ETV Test Plan
SolarChill B for domestic and “light” commercial use series

DTI Refrigeration and Heat Pump Technology
J.no. 1101
Test no. 1 – Type-test

December 2010
EMJA

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2. Introduction

Environmental technology verification (ETV) is an independent (third party) assessment of the performance of a technology or a product for a specified application, under defined conditions and quality assurance.

DANETV is a Danish center for verification of environmental technology.

This test plan is the implementation of a test design developed for performance verification of an environmental technology following the ETV method.

2.1. Verification protocol reference

J.no 1101 – SolarChill B - Verification Protocol

2.2. Name and contact of vendor

SolarChill Project Coordinator, Mr. János Maté

Contact: 5106 Walden St., Vancouver, BC., Canada V5W 2V7
Phone: +1-604-325-0943, E-mail: jmate@telus.net

2.3. Name of centre/test responsible

Danish Technological Institute ,Verification Center, Refrigeration and Heat Pump Technology, building 2, Gregersensvej, DK-2630, Taastrup, Denmark.

Verification responsible: Emil Jacobsen (EMJA), e-mail: emil.jacobsen@teknologisk.dk, phone: +45 7220 2323

Internal reviewer: Bjarke Paaske, e-mail: bjarke.paaske@teknologisk.dk, Phone: +45 7220 2037

2.4. Expert group

The expert group assigned to this verification and responsible for review of the verification plan and report documents includes:

Preben Munter (PM), SEAS-NVE, phone +45 7029 2457, e-mail pm@seas-nve.dk

3. Test design

The testing of SolarChill B refrigerator is based two existing standards. The type-test is based on existing standard WHO/PQS/E03/RF05-VP.2 (20.05.2010), which is a standard for testing solar powered refrigerators and water-pack freezers without battery storage. The standard deal with performance, quality and safety, and includes tests for evidence of conformity, power consumption, day/night test, and the like.

As the above mentioned standard has been developed for verifying the performance vaccine coolers some alterations to the temperature requirements, test packages, and packing plan have been made. Changes to temperature are based on the existing European Standard EN ISO 15502 clause 6, changes to the test packages are made in accordance with clause 8.5, and changes to the packing plan are made in accordance with clause 13.3.

These alterations have been made to ensure the verification of proper food safety and hygiene, and relevance to the intended use of the product, which is refrigeration of perishable foods and drinks. EN ISO 15502 is a standard test of characteristics for household refrigerating cabinets.

Furthermore, to give a better idea of how the refrigerator will perform in an actual setting only being powered by a PV array, the voltage and current supplied from the PV array will be measured at the maximum power point at different solar radiation levels according to a solar radiation reference period. The measured voltage and current will then be the values used when the refrigerator is supplied by an external power supply during different performance related tests carried out in a climate chamber. Establishing the actual performance characteristics of the PV array prior to the tests in the climate chamber ensures that vendor claims are verified and that tests between different models and makes are comparable. Further information about the test can be found in appendix 4.

These above mentioned test are done in order to verify the following target and effect(s):

The target of the product is:

- Adequate cooling of refrigerated products using solar power only.

The effect of this application is primarily:

- Refrigeration of products without external power supply or batteries.

Secondarily the application will:

- Improve food safety and food hygiene in developing countries.
- Provide refrigeration technology to people with a need or wish to refrigerate food or drinks in parts of the world with no or unreliable electricity supply.
- Provide a more reliable, safer and cleaner form of refrigeration than kerosene refrigerators.
- Provide a refrigeration technology that is environmentally friendly as it does not use any ozone depleting or potent global warming substances.
- Improve on existing solar powered cooling technologies by bypassing the use of conventional lead batteries which have proven to be a major obstacle to the uptake of solar technology in developing countries.

The test method is described in appendix 4 – In-house test methods.

3.1. Test site

The performance tests are carried out in a climate chamber at the Danish Technological Institute in Taastrup.

3.2. Type of site

The climate chamber at DTI in Taastrup, Denmark is accredited for performance tests according to ISO 15502.

3.3. Addresses

The address of the site is:
Danish Technological Institute, Centre for Refrigeration & Heat Pump Technology,
Gregersensvej, DK-2630 Taastrup

3.4. Descriptions

The SolarChill B refrigerator series is characterized by appliances having well insulated cabinets with internal ice storage, and solar powered DC compressors without battery backup. The compressors are filled with a natural refrigerant. The ice storage is placed close to the evaporator, and has the function of a thermal energy storage.

At the moment the SolarChill B refrigerator series consists of a lineup of two different models, an upright type and a chest type, with the possibility of more to come in the future.

3.5. Tests

3.5.1. Test methods

The test method used is described in appendix 4 – In-house test methods.

3.5.2. Test staff

The test staff is:

Lene Klemgaard	Sampling and reporting
Hans Walløe	Head of laboratory

3.5.3. Test schedule

Task	Timing
Application definition document	Oct. 2010
Verification protocol with test plan	Oct. / Nov. 2010
Test	Jan. 2011
Test reporting	Jan. 2011
Verification	Feb. 2011
Verification report	Feb. 2011
Verification statement	Feb. 2011

3.5.4. Test equipment

The test equipment includes:

Climate chamber

- Temperature sensor for ambient air
- Humidity sensor for ambient air

Refrigerator

- M-packets according to ISO 15502

PV array

- UI-curve tracer
- Thermocouple, or a UI-curve tracer reference cell with internal temperature measurement.

All data are collected via a humidity sensor, thermocouples and data acquisition unit(s).

3.5.5. Operation conditions

During operation the refrigerator is adjusted to the following settings:

Temperature

- The target temperature is the warmest permissible storage temperature of each compartment, according to Table 1. The thermostat should thus be set so that the target temperature *in the warmest* compartment is within a tolerance of -2 K / + 0 K.

Table 1 Storage temperature limits

Compartment	Fresh-food		Chill	Cellar
Temperature alias	t_{1m}, t_{2m}, t_{3m}	t_{ma}	t_{cc}	t_{cm}
Target temperature [°C]	$0 \leq t_{1m}, t_{2m}, t_{3m} \leq 8$	≤ 4	$-2 \leq t_{cm} \leq 3$	$8 \leq t_{cm} \leq 14$

3.5.6. Operation measurements

The system is operated under various conditions before the performance test to assure that everything is working correctly. Data collection from all measuring equipment is evaluated to check that the system is running as planned.

3.5.7. Test matrix

The methods described in appendix 4 (In-house test methods) and appendix 5 (In house data processing) is followed during the test.

3.5.8. Product maintenance

No maintenance is required for testing the product.

3.5.9. Health, safety and wastes

The use of this product does not imply special health, safety and waste issues. Work during testing will comply with the general rules regarding safety at DTI.

4. Reference analysis

4.1. Analytical laboratory

No external analytical laboratories are used for this verification process. All measuring and data processing are executed by the DTI test staff.

The test sub-body is responsible that:

- The performance test is carried out according to the test plan
- Data processing is carried out according to the methods described in the test plan
- Adequate internal reviews are performed on both test setup and data processing
- All procedures are carried out according to the Centre Quality Manual

4.2. Analytical parameters

The parameters processed to verify the effect of the product are:

PV array:

- Voltages, U_{Pmax}, at maximum power points
- Currents, I_{Pmax}, at maximum power points

Refrigerator:

- Temperatures of M-packages

Furthermore the temperature and relative humidity of the ambient air in the climate chamber are logged throughout the tests in order to assure that conditions are stable during the entire test period.

4.3. Analytical methods

Data related to performance characteristics are processed according to ISO 15502.

Data related to the performance of the PV array are processed according to the description in appendix 5 – In-house data processing.

4.4. Analytical performance requirements

A specially designed Excel spreadsheet is used to calculate the performance from the measured parameters related to the PV array. As data are copied between several files, thorough reviews are performed as described in appendix 5.

5. Data management

5.1. Data storage, transfer and control

The data to be compiled and stored are summarized in table below. Analytical raw data are filed and archived according to the specifications of the quality management system.

Data type	Data media	Data recorder	Data recording time	Data storage
Test plan and report	Protected PDF-Files	Test responsible	When approved	Files and archives at TI
Log files	In-house file format	Technician, TI	During collection	Files and archives at TI
Calculations	In-house application / excel file	Test responsible	During calculation	Files and archives at TI
Final result and verification report	Protected PDF-files	Test responsible	After testing	Files and archives at TI

6. Quality assurance

6.1. Test plan review

Internal review of the test plan is done by BJPA
External review of the test plan is described in 1.4

6.2. Performance control

The appliance is tested for functioning thoroughly before the verification tests are initiated.

6.3. Test system control

Test and measuring equipment is checked against references or calibrated to ensure accurate values as described in appendix 4 – In-house test methods. This is done prior to testing and no intermediate check or calibration is necessary throughout the test period.

6.4. Data integrity check procedures

All transfer of data both handwritten and electronic, is subjected to 100 % control by another person.

Approved spread sheets and calculation programs for calculation of results is subjected to 100 % control to assure correct calculations and results.

Data input in spread sheets and calculation programmes is subjected to 100 % control, in order to secure correct calculations and results.

6.5. Test system audits

No audit is performed

6.6. Test report review

Internal review of the test report was done by BJPA
External review of the test report was done by the expert stated in chapter 1.4.

7. Test report

The test report will be included as an appendix in the verification report. The test report will contain the test plan except for this chapter 7 which will be replaced by a Test result chapter according to the DANETV Centre Quality Manual, including 7.1 Test performance summary, 7.2 Test measurement summary, 7.3 Test quality assurance and 7.4 Deviations from test plan.

Appendix 1 Terms and definitions used in the verification protocol

Terms and definitions used in the protocol are explained in Table 1:

Table 1 - Terms and definitions used by the DANETV test centers

Word	**DANETV**	**Comments on the DANETV approach**
Analytical laboratory	Independent analytical laboratory used to analyse test samples	The test center may use an analytical laboratory as subcontractor
Application	The use of a product specified with respect to matrix, target, effect and limitations	The application must be defined with a precision that allows the user of a product verification to judge whether his needs are comparable to the verification conditions
DANETV	Danish center for verification of environmental technologies	None
(DANETV) test center	Preliminary name for the verification bodies in DANETV with a verification and a test sub-body	Name will be changed, when the final nomenclature in the EU ETV has been set.
Effect	The way the target is affected	The effect could be reduced energy consumption, better cooling performance etc.
(Environmental) product	Ready to market or prototype stage product, process, system or service based upon an environmental technology	The product is the item produced and sold and thus the item that a vendor submit for verification
Environmental technology	The practical application of knowledge in the environmental area	The term technology is covering a variety of products, processes, systems and services.
Evaluation	Evaluation of test data for a technology product for performance and data quality	None
Experts	Independent persons qualified on a technology in verification	These experts may be technical experts, QA experts for other

Word	DANETV	Comments on the DANETV approach
		ETV systems or regulatory experts
Matrix	The type of material that the product is intended for	Matrices could be cooling systems, cabinets, heat exchangers etc.
Method	Generic document that provides rules, guidelines or characteristics for tests or analysis	An in-house method may be used in the absence of a standard, if prepared in compliance with the format and contents required for standards.
Performance claim	The effects foreseen by the vendor on the target (s) in the matrix of intended use	None
Performance parameters	Parameters that can be documented quantitatively in tests and that provide the relevant information on the performance of an environmental technology product	The performance parameters must be established considering the application(s) of the product, the requirements of society (regulations), customers (needs) and vendor claims
Procedure	Detailed description of the use of a standard or a method within one body	The procedure specifies implementing a standard or a method in terms of e.g.: equipment used
Producer	The party producing the product	None
Standard	Generic document established by consensus and approved by a recognized standardization body that provides rules, guidelines or characteristics for tests or analysis	None
Target	The property that is affected by the product	Targets could be temperature [° C], energy [kWh] etc.
Test center, test sub-body	Sub-body of the test center that plans and performs test	None
Test center, verification sub-body	Sub-body of the test center that plans and performs the verification	None

Word	DANETV	Comments on the DANETV approach
Test/testing	Determination of the performance of a product for parameters defined for the application	None
Vendor	The party delivering the product to the customer	Can be the producer
Verification	Evaluation of product performance parameters for a specified application under defined conditions and adequate quality assurance	None

Appendix 2 References (verification protocols, requirement documents, standards, methods)

1. DANETV. Center Quality Manual, 2008

2. European Parliament and Council. Directive 2006/42/EC of the 17th May 2006 on machinery and amending Directive 95/16/EC (recast).

3. European Council: Directive 89/655/EEC of 30 November 1989 concerning the minimum safety and health requirements for the use of work equipment by workers at work (amended 2007/30/EC).

4. ISO 12100-2:2003: Safety of machinery - Basic concepts, general principles for design - Part 2: Technical principles

5. WHO/PQS/E03/RF05-VP.2 (20.05.2010) – Refrigerator or combined refrigerator and water-pack freezer:compression-cycle. Solar direct drive without battery storage.

6. European Standard EN ISO 15502 – Household refrigerating appliances

7. Measurement protocol for energy reductions in Refrigerated display cabinets for ETV tests at DANETV

Appendix 3 Application and performance parameter definitions

This appendix defines the application and the relevant performance parameters application as input for verification and test of an environmental technology following the DANETV method.

A3.1 Applications

A3.1.1 Matrix/matrices

- Food and drinks

A3.1.2 Target(s)

The target of the product is:

- Adequate cooling of refrigerated products using solar power only with no battery storage

A3.1.3 Effects

The effect of this application is primarily:

- Refrigeration of products without external power supply or batteries.

Secondarily the application will:

- Improve food safety and food hygiene in developing countries.
- Provide refrigeration technology to people with a need or wish to refrigerate food or drinks in parts of the world with no or unreliable electricity supply.
- Provide a more reliable, safer and cleaner form of refrigeration than kerosene refrigerators.
- Provide a refrigeration technology that is environmentally friendly as it does not use any ozone depleting or potent global warming substances.
- Improve on existing solar powered cooling technologies by bypassing the use of conventional lead batteries which have proven to be a major obstacle to the uptake of solar technology in developing countries.

Appendix 4 In-house test methods

The type-test is based on existing standard WHO/PQS/E03/RF05-VP.2 (20.05.2010), which is a standard for testing solar powered refrigerators and water-pack freezers without battery storage. The standard deal with performance, quality and safety, and includes tests for evidence of conformity, power consumption, day/night test, and the like.

As the above mentioned standard has been developed for verifying the performance vaccine coolers some alterations to the temperature requirements, test packages, and packing plan have been made. Changes to temperature are based on the existing European Standard EN ISO 15502 clause 6, changes to the test packages are made in accordance with clause 8.5, and changes to the packing plan are made in accordance with clause 13.3.

These alterations have been made to ensure the verification of proper food safety and hygiene, and relevance to the intended use of the product, which is refrigeration of perishable foods and drinks. EN ISO 15502 is a standard test of characteristics for household refrigerating cabinets.

Furthermore, to give a better idea of how the refrigerator will perform in an actual setting only being powered by a PV array, the voltage and current supplied from the PV array will be measured at the maximum power point at different solar radiation levels according to a solar radiation reference period. The measured voltage and current will then be the values used when the refrigerator is supplied by an external power supply during different performance related tests carried out in a climate chamber. Establishing the actual performance characteristics of the PV array prior to the tests in the climate chamber ensures that vendor claims are verified and that tests between different models and makes are comparable.

The solar reference periods used during the test of the PV array and the refrigerator performance tests is based on existing standard IEC 62124, which is a standard PV system design verification. The reference periods that can be used during testing are as follows:

1 kWh/m^2/day reference period

5 hours at 200 w/m^2
19 hours at 0 w/m^2

Table 2 Low solar radiation reference period

3.5 kWh/m^2/day reference period

1 hour at 50 w/m^2
2.5 hours at 250 w/m^2
0.5 hours at 350 w/m^2
4 hours at 450 w/m^2
0.5 hours at 350 w/m^2
2.5 hours at 250 w/m^2
1 hour at 50 w/m^2
12 hours at 0 w/m^2

Table 3 medium solar radiation reference period

6 kWh/m^2/day reference period

1 hour at 100 w/m^2
3 hours at 500 w/m^2
4 hours at 700 w/m^2
3 hours at 500 w/m^2
1 hour at 100 w/m^2
12 hours at 0 w/m^2

Table 4 high solar radiation reference period

Type-testing procedure

The following tests are to be carried out by an independent ISO 17025 testing laboratory. One sample of the appliance to be tested is required for testing.

The specific tests listed below apply equally to moderate zone, temperate zone and hot zone appliances. Relevant test chamber temperatures are given in the following format; M: 25ºC for moderate zone, T: 32ºC for temperate zone and H: 43ºC for hot zone. The humidity in the test chamber during the tests should be between 45 – 75 % RH.

All refrigerator temperature and power measurements are done with readings and accuracy according to ISO 15502.

Before starting the tests it is secured that all measuring equipment complies with the accuracy specified by ISO 15502. All sensors and meters are either calibrated or checked against calibrated equipment.

Before the performance tests of the appliance the appropriate thermostat setting should be found in order to reach the target temperature. The target temperature is the warmest permissible storage temperature of each compartment, according to Table 5. The thermostat should thus be set so that the target temperature *in the warmest* compartment is within a tolerance of -2 K / + 0 K.

Compartment	Fresh-food		Chill	Cellar
Temperature alias	t_{1m}, t_{2m}, t_{3m}	t_{ma}	t_{cc}	t_{cm}
Target temperature [°C]	$0 \leq t_{1m}, t_{2m}, t_{3m} \leq 8$	≤ 4	$-2 \leq t_{cm} \leq 3$	$8 \leq t_{cm} \leq 14$

Table 5 Storage temperature limits

During the various performance tests of the appliance, the appliance is to be powered in accordance with a current and voltage equal to the average values which are measured and calculated during test 2 (PV array performance test) .

Furthermore, during test 2 (PV array performance test) the module temperature shall be monitored and recorded with either:

1. A thermocouple securely fastened to the backside of the module or
2. An UI-curve tracer reference cell with internal temperature measurement.

NOTE. It is prerequisite that if the PV array used during testing is prone to initial degradation, it must be subjected to light soaking according to IEC 61215 / IEC 61646. (In example, amorphous silicon photovoltaic cells show an initial reduction of maximum power of up to 20 % within the first 6 months)

Test 1: Type-examination
Type-examination is carried out as follows:

Step 1: Unpack the product. Using the manufacturer's installation instructions only, set up the system components. Record any problems encountered.

Step 2: Check for similarities with previously tested products to ensure a re-badged version of an identical product is not tested. Also ensure to inspect the product for any defects, damage, or problems which make it difficult or impossible to test the product.

Step 3: Tabulate the following information for the appliance being examined.

Identification:

- Model
- Legal manufacturer or reseller
- Product type
- Country of origin
- Conformity assessment markings
- Temperature rating against which the appliance is to be tested.

Interface requirements:

- The terminals where the PV array is to be connected to the refrigerator should be clearly indicated and marked with polarity.

- No special tools should be required for assembling of the different parts of the system. (Preferably an adjustable spanner and a slotted screwdriver would be sufficient).

- All terminals and connections should be adequately electrically isolated.

Materials:

- The refrigerant should be a natural refrigerant. No fluorocarbon refrigerants are accepted in SolarChill technology.

- The thermal insulation foaming agent should comply with the limitations set by the Montreal Protocol on the elimination of ozone-depleting materials. No fluorocarbon gasses are allowed.

- The refrigerator, PV array or any other component should not contain lead (except in PV cell solderings), mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) or polybrominated biphenyl ethers (PBDE)

Instructions for users:

- User and maintenance instructions should cover the following topics:

    - Installation procedures
    - Basic guidelines for food storage, shelf life, and hygiene.
    - Simple daily, weekly, and monthly maintenance tasks
    - Periodic preventative maintenance checks
    - Diagnostic and repair procedures
    - Itemized list of spare parts including part numbers
    - End-of-life resource recovery and recycling procedures

The instructions are to be written for users and repair technicians in English as well as the native language where the product is to be sold. Preferably the manual should be elaborated with pictograms and/or pictures enabling a vast majority of intended users to comprehend the above listed topics.

Acceptance criteria:

Inspection indicates full conformity with all major specification requirements as outlined in step 3 of this test. Setup must be straightforward and trouble-free.

Test 2: PV array performance test
The PV array performance test for the different reference periods are carried out as follows:

1 kWh/m^2/day reference period

Step 1: Set up and prepare the PV array making sure that no shadows are affecting any part of the PV array. Also prepare the UI-curve tracer. The cell temperature shall also be recorded with a thermocouple mounted securely on the backside of the cell, or with a reference cell (with build-in temperature sensor) placed co-planar to the tilt-angle +/- 5°.

Step 2: Measure the voltage (U_{Pmax}) and current (I_{Pmax}) at the maximum power point at a solar radiation level above and below the different level(s) listed in Table 2. Also record the approximate average cell temperature during each measured level.

Note!
This measurement is not to be made at radiation level 0 w/m^2. The actual solar radiation level where each measurement is made may differ up to + or - 50 w/m^2 for each reference level being measured. For example, if U_{Pmax} and I_{Pmax} is to be measured at a reference radiation level of 500

w/m^2, the actual measurements can be made at the intervals; below E ∈ [450 w/m^2; 500 w/m^2], and above E ∈ [500 w/m^2; 550 w/m^2]

Step 3: Repeat step 2 once for each radiation level listed in Table 2.

Step 4: Record all measured values in the Excel file which has been prepared in advance, and calculate the averages as outlined in appendix 5 (In-house data processing)

3.5 kWh/m^2/day reference period

Step 1: Set up and prepare the PV array making sure that no shadows are affecting any part of the PV array. Also prepare the UI-curve tracer making sure that the reference irradiance cell used is placed co-planer to the PV array within +/- 5° of the tilt angle.

Step 2: Measure the voltage (U_{Pmax}) and current (I_{Pmax}) at the maximum power point at a solar radiation level above and below the different level(s) listed in Table 3. Also record the approximate cell temperature during each measured level.

Note!
This measurement is not to be made at radiation level 0 w/m^2. The actual solar radiation level where each measurement is made may differ up to + or - 50 w/m^2 for each reference level being measured. For example, if U_{Pmax} and I_{Pmax} is to be measured at a reference radiation level of 500 w/m^2, the actual measurements can be made at the intervals; below E ∈ [450 w/m^2; 500 w/m^2], and above E ∈ [500 w/m^2; 550 w/m^2]

Step 3: Repeat step 2 once for each radiation level listed in Table 3.

Step 4: Record all measured values in the Excel file which has been prepared in advance, and calculate the averages as outlined in appendix 5 (In-house data processing)

6kWh/m^2/day reference period

Step 1: Set up and prepare the PV array making sure that no shadows are affecting any part of the PV array. Also prepare the UI-curve tracer making sure that the reference irradiance cell used is placed co-planer to the PV array within +/- 5° of the tilt angle.

Step 2: Measure the voltage (U_{Pmax}) and current (I_{Pmax}) at the maximum power point at a solar radiation level above and below the different level(s) listed in Table 4. Also record the approximate cell temperature during each measured level.

Note!
This measurement is not to be made at a solar radiation level of 0 w/m^2. The actual solar radiation level where each measurement is made may differ up to + or - 50 w/m^2 for each

reference level being measured. For example, if U_{Pmax} and I_{Pmax} is to be measured at a reference radiation level of 500 w/m^2, the actual measurements can be made at the intervals; below E ∈ [450 w/m^2; 500 w/m^2], and above E ∈ [500 w/m^2; 550 w/m^2]

Step 3: Repeat step 2 once for each radiation level listed in Table 4.

Step 4: Record all measured values for irradiation and corresponding voltages (U_{Pmax}) and currents (I_{Pmax}) at the different maximum power points in the Excel file which has been prepared in advance, and calculate the averages as outlined in appendix 5 (In-house data processing)

Acceptance criteria:

No acceptance criteria have been set. STC values from the manufacturer data sheet should match the STC values measured during testing. If these values do not match it should be reported in the test summary of the test report.

Test 3: Stable running test
Stable running and power consumption test is carried out as follows:

Step 1: Set the test chamber temperature to the relevant temperature; M: +25ºC, T: +32ºC or H: + 43ºC.

Step 2: Pack the appliance with test packages and M-packages. Load the appliance in such a way that all designated compartments (fresh-food, cellar compartment, or chill compartment) contain a loading equal to the principles outlined in ISO 15502 clause 13.3.1[1] as seen in Table 6. The test packages should be evenly distributed on the loading surfaces in each compartment and the M-packages should be placed according to the principles outlined in ISO 15502 clause 13.3.2.7 and figure 17. The test packages and M-packages used should be prepared in accordance with ISO 15502 clause 8.5.

Storage volume, V, of chill / fresh-food / cellar compartment [l]	No. of packages (500 g)
V < 10	2
10 ≤ V ≤ 20	3
20 ≤ V ≤ 30	4
30 ≤ V ≤ 40	5
…	…

Table 6 chill / fresh-food / cellar compartment storage load

[1] Where necessary replace the word “chill” with “fresh-food” or “cellar”. If any designated compartment has a storage volume larger than 80 l there should be placed one additional 500 g test package for each additional 10 l of storage volume.

Step 3: Turn on the appliance, adjust the thermostat so that the target temperature *in the warmest* compartment is within a tolerance of -2 K / + 0 K according to Table 5, and close the lid or door of the appliance and leave it to stabilize and reach a state where the compressor is cycling due to thermostat regulation.

Step 4: After temperature stabilization has occurred record the temperatures every minute for 24 hours. During this period also measure the power consumption and determine the compressor duty cycle. The compressor duty cycle should be measured from the ends of two cycles approximately 24 hours apart. Calculate and report the percentage "on" time over this period, report the power consumption in kWh/day and report the solar power profile used during the test.

Acceptance criteria:

Temperatures measured in all of the M-packages that are within the ranges specified in ISO 15502 clause 6.

Test 4: Holdover time
The holdover time test is carried out as follows:

Step 1: Set the test chamber temperature to the relevant temperature; M: +25ºC, T: +32ºC or H: + 43ºC.

Step 2: Make sure that all M-packages and test packages in the appliance are placed as outlined in step 3 of test 2 (stable running and power consumption)

Step 3: Turn the appliance on and close the lid or door of the appliance and leave it to stabilize and reach a state where the compressor is cycling due to thermostat regulation. (Adjustment to the thermostat should not be necessary)

Step 4: After temperature stabilization has occurred switch off the power supply at the end of the last compressor ON cycle immediately before the 0 w/m^2 period of the cycle. If the compressor already cycled off at this point record the elapsed time since the end of the previous compressor-on cycle (t).

Step 5: Monitor the temperature of the M-packages. At the moment when the upper temperature limit[2] of any M-package in any compartment has been exceeded by 4 K, record the elapsed time since switch off and add this to the value (t) recorded in step 4. Record the position of the first M-package exceeding the temperature limit by 4 K.

Acceptance criteria:

A minimum holdover time (t) of 18 hours.

[2] See ISO 15503 clause 6

Test 5: Half reload test
The half reload test is carried out as follows:

Step 1: Set the test chamber temperature to the relevant temperature; M: +25°C, T: +32°C or H: + 43°C.

Step 2: Unload M-packages and test packages corresponding to a resulting loading which is equal to 50% of the loading outlined in step 3 of test 2 (stable running and power consumption). Place the unloaded M-packages and test packages in the test chamber to acclimatize to test chamber temperature.

Step 3: Turn the appliance on and close the lid or door of the appliance and leave it to stabilize and reach a state where the compressor is cycling due to thermostat regulation.

Step 4: At the end of the last compressor ON cycle immediately before the 0 w/m^2 period of the cycle reload the acclimatized M-packages and test packages and monitor the temperature for the next 12 hours.

Acceptance criteria:

A temperature of all M-packages below 10°C within 12 hours.

Appendix 5 In-house data processing

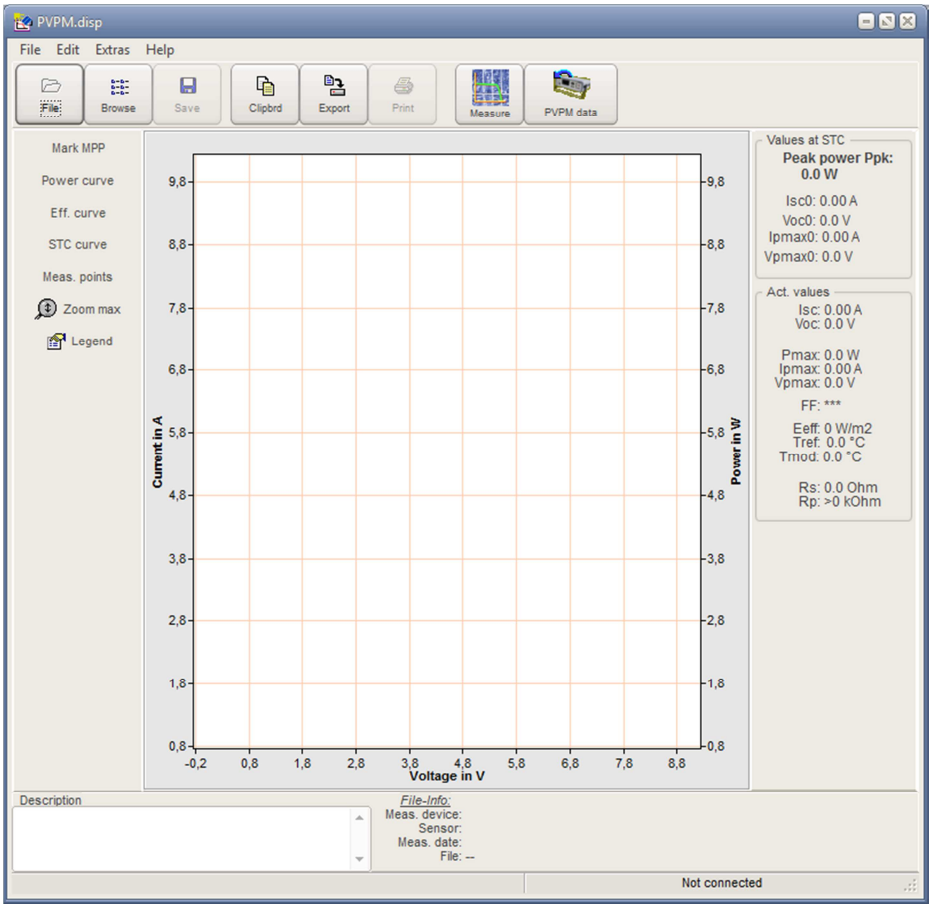
Data processing

PV array performance test

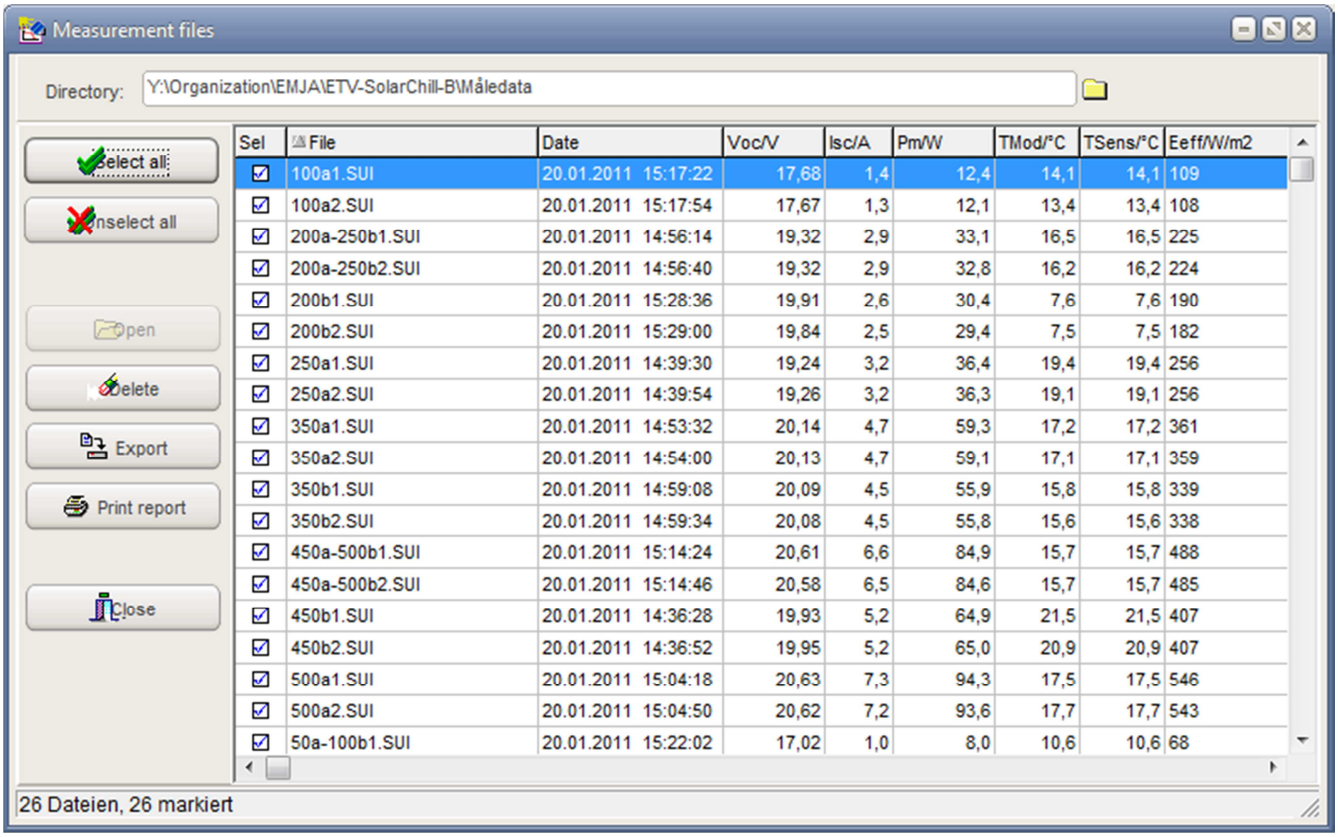
UI-curve tracer files
Data from the UI-curve tracer are in the .SUI file format. Measurements made for each radiation level in a given solar reference period are measured and automatically stored and named in the internal memory of the UI-curve tracer, after the time the measurement has taken place, in the following format: [<DD>-<MM>-<YYYY> <hh>_<mm>_<ss>].

Each file is uploaded and opened via the program PVPM.disp. When uploading data from the UI-curve tracer each filename should be renamed to the following format for future reference: [<radiation level><X><series number>] where X denotes ‘a’ for above and ‘b’ for below the target radiance level. *In example, a file containing data from the first measurement series below a target reference level of 100W should be named: “100b1”*

Using the “File” button located in the upper left corner of the PVPM.disp program (Figur 1) check all the .SUI files containing data and click the “Print report” button (Figur 2). Sort the reports in ascending order and prepare for manual input in the Excel spread sheet.



Figur 1 The PVPM.disp main program with "file" botton located in upper left corner



Sel	File	Date	Voc/V	Isc/A	Pm/W	TMod/°C	TSens/°C	Eeff/W/m2
☑	100a1.SUI	20.01.2011 15:17:22	17,68	1,4	12,4	14,1	14,1	109
☑	100a2.SUI	20.01.2011 15:17:54	17,67	1,3	12,1	13,4	13,4	108
☑	200a-250b1.SUI	20.01.2011 14:56:14	19,32	2,9	33,1	16,5	16,5	225
☑	200a-250b2.SUI	20.01.2011 14:56:40	19,32	2,9	32,8	16,2	16,2	224
☑	200b1.SUI	20.01.2011 15:28:36	19,91	2,6	30,4	7,6	7,6	190
☑	200b2.SUI	20.01.2011 15:29:00	19,84	2,5	29,4	7,5	7,5	182
☑	250a1.SUI	20.01.2011 14:39:30	19,24	3,2	36,4	19,4	19,4	256
☑	250a2.SUI	20.01.2011 14:39:54	19,26	3,2	36,3	19,1	19,1	256
☑	350a1.SUI	20.01.2011 14:53:32	20,14	4,7	59,3	17,2	17,2	361
☑	350a2.SUI	20.01.2011 14:54:00	20,13	4,7	59,1	17,1	17,1	359
☑	350b1.SUI	20.01.2011 14:59:08	20,09	4,5	55,9	15,8	15,8	339
☑	350b2.SUI	20.01.2011 14:59:34	20,08	4,5	55,8	15,6	15,6	338
☑	450a-500b1.SUI	20.01.2011 15:14:24	20,61	6,6	84,9	15,7	15,7	488
☑	450a-500b2.SUI	20.01.2011 15:14:46	20,58	6,5	84,6	15,7	15,7	485
☑	450b1.SUI	20.01.2011 14:36:28	19,93	5,2	64,9	21,5	21,5	407
☑	450b2.SUI	20.01.2011 14:36:52	19,95	5,2	65,0	20,9	20,9	407
☑	500a1.SUI	20.01.2011 15:04:18	20,63	7,3	94,3	17,5	17,5	546
☑	500a2.SUI	20.01.2011 15:04:50	20,62	7,2	93,6	17,7	17,7	543
☑	50a-100b1.SUI	20.01.2011 15:22:02	17,02	1,0	8,0	10,6	10,6	68

Figur 2 PVPM.disp sub program with bottons for selecting files and printing reports (left side of figure)

Excel file
All data related to the PV array performance test is processed via a basic Excel spread sheet prepared in advance. Copies of the Excel spreadsheet are created for each appliance that is tested. The Excel spread sheet of a given appliance is named "ETV SolarChill B – <*make and model*>" (where "make and model" respectively is the manufacturer and the model number or name)

Thermal characteristics, related to the PV cells, used in the calculation of simulation values are obtained from a manufacturer data sheet and inserted in cell H10 – H12. If no thermal characteristics are available or obtainable the following standard values are used: NOCT = 50 °C, U_{OC} = -0.4 %/K, and I_{SC} = 0.05 %/K.

1 kWh/m^2/day reference period
Data from each UI-curve tracer report is filled into the corresponding green input cells B10 - B13 & C10 - C13 (measurement series 1) and B18 - B21 & C18 - C21 (measurement series 2)

Data for use in solar simulation, test 3-5, are generated in blue output cells C25 - C26

3.5 kWh/m^2/day reference period
Data from each UI-curve tracer report is filled into the corresponding green input cells B32 - B35 & C32 – C35 & … & I32 - I35 (measurement series 1) and B40 – B43 & C40 – C43 & … & I40 – I43 (measurement series 2)

Data for use in solar simulation, test 3-5, are generated in blue output cells C47 – C48 & E47 – E48 & G47 – G48 & I47 – I48

6 kWh/m^2/day reference period
Data from each UI-curve tracer report is filled into the corresponding green input cells B54 – B57 & C54 – C57 & … & G54 – G57 (measurement series 1) and B62 – B65 & C62 – C65 & … & G62 – G65 (measurement series 2)

Data for use in solar simulation, test 3-5, are generated in blue output cells C69 – C70 & E69 – E70 & G69 – G70

KFS report generator files
All temperatures, times, and energy usage data, related to the performance of the appliance are collected by the means of in-house software “KFS report generator” and stored as .txt files on a local laboratory hard drive.
Files are opened using the “KFS report generator” program and temperature and energy curves can either be viewed in the programme or printed as diagrams containing a time axis.

The data processing procedure is visualized in Figure 1 at the end of this appendix.

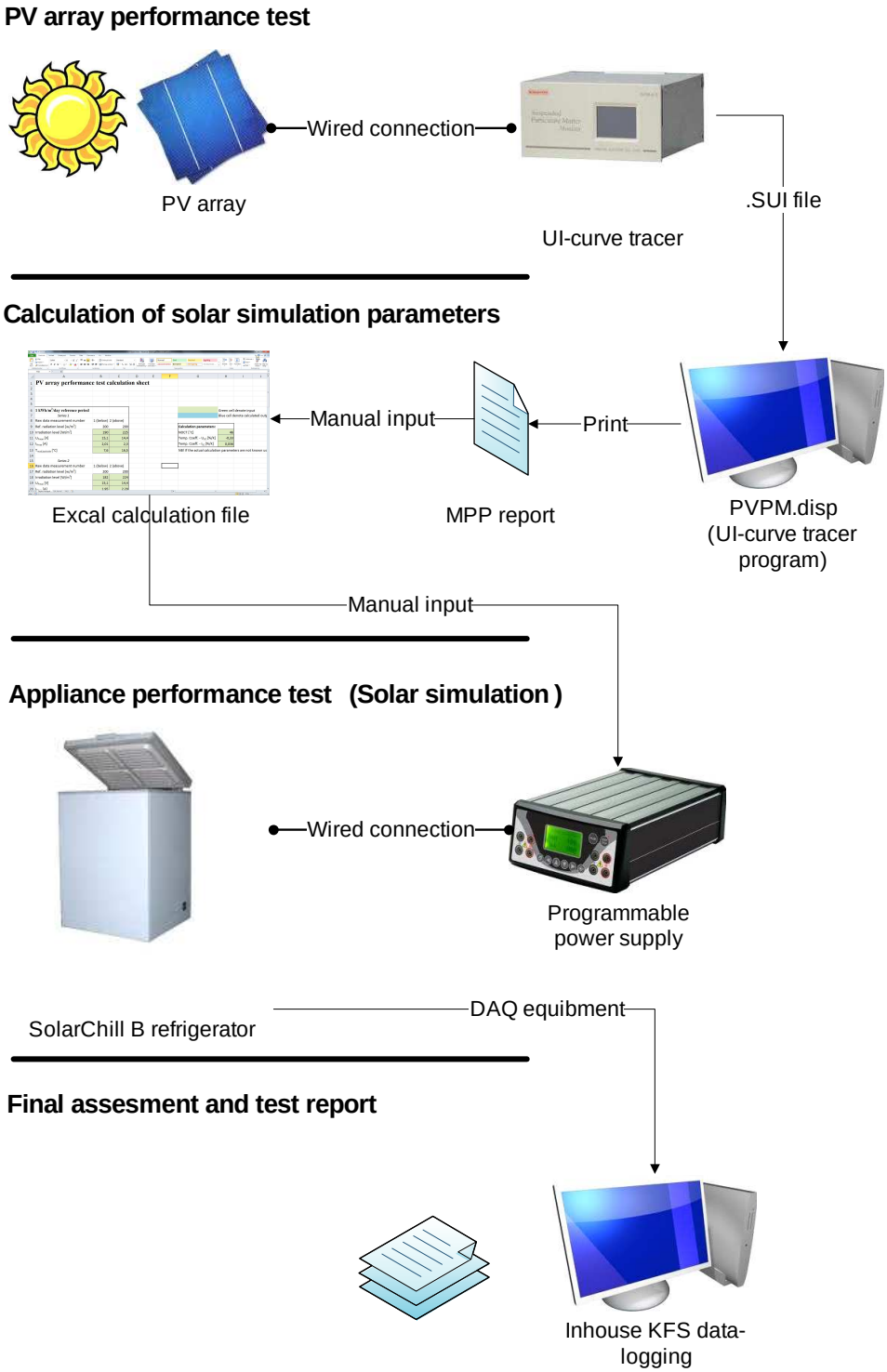


Figure 1 diagram visualizing the data flow and test workflow in general

Appendix 6 Data reporting forms

All data are reported in the prepared Excel spreadsheets and EES Calculation files, as described above. Results are collected and commented in the test report.