NSolV8

Description of New Features

V1.1 17 April 2020

1 File structure

NSolV8 uses a “pv8” file to store system specific data.

The program can also import and convert “pv7” files from NSolVx but cannot import any older version of files.

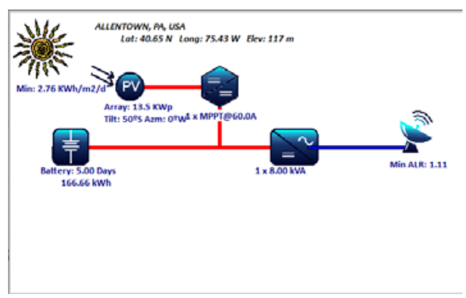
2 System Configurations

The program will now analyze six different types of systems:

1. DC Bus PV
2. AC Bus PV
3. DC Bus Hybrid –Genset w/ rectifier
4. Mixed Bus Hybrid – AC Genset through inverter
5. AC Bus Hybrid
6. Grid Tied

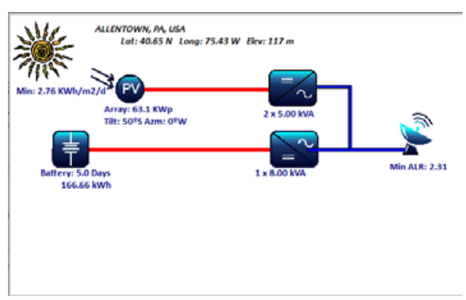
2.1 DC Bus PV

This configuration is the same as “Standalone PV” in NSolVx. The array charges the battery through a DC control/charger. The configuration supports both DC loads and optional AC loads through a “Battery Inverter.” All calculations are based on DC amp-hours. Battery calculations are slightly different than NSolVx (see below).



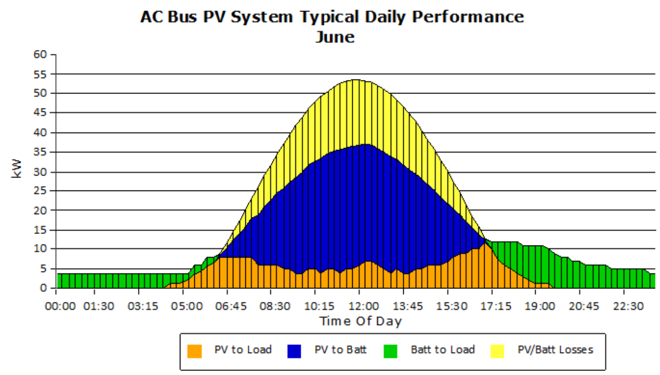
2.2 AC Bus PV

In this configuration, the PV is connected to the system through a “GridTie Inverter” which is tied to the “Battery Inverter” on the AC side of both inverters. The calculations use kWh hours, so all loads should be AC (the program will post a warning but will not convert DC loads). Battery calculations use “DC Round Trip Efficiency”(DCRTE) combined with battery inverter efficiency to account for charging losses. (see below)



To analyze the performance, the program creates a 24-hour load profile (see below) for each month and then calculates both the load and solar output for each 15-minute period. Energy from the PV array is sent directly to the load when possible. If the load is greater than PV output, the battery is discharged through the “Battery Inverter” to make up the difference. If the PV output is greater than the load, excess energy goes "backwards" through the battery inverter to charge the battery.

A "typical day" system performance profile is shown in the "Daily" tab. This chart show where the load is supplied directly from the PV array, where it is supplied directly from the load and where the excess energy from the PV is used to charge the battery. The top area in this chart shows the losses due to the round-trip passage of energy from the array to the battery during the day and from the battery back out to the load at night. Note that all battery round-trip losses are assigned to charging – this is for convenience in calculations only.

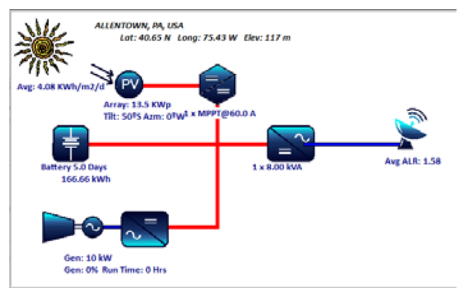


Note – `PV_to_Load_Efficiency = Battery_DCRTE * Battery_Inverter_Efficiency^2`.

These losses will be smaller for higher battery inverter efficiency and higher battery DCRTE (such as with lithium batteries).

2.3 DC Bus Hybrid – DC Genset

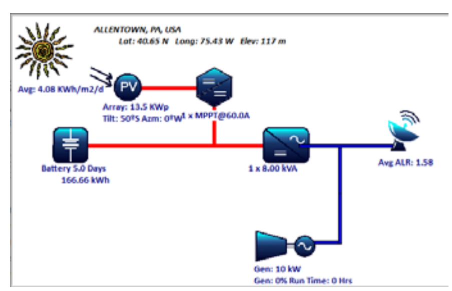
This is equivalent to the "DC Bus Hybrid" in NSolVx. The array charges the battery through a DC control/charger. The generator charges the battery through an AC-DC rectifier. The configuration supports both DC loads and optional AC loads through a "Battery Inverter." All calculations are based on DC amp-hours. Battery calculations are slightly different than NSolVx (see below).



To calculate the generator requirement, the systems calculates the monthly deficit from PV energy, then calculates how many hours the generator will need to run (using the amp rating of the rectifier) to supply this energy.

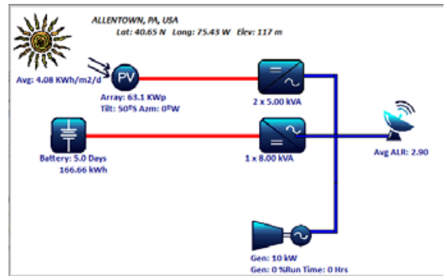
2.4 Mixed Bus Hybrid – AC Genset

This is equivalent to the "DC Bus Hybrid" in NSolVx. The array charges the battery through a DC control/charger. The generator charges the battery through the "Battery Inverter". The configuration supports both DC loads and optional AC loads through a "Battery Inverter." All calculations are based on DC amp-hours, so this mode will support mixed AC and DC loads. Battery calculations are slightly different than NSolVx (see below).



To calculate the generator requirement, the systems calculates the monthly deficit from PV energy, then calculates how many hours the generator will need to run (using the amp rating of the rectifier) to supply this energy. This differs slightly from the DC Bus calculation in that the generator is also supplying the load while it is operating.

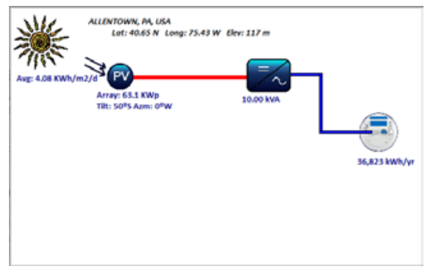
2.5 AC Bus Hybrid



This configuration is based on the AC Bus PV: the PV is connected to the system through a "GridTie Inverter" which is tied to the "Battery Inverter" on the AC side of both inverters and the generator charges the battery through the AC side of the "Battery Inverter." The calculations use kWh hours, so all loads should be AC (the program will post a warning but will not convert DC loads). Battery calculations use "DC Round Trip Efficiency" combined with battery inverter efficiency to account for charging losses. (see below)

To calculate the generator requirement, the systems calculates the monthly deficit from PV energy, then calculates how many hours the generator will need to run (using the amp rating of the battery inverter) to supply this energy. This differs slightly from the DC Bus calculation in that the generator is also supplying the load while it is operating.

2.6 Grid Tied



This is equivalent to the "Grid Tied" configuration. All PV energy is exported to the grid through a "GridTie Inverter." There are no loads.

A "Lifetime Output" calculation has been added based on the "Design Life" and "PV Degradation" factors. See section on "End-Of-Life" calculations below.

3 Design for End-Of-Life

3.1 Why End-of-Life?

NSol! software has historically provided both energy balance (array-load-ratio) and statistical performance (LOLP and BSOC) analyses. These have been based on the datasheet ratings of the critical components – PV modules and batteries.

However, both PV modules and batteries degrade with age, so the overall performance of the system will change as the key components age. One way to deal with this is to simply increase component sizes to add a "safety margin."

We have added a feature to the analysis to allow calculation of system performance at the "end-of-life." The selectio9n for this feature is on the "System"{ tab in the system input portion of the screen. When activated, the performance analyses will use degraded values of the component ratings based on a specified "design life." The on-screen and printed reports will indicate that "End-of-Life" is being used.

3.2 End-of-Life Factors

There are three factors used in end-of-life calculations:

- **Design Goal** (years) – this is used to determine the end-of-life rating of the PV array. It is not used for battery capacity. This can be set to any value, depending on what analysis is required. (see example below)
- **PV Degradation %/yr** – This is the rate at which the PV module will degrade. It can be calculated from a datasheet by dividing the warranted end-of-life output (typically 80-85%) by the

warrantied life (typically 20-25 years). This value is not recorded in the PV module database – it must be entered manually. Typical values are between 0.5% and 0.8% per year.

- **Battery % at End-of-Life** – Since it is possible that a battery may be replaced one or more times during the life of an off-grid system, this value is not based on annual degradation, but instead on the degraded value at the end of the design life. Depending on the battery technology and manufacturer, this is typically between 50% and 80% of initial capacity.

3.3 End-of-Life Example – Off Grid

A DC Bus PV system with minimum ALR of 1.18 and a 6-day battery at start-of-life.

Assuming PV degradation of 0.8%/year and battery degradation of 70% after five years, the system would have a minimum ALR of 1.14 and LOLP of 2.7%.

If the battery was replaced with the same type of battery, the system would have a minimum ALR of 1.09 and an LOLP of 5.2% in December and 1.4% in November.

After a second and third battery replacement, but keeping the same modules, the system in year 20 would have a minimum ALR of 0.99 and an LOLP of 11.7% in December, 4.5% in November and 1.4% in January.

A hybrid system which showed 84% PV and 304 hours of generator operation in year one would be 71% PV by year 20 (assuming battery replacement and degradation so that the capacity in year 20 was 70% of design) and fuel use would increase to more than 500 liters.

3.4 End-of-Life -- Grid-Tied Systems

Since there are no loads in grid-tied systems, end-of-life calculations for ALR, LOLP and BSOC have no meaning. The end-of-life performance is simply the output of the system in the design year, assuming standard values of insolation.

However, the program will use the “Design Goal” and “PV Degradation” values to calculate the cumulative kWh production of the system over the design life. This is done regardless of whether “End-of-Life” is selected.

4 Load Profiles

4.1 Standard Load Profile

There are six standard load profiles available:

1. Daytime – all loads occur between 6 am and 6 pm.
2. 75% Day – 75% of loads during day, 25% during night hours
3. Day/Night – loads split evenly between day and night
4. 75% Night – 75% of loads during night hours, 25% during daylight
5. Night – all loads at night
6. Lighting – Loads calculated based on the number of hours of darkness.

Note that these load profiles conflict with the specified “number of hours” in each load – for example, in a “night” load, the “Size” of the load is multiplied by the “hours” and then all loads are assigned to night, which means that the night loads are double the size of the specified load if “hours” is set to 24. It is up to the person using the program to keep these conflicts balanced with actual loads.

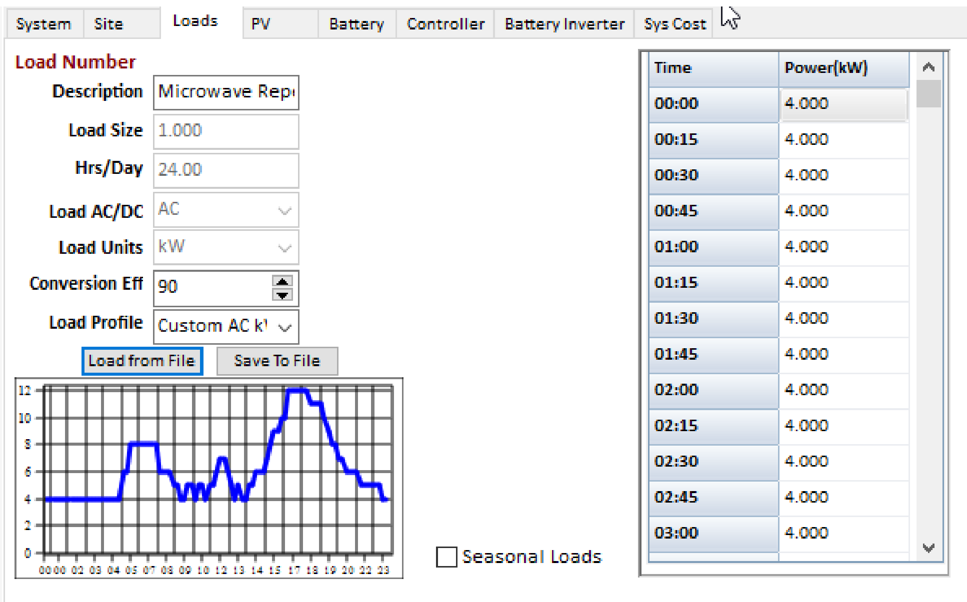
The load profiles for each of the ten loads are summed and then converted to amp-hours for DC bus systems and kWh for AC bus systems.

Note also that the program will flag if DC loads are specified for AC bus systems, but will not automatically convert all loads to AC.

4.2 Custom Load Profile

The seventh load profile is "Custom AC kW." In this case, only the first load is used, and it must be specified as AC kW. This will also display a grid showing the loads for each 15 minutes during the day. These loads can be manually adjusted using the grid.

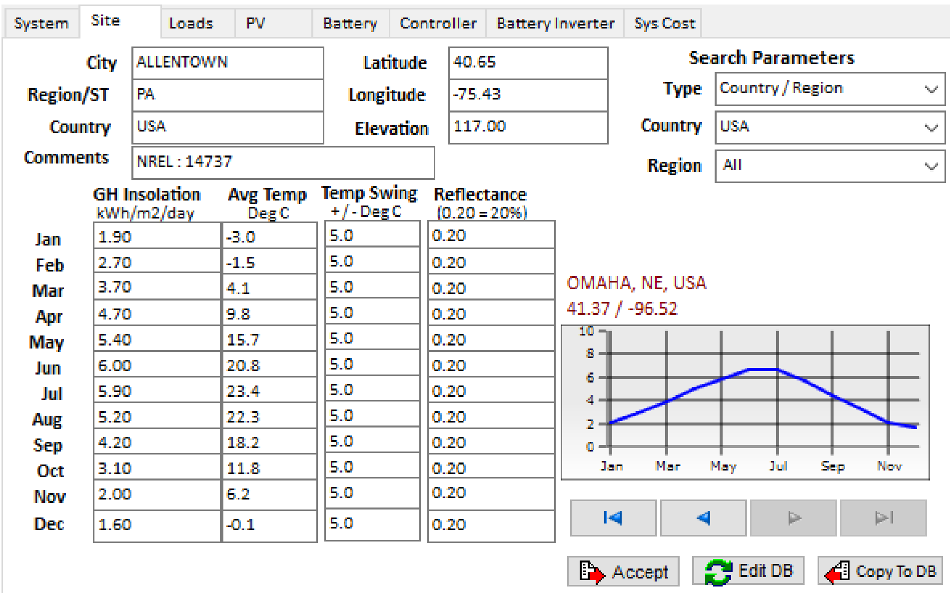
Load profiles can also be loaded from a text file which contains 96 values of AC kW. The program will allow the user to modify these profiles and then save them for loading later.



5 Database Search / Sort Enhancements

5.1 Site Database

The site database is fundamentally the same, but we have changed the search process and added a “Copy to DB” button to facilitate adding new sites.



Clicking on the “Type” box offers a choice of Country/Region, City or Latitude / Longitude sources.

Clicking on the “Country” box brings up a list of Countries in the database. If a country has more than one region/state, the “Region” box can be used to filter the database further.

After choosing City in the Type box, the user can search for city names across the entire database (not sorted by country/region). Just start typing in the name.

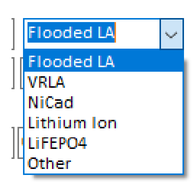
The user can also search by latitude and longitude. Enter search values in the appropriate boxes and click on “Search Lat/Long” The program will filter the database to +/- 2 degrees of latitude and +/- 5 degrees of longitude. Activating any other search will clear the Latitude/Longitude search.

5.2 PV Module Database

The PV Database is fundamentally the same.

The PV Tab now allows users to filter the database by Manufacturer and/or Rating (Wp).

5.3 Battery Database



The Battery Database is fundamentally the same, except that the Battery “Type” has been extended to cover more specific technologies”

- Flooded Lead Acid
- VRLA – including AGM and gel
- NiCad – Flooded NiCad
- Lithium Ion – Most standard Li Ion technologies with the exception of LiFePO4
- LiFePO4 – Lithium Iron Phosphate

The Battery Tab now allows users to filter the database by Manufacturer, Rating (Wp) and/or Rating (Amp-Hr).

The Battery Tab also now includes three sizing factors, which are discussed in detail under the section on batteries

- Average Daily Cell Volts (%) – This number is used only to convert loads specified as Watts, Wh and kWh to amp-hours. The rational is that a typical battery (especially lead acid) spends most of its time above the nominal voltage, so a higher voltage will require less amps. A value of 100% is more conservative than 105%.
- Average Charge Volts (%) – This value is used in DC bus PV and DC Bus/Mixed Bus configurations that use MPPT Controllers. It is used to convert the watts from the array into amps for amp-hour calculations. It is not used in AC bus calculations. The program gives the user the option of setting this to a default by battery type or setting a custom value. The default battery for each battery type is based on the average battery voltage during a typical recharge cycle. Higher values are more conservative. Defaults:
    - Flooded Lead Acid 115%
    - VRLA 114%
    - NiCad 116%
    - Li Ion (std) 111%
    - LiFePO4 109%
    - Other 114%
- Battery DC RTE (%) – Battery DC Round-Trip-Efficiency. This is used in AC bus systems to correct for energy (versus coulombic) losses in battery charging. The program gives the user the option of setting this to a default by battery type or setting a custom value. Lower values are more conservative. It is important to note that this is the RTE for the DC battery only – two way inverter losses are calculated separately. Defaults:
    - Flooded Lead Acid 80%
    - VRLA 85%
    - NiCad 85%
    - Li Ion (std) 95%
    - LiFePO4 95%
    - Other 85%

  Note – the VRLA values assume some variation of “partial-state-of-charge” operation, which means that batteries are not held at high voltages for long periods of time, but instead are subject to more efficient two-stage charging. Flooded batteries have a lower efficiency since they must be fully charged more often to prevent sulfation and electrolyte stratification.

5.4 Controller Database

The Controller Database is fundamentally the same.

The Controller Tab now allows users to filter the database by Manufacturer, Type (Standard vs MPPT), DC Voltage and/or Rating (A).

5.5 Inverter Databases

The Inverter Database is fundamentally the same.

The NSolVx “Inverter” tab has been split into two tabs – “Battery Inverter” and “GridTied Inverter” tabs since AC bus systems will require both types of inverters.

The “Battery Inverter” tab now allows users to filter the database by Manufacturer, Type (Standard vs Grid-Battery), DC Voltage and/or Rating (kVA).

The "Grid-Tied Inverter" tab now allows users to filter the database by Manufacturer, Max Open Circuit Voltage and/or Rating (kVA).

6 Battery calculations

6.1 Batteries series

In NSolVx, the DC system voltage was set separately from the battery voltage (Battery series x Unit Volts), which led to potential calculation errors. The "System Voltage" was also limited to a select number of values. To provide more flexibility in selecting DC system voltages, this value is now set directly by the battery specification (Battery series x Unit Volts).

6.2 Average Daily Cell Volts (%)

Average Daily Cell Volts (%) – This number is used only to convert loads specified as Watts, Wh and kWh to amp-hours. The rational is that a typical battery (especially lead acid) spends most of its time above the nominal voltage, so a higher voltage will require less amps. A value of 100% is more conservative than 105%.

6.3 Average battery charge voltage

Average Charge Volts (%) – This value is used in DC bus PV and DC Bus/Mixed Bus configurations that use MPPT Controllers. It is used to convert the watts from the array into amps for amp-hour calculations. It is not used in AC bus calculations. The program gives the user the option of setting this to a default by battery type or setting a custom value. The default battery for each battery type is based on the average battery voltage during a typical recharge cycle. Higher values are more conservative. Defaults:

- Flooded Lead Acid 115%
- VRLA 114%
- NiCad 116%
- Li Ion (std) 111%
- LiFePO4 109%
- Other 114%

6.4 Battery DC Round Trip Efficiency

Battery DC RTE (%) – Battery DC Round-Trip-Efficiency. This is used in AC bus systems to correct for energy (versus coulombic) losses in battery charging. The program gives the user the option of setting this to a default by battery type or setting a custom value. Lower values are more conservative. It is important to note that this is the RTE for the DC battery only – inverter losses during charge and discharge are calculated separately. Defaults:

- Flooded Lead Acid 80%
- VRLA 85%
- NiCad 85%
- Li Ion (std) 95%
- LiFePO4 95%
- Other 85%

Note – the VRLA values assume some variation of "partial-state-of-charge" operation, which means that batteries are not held at high voltages for long periods of time, but instead are subject to more efficient two-stage charging. Flooded batteries have a lower efficiency since they must be fully charged more often to prevent sulfation and electrolyte stratification.

6.5 Waterfall Chart / Table correction

The BSOC "Waterfall" chart and table have been corrected to show the proper "SOC Bins" for systems with maximum DOD other than 80%

7 Other Factors

7.1 AC System Voltage

AC system voltage in NSolVx was set separately from inverter voltage which led to potential calculation errors. The AC system voltage is now set by the battery inverter voltage.

8 Solar Position Chart

NSolV8 how include a chart and a table showing solar position in the "reference day" of each month (typically within a couple days of the middle of the month).

These can be used to manually estimate shading losses. Full shading analysis of the wide variety of systems and array sizes covered by NSolV8 in not possible within the present calculation structure.

9 Exports and Reports

9.1 "Copy-to-Clipboard" from screens

NSolVx introduced the ability to "right-click" on certain charts and tables to copy them to the clipboard.

NSolV8 extends this feature to the summary results (lower left quadrant) for each system configuration.

In addition, it is now possible to copy the block diagram (upper left quadrant) – this is done by clicking on the small square button in the lower right of the block diagram.

The graphs and block diagrams can be pasted into documents such as proposals and manuals. The tables can be pasted into spreadsheets for further analysis and custom graphing.

The component input screens (upper right quadrant) currently do not support copy-to-clipboard.

9.2 "Export" Menu Button

The "Export" menu button now provides custom outputs for each system configuration. Each file includes system configuration and system performance data. These are saved as "tab-separated" files with a ".prn" extension. They can be easily imported into a spreadsheet program.

9.3 Printed Reports

The printed reports have received minor modifications to accommodate new system configurations. The "Load Summary" report now includes a chart of the Load Profile used in system calculations.