the penalty payments apply. This area shows the total amount of penalties during the support period, based on the forecasted sales levels versus the take-or-pay threshold.
- Performance Payments. This area shows the total amount of performance-based payments, assuming that all performance criteria are met. The total amount equals the provided annual performance-based payment multiplied by the total performance payment support period in years.
- CAPEX Grants. This area shows the total amount of capital expenditure grants. This amount equals the provided effective capital expenditure grant percentage multiplied by the total eligible capital expenditure.
- OPEX Grants. This area shows the total amount of operational expenditure grants. This amount equals the provided effective operational expenditure grant percentage multiplied by the total eligible operational expenditure during the support period.
- Soft Loans. If soft loans are provided at a below-market interest rate, this area shows the total discount value.

Emissions Reduction

This graph is marked by (13) on the Dashboard Overview on page 6. It shows total CO_2, NO_X and PM emissions reductions. The emissions reductions scope depend on which option in the 'SELECT VEHICLES' box is checked:

- Supported vehicles: only supported vehicles (from FCEV demand aggregation and the fuel cell bus project) are included. Reduction values are based on emission data provided in the Car Input Module (with respect to FCEV demand aggregation) and the Bus Input Module (with respect to fuel cell buses).
- All vehicles: all vehicles refuelling at the HRS are included. Reduction values are based on emission reduction values provided in the General Input Parameter section (refer to paragraph 2.2.1).

Note: The unit of measure can be adjusted for each emission type. You can use this feature to select your favourite unit of measure or to make sure all bars are clearly visible in this graph.

Earnings and Cash Flow Graph

This graph is marked by (17) on the Dashboard Overview on page 6. By clicking on one of the option buttons in the 'Select Graph' section, HIBIT shows one of the following graphs:

- Earnings Before Interest, Taxes, Depreciation and Amortisation (EBITDA): This is a measure of the HRS' ability to produce income on its operations in a given year. It is calculated as HRS' revenues less its operational expenses but not subtracting its tax liability, interest paid on debt, amortisation or depreciation. EBITDA is usually used by investors to compare operational profitability of projects without considering their differences in capital expenditure, funding structure or taxation. Investors usually require a positive EBITDA at all times as each HRS should produce enough income to at least cover its operating costs.
- Earnings Before Taxes (EBT): This is an indicator of the HRS financial performance calculated as total revenues minus total expenses, excluding tax. EBT is also an item of the HRS income statement that shows how much the company has earned in a year.
- Operating Cash Flow (OCF): This is a measure of the amount of cash generated by the HRS' normal business operations. It is calculated as total revenues minus operating costs minus interest expenditure minus changes in working capital. Investors usually require a positive OCF at all times. However, in the first years of operation OCF may be (slightly) negative as there may be no revenues yet while operating expenditure and interest have to be paid.
- Annual Free Cash Flow (FCF): This is a measure of how much cash a HRS generates after accounting for capital expenditure. Annual FCF is calculated by subtracting capital expenditure from OCF. Investors are interested in FCF development, as a positive FCF

means that the HRS has the capacity to pay out dividends, to reduce debts or to fund additional investments.

- Cumulative Free Cash Flow (Valley of Death): This is the total sum of annual FCFs. Cumulative FCF is usually shaped like a bathtub: after a period of negative FCFs (mainly as a result of required early revenues being lower than operating expenditure) the cumulative FCF line reaches a turning point and starts to move upward. In the year it crosses the zero-line all expenditure has been earned back (including borrowing costs). The lower the bottom of the bathtub and the longer it takes to cross the zero-line, the more risky the investment is usually considered to be.

Funding Sources and Application

This graph is marked by (16) on the Dashboard Overview on page 6. It shows, for each support scheme, which funding sources are available and how they are spent. The period considered is the maximum support scheme period (the largest support instrument period, based on period information in the support scheme parameter section). Funding application usually consists of capital expenditure and negative cash flows. Important funding sources are: capital expenditure grants (if provided), soft loans (if provided), available excess cash flow, share capital (refer to paragraph 2.2.1 under 'Share Capital') and regular loans. This graph helps investors to evaluate financial structure robustness per support scheme.

HRS Income Breakdown per Support Scheme

These graphs are marked by (18), (19) and (20) on the Dashboard Overview on page 6. They specify all sources of HRS income during its first 15 years of operation. These graphs can be used to evaluate the quality and robustness of HRS revenues. Revenues from hydrogen sales are considered to be more robust than revenues from grants.

3.2 Bus Output Module

The Bus Output Module can be accessed by clicking its tab in the area marked by (A) in figure 1 (page 10). Information in the Bus Output Module can be expanded (more information) or collapsed (fewer information) by clicking either + (expand) or − (collapse) anywhere in the left margin.

This module presents structured output information based on data input provided in the Fuel Cell Bus Project section (refer to paragraph 2.2.3) and in the Bus Input Module (refer to paragraph 2.4).

Impact on Costs Section

This section summarises the following data:

A. Total Fuel Cell Buses in Service: Total number of fuel cell buses in operation per year.

B. Total Fuel Cell Buses Mileage: Total mileage of all fuel cell buses in service.

C1. Total Fuel Cell Buses H_2 Consumption: This is the total hydrogen volume required to refuel all fuel cell buses in service.

C2. Total Fuel Cell Buses H_2 Consumption at Contracted HRS: This is the total hydrogen volume for bus refuelling, provided by the involved HRS. This is usually equal to the total fuel cell buses hydrogen consumption, unless HRS Loyalty is set at a lower percentage than 100%.

D. Total Fuel Cell Buses Vehicle and Fuel Costs: Total costs of fuel cell bus operations.

E. Total Reference Bus Vehicle and Fuel Costs: Total costs of reference bus operations.

F. Total Fuel Cell Bus Extra Vehicle and Fuel Costs: D minus E.

G. Total Costs of Extra Fill-Up Time: Total extra fill-up time required for all fuel cell buses in service, multiplied by the bus driver cost per hour.

H. Total Costs of Reference Bus Redundancy: Total costs for operating reference buses as an instant backup.

I. Total One-Off Costs: One-off costs provided in the Bus Input Module.

J. Total Extra Costs: All extra costs incurred by fuel cell bus operations compared to reference bus operations.

Emissions Reduction Section

This section shows CO_2 NO_X and PM emissions reduction from fuel cell bus operations compared to reference bus operations. Note: Emissions reduction may be negative during periods of reference bus redundancy. Emissions from redundant reference buses are included in emissions calculations.

3.3 Reference and Support Schemes Detailed Financial Information

Detailed financial information is available in the reference and support scheme worksheets, marked by (A) in figure 1 (page 10).

In each worksheet rows can be expanded (more information) or collapsed (fewer information) by clicking either + (expand) or − (collapse) anywhere in the left margin.

Key Data

The Key Data section provides information on the following volume levels:

- HRS Capacity: This number shows the available HRS refuelling capacity per year, based on HRS capacity input and investment phasing input.
- Reference H_2 Sales: The hydrogen reference sales level is equal to the autonomous sales level (without support scheme and bus project effects).
- H_2 Sales from Fuel Cell Bus Project: Shows the hydrogen sales volume generated by the refuelling of buses in the fuel cell bus project. These volumes are based on input provided in the Fuel Cell Bus Project section (refer to paragraph 2.2.3) and in the Bus Input Module (refer to paragraph 2.4).
- H_2 Sales from FCEV Aggregated Demand & After Effects (kg): Shows the total additional annual sales volumes from aggregated demand, including their after effects. These volumes are based on input provided in the demand aggregation section of each support scheme (refer to paragraph 2.2.5) and in the Car Input Module (refer to paragraph 2.3).
- Total H_2 Sales (kg): The sum of reference, bus project and aggregated demand sales.
- Demand Aggregation Vehicles: This section shows the number of target and real demand aggregation vehicles, based on input provided in the demand aggregation section of each support scheme (refer to paragraph 2.2.5) and in the Car Input Module (refer to paragraph 2.3). This section also shows FCEV vehicle underperformance in totals per year (total underperformance) and in unique vehicles per year (underperformance penalty level).
- H_2 Take-or-Pay Threshold: Shows the annual take-or-pay threshold: if total sales are below this threshold, take-or-pay penalty payments apply.
- H_2 Take-or-Pay Penalty Level: Shows the difference between the actual total sales volume and the threshold – this is the volume to which the penalty payment applies.
- Gas Volume: Shows the volume of gas used in case of steam methane reforming.
- Electricity Volume: Shows the total electricity volume required for HRS operations.

Profit and Loss Statement

This statement shows the HRS profits and losses, assuming that the HRS is a separate entity (more information in chapter 4). It specifies HRS revenue sources, operating costs, depreciation, interest costs and income tax.

Cash Flow Statement

This statement shows HRS cash flow in the following categories:

- Cash Flow from Operating Activities: This is cash flow from everyday HRS operations. It includes revenues, expenses, interest, taxation and changes in working capital.
- Cash Flow from Investing Activities: This part shows annual capital expenditure and capital expenditure grants.

- Cash Flow from Financing Activities: This part shows equity and debt contributions and repayments. It includes a soft loans overview, based on your soft loan input per support scheme (refer to paragraph 2.2.8).

Balance Sheet

The balance sheet is a specified annual statement of the HRS assets, liabilities and capital.

Support Cash Flow

This sections shows all cash flows related to support instruments.

Key Financial Ratios

Here you will find some of the ratios specified in the Key Output Figures and Ratios section of the Dashboard worksheet. Refer to paragraph 3.1.1.

Annual Financial Ratios

This section includes a number of financial ratios used by investors to evaluate a HRS business case. It includes ratios in the following categories:

- Rating: Includes ratios indicating operating results versus applied capital.
- Income Statement: Includes operating performance ratios.
- Financial Structure: Includes ratios indicating HRS financial health.
- Debt Service Capacity: Includes ratios indicating HRS capacity to pay interest and repay principle loans amounts.

Note: Annual financial ratios may appear as uncommon numbers in specific years as the HRS business case has not yet been sculpted or optimised. However, the total set of ratios should give you a good general impression of the HRS financial health.

Demand Aggregation Details

Scheme 1, 2 and 3 worksheets include a Demand Aggregation Details section. This section specifies all information related to demand aggregation, based on data provided in the demand aggregation section of each support scheme (refer to paragraph 2.2.5) and in the Car Input Module (refer to paragraph 2.3). It includes the following categories:

- Number of Vehicles per Reference Vehicle Type During Project Period: Shows the annual number of vehicles included in the demand aggregation group.
- H_2 Sales per Reference Vehicle Type During Project Period: Shows the hydrogen volume being sold per vehicle profile group (each vehicle profile is indicated by its reference vehicle).

- Cost Difference Reference Vehicle and FCEV: Shows the total cost difference amount between the reference vehicle and the FCEV per vehicle profile group.
- CO_2 Reduction per Reference Vehicle Type: Shows the total level of CO_2 reduction per vehicle profile group.
- NO_X Reduction per Reference Vehicle Type: Shows the total level of NO_x reduction per vehicle profile group.
- PM Reduction per Reference Vehicle Type: Shows the total level of PM reduction per vehicle profile group.

Total Emissions Reduction Details

Scheme 1, 2 and 3 worksheets include a Total Emissions Reduction Details section. This section specifies total CO_2, NO_X and PM reduction volumes:

- of all sponsored vehicles (bus project buses and demand aggregation FCEVs);
- of all autonomous vehicles;
- of all vehicles (sponsored and autonomous) refuelling at the involved HRS.

3.4 When is a HRS Business Case Bankable?

It requires an expert eye to evaluate HRS bankability. However, HIBIT provides key information giving a general insight into HRS bankability based on the following rules of thumb.

Internal Rate of Return (IRR)

When the total assets life period is considered, the project IRR is ideally equal to or higher than the target-IRR. However, during the scaling-up period of new business, project IRR may be lower than its target value, especially if focus is on the acquisition of a solid market position and market share.

Net Present Value

When the total assets life period is considered, the project NPV is ideally equal to or higher than zero. A negative NPV may be acceptable because of similar reasons as mentioned above.

Discounted Payback Period

The discounted payback period is ideally smaller than HRS assets life. In other words: the investment including borrowing costs should be earned back before asset replacement occurs. Most investors require a buffer, meaning that the discounted payback period should be at least a few years shorter than HRS asset life. Some investors additionally assume absolute payback time

limits, for example five or ten years. Such limits apply if investors consider HRS income beyond this time limit to be highly uncertain.

Demand Aggregation

Obviously, the number of vehicles required to meet required hydrogen sales from demand aggregation has to be realistic and manageable. If you have doubts about this required number you may have to reduce demand aggregation volumes and increase other support parameters to improve HRS business case bankability.

Financial Structure

Senior debt investors not only require sufficient cash flow, but also sufficient comfort from the HRS financial structure. Guarantee capital (equity + soft loans) serves as a buffer for debt investors. Therefore, debt investors usually require a minimum level of guarantee capital. The required level depends on HRS risk and could generally be anywhere between 10% and over 50%.

4 Assumptions and Functional Model Description

4.1 Introduction

HIBIT is a business case tool based on a project financing approach. This means that each HRS is considered as a separate legal entity with its own profit and loss statement, cash flow statement and balance sheet.

HIBIT isolates the HRS business case from the operator's operational manage, so that HRS performance can be evaluated independently from other activities.

4.2 Main Assumptions

Cash Flow Timing

All cash flows in a year are assumed to occur on 31 December. Balance sheet overviews also represent assets and liabilities on 31 December. There is one exception to this: initial phase 1 HRS investment takes place on 1 January, so that interest payments occurring during the HRS construction period are fully considered.

Dividends

If in any year total retained earnings are positive, HIBIT assumes dividend payments. Dividend payments are limited to the lowest value of available retained earnings and the level of excess cash.

Regular Loans

If in any year total available cash is less than total cash expenditure, HIBIT assumes regular loans to match the difference. In years where excess cash is available, HIBIT assumes repayment of these regular loans.

Tax Loss Carry-forward

In cases the HRS Legal Status is set as 'stand-alone', HIBIT assumes an unlimited tax loss carry-forward period. In other words: all tax losses can be deducted from future profits without any limitations.

4.3 Functional Model Description

Inflation

HIBIT performs all calculations in constant prices, meaning that inflation effects are not considered. Therefore HIBIT also uses real interest rates in its calculations, calculated as follows:

$$RI = \frac{(1+NI)}{(1+Infl)} - 1$$

with:

RI= Real Interest Rate,
NI = Nominal Interest Rate as provided by the user,
$Infl$ = Inflation Rate as provided by the user.

S-Curve Simulation

HIBIT contains one hidden worksheet: the Data Sheet. This worksheet contains the S-curve simulation calculations. This worksheet can be displayed by using the standard Microsoft Excel option 'unhide worksheet'. The S-curve resembles an accumulated normal distribution. The normal distribution reference curve is based on the following dummy values:

- X value range from -6 to +10,
- X value average equals 2,
- standard deviation equals 2,
- Z value range from -4 to +4.

Z values are equally distributed. The S-curve slope is determined by the user growth curve input (refer to paragraph 2.2.2 under 'Growth Curve Pattern'), using the following parameters:

- a 'very high' growth curve means that Z values are distributed across a 10-year period,
- a 'high' growth curve means that Z values are distributed across a 16-year period,
- a 'medium' growth curve means that Z values are distributed across a 23-year period,
- a 'low' growth curve means that Z values are distributed across a 33-year period,
- a 'very low' growth curve means that Z values are distributed across a 40-year period.

You can move the resulting distribution up to five years forward, meaning that the curve will start in year 1 at its original six-year value and will reach its maximum Z value five years earlier than originally indicated. You can also move the resulting distribution up to five years backwards, meaning that the curve will reach its maximum Z value five years later than originally indicated. Z values are calculated as follows:

$$Z_{(t)} = Z(min) + \frac{Z(max) - Z(min)}{n} \times t$$

with:

t = Any year between 0 and n

$Z_{(t)}$ = Z value in year t,

$Z(min)$ = Minimum Z value (=-4),

$Z(max)$ = Maximum Z value (=4),

n = Period corresponding with the selected growth curve period (10 to 40 years as indicated above).

Z values are translated into X values as follows:

$$X_t = \bar{X} + Z_t \times \sigma$$

with:

X_t = X value in year t,

$\bar{X}$ = Average X value (=2)

Z_t = Z value in year t as described above,

σ = Assumed standard deviation (=2).

X values are translated into a cumulative percentage distribution as follows:

$$F_{(x_t)} = \int_{-\infty}^{x_t} \frac{e - {x_t}^2/2}{\sqrt{2\pi}}$$

with:

$F_{(x_t)}$ = Cumulative percentage in year t,

x_t = X value in year t,

e = fundamental constant (=2.718281828459)

The cumulative percentage distribution is multiplied by the HRS commercial capacity, returning the HRS sales per year.

Calculations

HIBIT performs business case calculations using two items as the business case's 'valve':

- If in any year total available cash is less than total cash expenditure, HIBIT assumes regular loans to match the difference. In years where excess cash is available, HIBIT assumes repayment of these regular loans.
- If in any year total retained earnings are positive, HIBIT assumes dividend payments. Dividend payments are limited to the lowest value of available retained earnings and the level of excess cash.

This abovementioned method guarantees a balancing balance sheet at all times. However, HIBIT does not evaluate if additional regular loans are realistic; this is part of the user business case evaluation.

Appendices

A HRS Financial Support Instruments

Capital Expenditure Grants

CAPEX grants are the most common forms of HRS financial support at this time. CAPEX grants, usually one-off payments, reduce the HRS depreciation costs and external funding needs. CAPEX grants stimulate HRS development, not HRS use. Therefore, CAPEX grants are the best financial support option for establishing a basic HRS infrastructure in a period of limited FCEV availability.

Operational Expenditure Grants

OPEX grants cover fixed operational expenditure in periods of underutilisation. As is the case with CAPEX grants, OPEX grants are focused on bringing HRS operators' costs down rather than stimulating HRS revenues. This is most effective in periods of limited FCEV availability.

Performance-based Contracting

Performance-based contracting is a type of contracting where recurring payments are made in return for an agreed HRS performance level. The grant giver and HRS operator agree on a set of HRS performance criteria such as HRS back-to-back capacity, response times in case of HRS default, customer satisfaction et cetera. The certified HRS management system and customer surveys could be used for measuring performance. The HRS operator receives full payment if all performance criteria are met. Payment deductions apply in case of non-compliance. The system may also allow for bonus payments, for example if the HRS is compliant over a longer period or in case of outstanding customer satisfaction. Performance-based contracting stimulates HRS performance rather than just HRS availability and is a good alternative for CAPEX and OPEX grants, especially when utilisation rates increase. Scaling up HRS use may lead to technical performance issues. Performance-based payments are a funding source for the HRS operator while they offer the grant giver HRS performance certainty. Performance-based payment mechanisms are common practice in Design-Build-Finance-Maintain PPP projects, where public authorities pay contractors for infrastructure performance rather than just construction. In (road) infrastructure projects the term 'availability payment' is used, where 'availability' also includes performance criteria. Performance-based contracting requires more extensive contract management as performance has to be evaluated regularly, corresponding payment levels have to be set and possible disputes may need to be resolved.

Take-or-Pay Contracting

Take-or-Pay contracting is a contracting mechanism frequently used in situations that require large investments while there is only a small client base. The seller depends on just a few buyers to generate income to recover expenditure. Such business cases are usually not bankable without provisions that ensure a minimum level of revenues. HRS operators and their counterparty agree on realistic HRS sales volumes for a period of time. If sales fall below the

agreed volume, the counterparty will pay a penalty price per kilogram of hydrogen below the agreed level. The penalty price should at least cover fixed HRS expenditure. The HRS operator gets income certainty and the counterparty only has to pay if sales drop below the agreed level. The counterparty participates in the HRS risk. The risk is capped (to the agreed sales volume) and the counterparty will only pay if the risk occurs – which is different from a CAPEX grant where unrecoverable lump sum payments are made. Take-or-Pay contracting can be volume based, price based or both. Take-or-Pay contracting is an effective and efficient way to support HRS development in a period where FCEV volume growth is critical in the sense that HRS may become financially self-supporting unless FCEV volumes lag behind. Take-or-Pay contracts are not effective if the forecasted volume is low. In that case a CAPEX grant is a better alternative. Take-or-pay contracts have proved their value especially in energy projects with just one buyer.

Demand Aggregation

Demand aggregation shifts the focus from supporting HRS with grants to supporting FCEV procurement, leading to HRS revenues from actual HRS use. A demand aggregation strategy prevents the situation where HRSs burn money as a result of underutilisation. A key success factor in organising demand aggregation is local knowledge of user groups and car fleets that are potentially suitable to make the transition to FCEVs in the current situation with low HRS network coverage. Early private demand aggregation participation can be organised as follows:

- Identification of car fleet owners with a substantial fleet that is mainly used on a local/regional basis – preferably companies with a special interest in promoting themselves as green companies that care about the environment.
- Identification of potential early adopters: local regional drivers in the HRS area.

Soft Loans

The abovementioned HRS financial support tools are cash flow tools, leading to additional HRS income or reducing HRS expenditure. It is also possible to improve bankability by direct participation in the HRS funding. A soft loan is basically a loan on lenient terms and conditions compared to regular senior debt. Soft loans can improve bankability in two ways:

- their junior position[5] offers senior debt investors extra comfort which improves senior debt options and conditions;
- a lower interest rate provides 'cheap money', bringing debt service volumes down.

Soft loans are funding capital: the lender assumes interest payments and capital repayment.

[5] A junior position means that the loan has a lower repayment priority than other debts in the event of HRS financial default.

More information:
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