

Version 8 Pseudo Sub Hourly Simulation

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PVsyst SA www.pvsyst.com

Contents

1	Wor	king principle	3
	1.1	PVsyst prerequisites	3
	1.2	Data requirements	4
	1.3	Splitting data	5
	1.4	MEF conversion format	5
	1.5	Time shift	8
	1.6	Creating the MET files	9
	1.7	Batch simulation	10
	1.8	Gathering results	13
2	Adva	anced considerations	13
	2.1	Array temperature modeling	13
	2.2	Transposition of irradiance	15



1 Working principle

The basic idea of the approach consists in the following steps illustrated in the figure below:

- Split minute-level data into minute stamp slices, one for each minute stamp in the hour
- Apply the necessary time shift, and run them through the hourly simulation
- Re-assemble the (up to 60) hourly outputs to obtain the result of an equivalent sub-hourly simulation



In the following paragraphs we will explain in detail each of the steps.

1.1 PVsyst prerequisites

This procedure necessitates to heavily rely on time shifts for the conversion of weather data in MET files. In order to avoid the limitations applied to hourly data, it is essential to modify two advanced parameters (Home window > Settings > Edit advanced parameters):

dit advanced p	arameters					—	
🖌 Edit advi	anced parameters	Thes	e paramete	rs should be	modified	by expert u	isers only!
Category	All categories	\sim					
Show modifie	ed parameters only			Sea	arch time	shift	
Show modifie Description	ed parameters only		#	Sea	arch time Unit	shift Default	_ ♪
Show modified Description Sites and	ed parameters only d Weather data		#	Sea Value	arch time Unit	shift Default	_ ♪
Show modified Description Sites and Maxim	ed parameters only d Weather data num allowed time shift in weather data		#	Sea Value 100.00	unit Unit	shift Default	⊘



1.2 Data requirements

Data should be in 30, 20, 15, 12, 10, 5, 4, 3, 2, or 1 minute stamps.

Sub-hourly variations of irradiance can happen on short time scales (of the order of a couple minutes). The correction will be more accurate with finer resolution data.

Data should satisfy the usual requirements for weather data that will be imported in PVsyst. It should contain at least one of GHI, POA, DNI, as well as an ambient temperature measurement. Data should be organized as one time stamp per line.

Example: 1-minute data file

DATE (MM/DD/YYYY),HST,Global Horizontal Humidity [%],Avg Wind Speed @ 10m [m/s]	[W/m^2],Air	Temperature	[deg	C],Rel
1/1/2013,00:00,0,22.38,77.69,2.502				
1/1/2013,00:01,0,22.37,77.72,2.499				
1/1/2013,00:02,0,22.36,77.8,2.316				
1/1/2013,00:03,0,22.35,77.91,2.252				
1/1/2013,00:04,0,22.34,77.99,2.259				
1/1/2013,00:05,0,22.32,77.97,2.332				
•••				

The text above shows the plain text document with different colors for the columns.

In a spreadsheet program like Excel or LibreOffice Calc, the same snippet would look like this:

DATE (MM/DD/YYYY)	HST	Global Horizontal [W/m^2]	Air Temperature [deg C]	Rel Humidity [%]	Avg Wind Speed @ 10m [m/s]	
01.01.2013	00:00	0	22.38	77.69	2.502	
01.01.2013	00:01	0	22.37	77.72	2.499	
01.01.2013	00:02	0	22.36	77.8	2.316	
01.01.2013	00:03	0	22.35	77.91	2.252	
01.01.2013	00:04	0	22.34	77.99	2.259	
01.01.2013	00:05	0	22.32	77.97	2.332	



1.3 Splitting data

Starting from chronologically arranged data, the data should be split into several files, one for each different minute stamp in the data.

Example: contents of time stamp :01 data file



1.4 MEF conversion format

Each file should be processed with a specific MEF format file. The base for the MEF file can be built in PVsyst.

Gonversion of custom (s	sub-)hourly mete	o files										—	□ ×
Data source	3												
Source file	D:\PVsyst_wo	rkspaces\studies	_workspaces	\analysis\S	ubHourly\Ha	awaii\201301(11.txt				>	Choose	
Situation Country	United States	\sim	Site	Mahaiula						\sim	💡 New	Q Open	1
📥 Internal file	to be create	ed											
Site [Mahaiula		Source	Custom file							Kind of data	Imported	
Internal file name (*.ME	ET)	Mahaiula_Custon	_Imported.M	1ET							AB Char	nge file name	
Conversion													0
Conversion protocol file	e (*.MEF)			1	New Conversio	on format for cus	tom meteo file			\sim	C New	Q Open	1
											Conversion	Abor	t
								?	1	nformati	on		
										P	lease choose or construct the	Format file.	
													lose



Since the split minute stamp data are each in hour intervals, the "Time step" parameter should be 60.

🦩 Conversion of cu	istom (sub-)hourly r	meteo files - de	efinition of t	the impor	rt format file								-		x
Description	Hawaii minute da	ata			Plea	se specify th	e Date recordir	ıg mode.							
File name	HawaiiMinuteBas	e.MEF													
Consul Data 1	versities between														
General Date	variables Chaining	g			Variables	Description		Field no	Mult. 🍘	Unit 🕑	Information				
Source file organia	zation				Date	Date format	not yet defined								- 1
Hourly(Sub-hourly)	urly) Time	e step 60	Minute	s	- Meteo data	dahal haria	- tel loss distino								- 1
O Daily					GlobHor	Global horizo	ntal irradiation								- 1
Number of head	lines to be skipped	1			DittHor	Horizontal d	ttuse irradiation								- 1
L					- BeamHor	Horizontal b	eam irradiation								
Sample file		Sepa	rator		··· 🔲 DNIMeas	Measured be	am normal (D								- 1
📂 Choo	se	(); ()	Comma		··· 🔲 GIPMeas	Measured gl	obal on plane								- 1
		Ő	Space		··· 🔲 T_Amb	T amb.									- 1
		0	ТАВ		··· 🔲 TArrMes	Measured m	odule temper								
		0	Other :		··· 🔲 WindVel	Wind velocit	Y								
		0	Fixed width	n	··· 🔲 PrecWat	Precipitable	water column								- 1
					··· 🔲 RelHum	Relative hun	idity								- 1
The source file	e must hold one rec	ord per time st	tep (per line	=)	··· 🔲 Linke	Linke coeffic	ient								- 1
					AoD	Aerosol opti	al depth								
Custom source f	ile : D:\PVsvst_w	orkspaces\	studies w	orkspa	ces\analysis\SubH	ourly\Hawai	20130101.txt								
	1	2	3	4	ees (anal) 515 (5461	5 E	12010010101								~
1: DATE (1	MM/DD/YYYY)	HSTG1ob	oal HAir	Temp I	Rel Humidity [%	Avg Wind									
3:	1/1/2013	00:01	ŏ	22.37	77.7	2 2.499									
4:	1/1/2013	00:02	0	22.36	77.	8 2.316									
6:	1/1/2013	00:03	0 2	22.34	77.9	9 2.259									
7:	1/1/2013	00:05	0 2	22.32	77.9	7 2.332									
8:	1/1/2013	00:06	0	22.3	77.9	8 2.519									
9:	1/1/2013	00:07	9 3	22.29	7	8 2.478									
11:	1/1/2013	00:00		22.25	77.9	2.754									
12.	1/1/2012	00-10	0 1	<u>,, ,,</u>	77 0	el 0 exol									
`													 		1
												X Cancel	~	ок	

Date format will be the same for all files. Choose the option "Dates read on the file".

Conversion of custom (sub-)hourly meteo files - definition of the imp	ort format file — 🗆	х
Description Hawaii minute data File name HawaiiMinuteBase.MEF	Please choose the meteo variables to be recorded from the source file.	
File name HawaiMnuteBase.MEF General Date Variables Chaining Date type Reference year (1 jan - 31 dec, not leap year) Sequential dates (not read on the file) Sequential dates (not read on the file) Date from at Date format MM/DD/YY hhmm '1' = any non numeric character, '1' = separator ? Time base -Record time label O Legal Time Date format Dates read on the file. Daylight saving time Solar Time O Use summer/winter time changes Time shift I Use summer/winter time changes Minutes NB: If the dates are not sequencial (missing measurements), they have to be card on the file. Custom source file : D:\PVsyst_workspaces\studies_workspace 3	Variables Description Field no Mult. Unit Information Date Dates read on the file - M 1 1 1 MM/DD/YY 1 1 1 1 Meteo data 1 1 1 1 Meteo data 1 1 1 1 1 Meteo data 1 1 1 1 1 1 Diffior Global horizontal irradiation 1	~
1: DATE (BV/D0/YYYY) HSTCLOBAL HAIT Temp 2: 1/1/2013 00:00 0 22.38 3: 1/1/2013 00:02 0 22.38 4: 1/1/2013 00:02 0 22.38 5: 1/1/2013 00:03 0 22.38 6: 1/1/2013 00:04 0 22.32 0: 1/1/2013 00:05 0 22.32 0: 1/1/2013 00:06 0 22.32 9: 1/1/2013 00:07 0 22.32 10: 1/1/2013 00:07 0 22.32 11: 1/1/2013 00:07 0 22.32 12: 1/1/2013 00:07 0 22.32 14/1/2013 00:09 0 22.32 22.45	Rel Humidity (%) Avg Wind 77.69 2.602 77.73 2.499 77.8 2.316 77.59 2.255 77.59 2.255 77.59 2.315 77.9 2.315 77.9 2.315 77.9 2.315 77.9 2.478 77.9 2.4788 77.9 2.47	× >



Once the variables have been chosen, the base MEF file can be saved.

Conversion of cu	istom (sub-)hourly	meteo files - de	finition o	f the impo	t format file						-		х
Description	Hawaii minute d	ata											
File name	HawaiiMinuteBa	se MEE											
- inc manie													
General Date	Variables Chainir	ng			Variables	Description	Field no	Mult. 🕜	Unit 🕜	Information			
					Date	Dates read on the file - M							^
					··· MM/DD/YY		1						- 1
					hhmm		2						- 1
					🖹 Meteo data								_
					🗹 GlobHor	Global horizontal irradiation	3	1.000	W/m²				
					··· 🔲 DiffHor	Horizontal diffuse irradiation	n						- 1
					··· 🔲 BeamHor	Horizontal beam irradiation							- 1
					··· 🔲 DNIMeas	Measured beam normal (D.							- 1
					··· 🔲 GIPMeas	Measured global on plane							- 1
					🔽 T_Amb	T amb.	4	1.000	°C				
					TArrMes	Measured module temper							
					🤍 🗹 WindVel	Wind velocity	6	1.000	m/s				
					PrecWat	Precipitable water column							_
					- 🔽 RelHum	Relative humidity	5	1.000	ratio				~
-Custom source f	ile : D:\PVsvst \	workspaces\s	tudies	workspa	ces\analysis\SubH	ourly\Hawaii\20130101.t	xt						_
104	DD/YY 1	hhmm 2 Glob	Hor: I	Amb 4	RelHum S	WindVel							~
1: DATE () 2:	1/1/2013	HSTGloba 00:00	al HAi 0	r Temp 22.38	Rel Humidity [%] 77.69	Avg Wind 2.502							
3:	1/1/2013	00:01	0	22.37	77.72	2.499							
4:	1/1/2013	00:02	8	22.36	77.8	2.316							
6:	1/1/2013	00:04	ō	22.34	77.99	2.259							
7:	1/1/2013	00:05	0	22.32	77.97	2.332							
9:	1/1/2013	00:00	8	22.29	77.98	2.478							
10:	1/1/2013	00:08	0	22.27	77.98	2.687							
11:	1/1/2013	00:09	2	22.25	77.91	2.754							~
<													>
										X Cancel		ОК	



1.5 Time shift

On the basis of one MEF file, one can either make modifications for the other ones in PVsyst or directly by modifying the file contents.

The time shift ensures that the sun position will be set at the correct position during the import and simulation. With a time shift of zero, PVsyst will displace the sun position at the 30' minute after the time stamp (in case the time stamp is at the beginning of the recording interval), to be at the middle of the recording interval.

Since the middle of the recording interval in sub-hourly simulations does not happen at the 30' minute mark, the time shift should be adjusted. The time shift should be chosen as the difference between the 30' mark and the middle of the interval for the given file. Rounding up or down 1 minute is of negligible consequence.

Example: in 15 minute data, the time shift is given in the following table. The middle of the time intervals is 15/2 minutes after the time stamp. The necessary time shift is middle of the interval minus 30 minutes.

Minute stamp	Middle of the time interval	Minute time shift
0	7.5	-22
15	22.5	-7
30	37.5	8
45	52.5	23

Example: adjusting the time shift for time stamp :01, i.e., at -29 minutes.

Conversion of custo	om (sub-)hourly meteo files - definition of the impo	ort format file							-		x	
Description File name	Hawaii minute data TS01S HawaiiMinuteBase_TS01.MEF											
General Date Var Date type Reference year (Sequential dates © Dates read on the Date format MM/DD/YY hhmm '7' = any non numer Time base © Legal Time Solar Time Time shift 0 Hours	iriables Chaining (1 jan - 31 dec, not leap year) (not read on the file) (not read on the file) effe iric character, "!" = separator ? Record time label ? Image: Second time label ? <td cold="" label<="" td="" td<="" time=""><td>Variables Date MM/DD/YY hhmm Meteo data GlobHor Diffhor DeamHor DNIMeas GloMeas T,Amb T,ArrMes WindVel PrecWat</td><td>Description Dates read on the file - M Global horizontal irradiation Horizontal diffuse irradiation Horizontal deam irradiation Measured beam normal (D Measured global on plane T amb. Measured module temper Wind velocity Precipitable water column</td><td>Field no</td><td>Mult. ?</td><td>Unit ?</td><td>Information</td><td></td><td></td><td></td><td></td></td>	<td>Variables Date MM/DD/YY hhmm Meteo data GlobHor Diffhor DeamHor DNIMeas GloMeas T,Amb T,ArrMes WindVel PrecWat</td> <td>Description Dates read on the file - M Global horizontal irradiation Horizontal diffuse irradiation Horizontal deam irradiation Measured beam normal (D Measured global on plane T amb. Measured module temper Wind velocity Precipitable water column</td> <td>Field no</td> <td>Mult. ?</td> <td>Unit ?</td> <td>Information</td> <td></td> <td></td> <td></td> <td></td>	Variables Date MM/DD/YY hhmm Meteo data GlobHor Diffhor DeamHor DNIMeas GloMeas T,Amb T,ArrMes WindVel PrecWat	Description Dates read on the file - M Global horizontal irradiation Horizontal diffuse irradiation Horizontal deam irradiation Measured beam normal (D Measured global on plane T amb. Measured module temper Wind velocity Precipitable water column	Field no	Mult. ?	Unit ?	Information				
Custom source file 1: DATE (194 3: 4: 5: 6: 7: 8: 9: 10: 11: 12: 4: 0: 1: 0: 1: 0: 1: 0: 1: 0: 1: 0: 0: 0: 0: 0: 0: 0: 0: 0: 0	E: ClUsers, inio (Downloads) Temporary (H VDD YTY) HSTCLobal Hohir Temp 1/1/2013 00:01 0 22.37 1/1/2013 00:01 0 21.4 1/1/2013 03:01 0 21.4 1/1/2013 05:01 0	→ Relium awaii 7501.csv i p. Rel. Humidity 77.5 p. Rel. Humidity 77.5 p. 77.6 77.6 p. 77.6 77.6 p. 77.6 77.6 p. 77.6 77.7 p. 77.6 77.7 p. 77.6 77.6	Relative humidity	5		ratio		Cancel		ОК	*	



This parameter can also be modified directly in the MEF file, in a text editor. The tag to be modified or added is "TimeShiftF". This may or may not change in future PVsyst versions. When in doubt, always modify directly through PVsyst as above.

1	PVObject_=pvMeteoFormat
	Comment=Hawaii minute data TS01S
	Version=7.4.5
	Flags=\$00E1
	DateMode=ReadOnFile
6	DateFmtType=MMxDDxYY_hhmm
	FileType=SingleFile
	Separ=\$002C
9	NLigDeb=1
10	MeasureStep=60
11	TimeShiftF=-29
12	TypeInterv=1
4.5	

1.6 Creating the MET files

Once the MEF files are ready, it is straightforward to use the Custom file import functionality in PVsyst to create one MET file for each minute stamp.

Make sure that the name is appropriate and different for each import (e.g., reflects the time stamp), by clicking on "Change file name".

Once ready for the import, click on "Conversion".

Conversion of custom (sub-)hourly m	eteo files		– 🗆 X
Data source			
Source file C:\Users\m	io\Downloads\Temporary\HawaiiTS01.csv	>	Choose
Situation Country United States	Vew New	O Open	
📥 Internal file to be crea	ated		
Site Mahaiula	Source Custom file	Kind of data	Imported
Internal file name (*.MET)	Mahaiula_Custom_Imported.HET	$A \underline{]} B$ Chan	ge file name
Conversion			0
Conversion protocol file (*.MEF)	HawaiiMinuteBase_TS01.MEF Hawaii minute data TS01S	New	Q Open
Beginning Date / Hour	01/01/13 00:01	Conversion	C Abort
	Q		
			Close



1.7 Batch simulation

The simulations for each minute stamp can be run with the batch mode:

Advanced tools	
Optional further definitions, For refined data analysis only.	Output File
Hourly data storage	Batch simulation
Special graphs	Optimization tool
Q Comparisons	Aging Tool

Two parameters are essential:

- "Specify different meteo files"
- "Create hourly files"

C Definitions for Multiple Simulation runs in Batch		—		x
Definitions for Multiple Simulation runs in Batch Batch CSV Files Simulation parameters Results variables specification You should define here the input parameters that you will specify for each run Meteo and Save mode Plane orientation System Parameter Losses You can specify different meteo files for each run: either different years or different places Meteo and site specification Specify different meteo files Specify different meteo files Specify different project's sites Start from different VCi base files Create hourly files Create PDF Report (saved in /UserData/)	ne			×
✓ Activate batch mode for the next simulation	X Cancel	 ✓ 	ОК	

You should also make sure that the output file format is properly defined before running the simulation, and that the checkbox "Enable output file" is checked.



Special graphs	Optimization tool	NB: 1990 indicates a generic year, i.e. which doesn't correspond to really measured data for a given time						
Q Comparisons	(Aging Tool	Output File .csv						
Batch mode: parameter file								
_DEMO_COMMERCIAL_BatchParams_0.CSV								
Q System overview Simulation								

The contents of the batch parameter file should contain the MET files to be used. Example: batch file to run minute-level simulations.





SIM_6;Haw_TS5.MET;Haw_TS5.CSV;minute	stamp	5
SIM_7;Haw_TS6.MET;Haw_TS6.CSV;minute	stamp	0 6
SIM_8;Haw_TS7.MET;Haw_TS7.CSV;minute	stamp) 7



. . .

1.8 Gathering results

The batch run will result in a collection of output CSV files, one for each minute stamp. Since each row in these files represents a single and unique time stamp, it is possible to group data together once again.

2 Advanced considerations

The main processes in the simulation are well modeled as instantaneous processes; i.e., they do not depend on preceding time steps. This is why it is possible to split the simulation into independent minute stamps, and obtain reasonably accurate results.

However for certain secondary processes, the instantaneous modeling is not such a good approximation. Therefore, switching to a model that depends on the previous time steps can improve the accuracy further.

2.1 Array temperature modeling

Due to a thermal inertia of PV modules and structures of the order of minutes, a detailed modeling for the array temperature at the sub-hourly scale necessitates a dependence on the previous state of the system.

PVsyst allows using the array temperature as input variable of the simulation. One way to use this to account for thermal inertia, is to run the pseudo-sub-hourly simulation twice.

The first time, you should use the default instantaneous model for the array temperature. Gathering the results, you can analyze the temperature values obtained from the instantaneous model. It is then possible to establish a more accurate array temperature evolution by using an exponential smearing of the values, such as the Prilliman model (10.1109/JPHOTOV.2020.2992351).

By including the new array temperature data together with the weather raw data, you can now use "TArrMes" among the variables of the MEF.



Variables	Description	Field no	Mult. 🕜	Unit 🕜	Information
hhmm		2			
🗄 Meteo data					
GlobHor	Global horizontal irradiation	3	1.000	W/m²	
DiffHor	Horizontal diffuse irradiation				
BeamHor	Horizontal beam irradiation				
DNIMeas	Measured beam normal (D				
GIPMeas	Measured global on plane				
	<u>T amb.</u>	4	<u>1.000</u>	<u>°C</u>	
🗠 🗹 TArrMes	Measured module temper	8	1.000	°C	
··· 🗹 WindVel	Wind velocity Measured mod	dule temper	rature	m/s	
	8 1911 A 1				· · · · · · · · · · · · · · · · · · ·

In the variants to be simulated, Detailed losses > Thermal parameter, you can then select the option to use this array temperature data.

루 PV field detailed los	sses parameter								-		х
Thermal parameters are defined for the whole system											
Thermal parameter	Ohmic Losses	Module quality - LID - Mismatch	Soiling Loss	IAM Losses	Auxiliaries	Aging	Unavailability	Spectral correction			
	You can define either the Field thermal Loss factor or the standard NOCT coefficient: the program gives the equivalence!										
Field Thermal Los Thermal Loss facto Constant loss facto Wind loss factor UN Default value a "Free" mounte Domes Semi-integrate Integration wi	Sector of the standard NOCT coefficient: the program gives the equivalence! Performal Loss Factor Thermal Loss factor Constant loss factor U Output: Constant loss factor U Output: Constant loss factor U Output: Output: Constant loss factor U Constant loss factor U Constant loss factor U Output: Output: Output: Output: Output: Default value acc. to mounting Ones On't use the NOCT approach. This is quite Ones On't use the NOCT anyway Default value dentified with air duct behind Integration with fully insulated back Default value dentified by Other use the NOCT anyway See the NOCT anyway See the NOCT anyway Neta transpace tof the second transpace to the s										
Q System o	verview			Los	ses graph		🗙 Canc	el	🗸 ок		



2.2 Transposition of irradiance

As outlined in (https://userarea.eupvsec.org/proceedings/EU-PVSEC-2023/4DV.4.43/) transposition models, and in particular the typical Perez transposition coefficients are adapted to hourly value transposition, but generate a small bias when used on sub-hourly data.

In order to side-step this issue partially, it is possible to use POA values directly as input for the simulation. Note however that the separation between diffuse components and direct may be still affected by the biases in the Perez or Hay modeling, among other models used.

