



# DOE DPV Website Tutorial

*[dpv.epri.com](http://dpv.epri.com)*

**Matthew Rylander**  
**Jeff Smith**

April 8, 2014

# Using the Website

- Shortcuts to the three main items in the website
  - OpenDSS tool
  - Feeder models
  - Monitoring data

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## Welcome

The electric utility industry has a need to understand the feasibility of integrating wide-spread distributed photovoltaic (PV) systems. High-penetration scenarios expected across different regions and system sizes. Impacts to the utility are not fully known for significance and quantities of grid-connected PV installations.

Supported by member utilities and the **U.S. Department of Energy**, EPRI collects multi-year, high-resolution data across geographically diverse distribution systems. EPRI then processes and manages that data, in order to assess the true variability of solar generation potential impact on utility operations and planning. Data of distribution feeders across the U.S. have been evaluated—and hundreds of remote monitoring systems have been deployed.

Results are published from ongoing project work to the interest of both private and public solar industry at international, federal, state, and local levels.

EPRI has created this public website to serve as a resource for power system studies. Here, you can learn about distributed PV systems. In addition, this site provides **data sets** at no cost.

Be sure to visit DOE's **SunShot Initiative** High Impact topics.

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## OpenDSS

OpenDSS is a freely-available, open-source electrical power system analysis tool used to simulate distribution-level power systems. It supports nearly all frequency domain (sinusoidal steady-state) analyses commonly performed on electric utility power distribution systems.

In addition, it supports many new types of analyses that are designed to meet future needs related to smart grid, grid modernization, and renewable energy research.

OpenDSS has been used since 1997 in support of various research and consulting projects requiring distribution system analysis. Many of the features found in the program were originally intended to support the analysis of distributed generation interconnected to utility distribution systems and that continues to be a common use.

Other features support analysis of such things as energy efficiency in power delivery and harmonic current flow. OpenDSS is designed to be indefinitely expandable so that it can be easily modified to meet future needs.

For download information, documentation, and test cases, please visit the [EPRI Smart Grid Resource Center](#).



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## Simulation Tool – OpenDSS

The OpenDSS is a comprehensive electrical power system analysis tool used to simulate distribution-level power systems. It supports nearly all frequency domain (sinusoidal steady-state) analyses commonly performed on electric utility power distribution systems. In addition, it supports many new types of analyses that are designed to meet future needs related to smart grid, grid modernization, and renewable energy research. OpenDSS has been used since 1997 in support of various research and consulting projects requiring distribution system analysis. Many of the features found in the program were originally intended to support the analysis of distributed generation interconnected to utility distribution systems and that continues to be a common use. Other features support analysis of such things as energy efficiency in power delivery and harmonic current flow. The OpenDSS is designed to be indefinitely expandable so that it can be easily modified to meet future needs.

### OpenDSS Download Files

This is the main site for obtaining the release versions of the program. You can also get to other parts for the OpenDSS site by following the menu items. Note that release versions are posted irregularly every 3-4 months. If you want to keep up with the latest additions to the program you can either build from the source code or obtain the latest beta build from the Code repository:

[32-Bit Version](#)

[64-Bit Version](#)

While the newer versions have the more up-to-date features and bug fixes such as those described in the latest [Tech Notes](#) in the Wiki or in the [Discussion Forum](#), they could be less tested.

Links allow the user to download and install the latest version of the software

# Feeder Models

EPRI.com

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## Hosting Capacity Method

EPRI is currently leading multiple efforts throughout the U.S. to assess how future high penetration PV integrates into distribution feeders of various types, load mixes, and solar characteristics. This work combines both detailed feeder data along with field measurements to examine a wide range of PV deployment scenarios and penetration levels.

The linked report below discusses the analysis developed by EPRI to determine distributed PV impact to a specific feeder. The analysis uses a stochastic approach when creating potential PV deployment scenarios. The stochastic nature of the analysis takes into account the uncertainty in the size and location of potentially installed PV systems. Through the examination of power quality and reliability related issues for thousands of potential scenarios, the feeder response is used to determine the total amount of PV that will likely cause an adverse impact to the feeder. This amount of PV is considered the feeder's hosting capacity, or the maximum amount of PV that can be accommodated. The feeder modeling, analysis, and evaluation of issues to determine hosting capacity are all discussed in detail in this report:

[Stochastic Analysis to Determine Feeder Hosting Capacity for Distributed Solar PV](#)

## Further Reading:

### EPRI Reports

*Integration of Photovoltaic Generation into Distribution Systems*, EPRI, Palo Alto, CA: 2010. 1020870.

*Modeling High-Penetration PV for Distribution Analysis: Solar PV Systems and Relevant Grid-Related Responses*. EPRI, Palo Alto, CA: 2011. 1021980.

- Description of hosting capacity
- Three feeder models
- Links included to reports

# Feeder Models

EPRI.com

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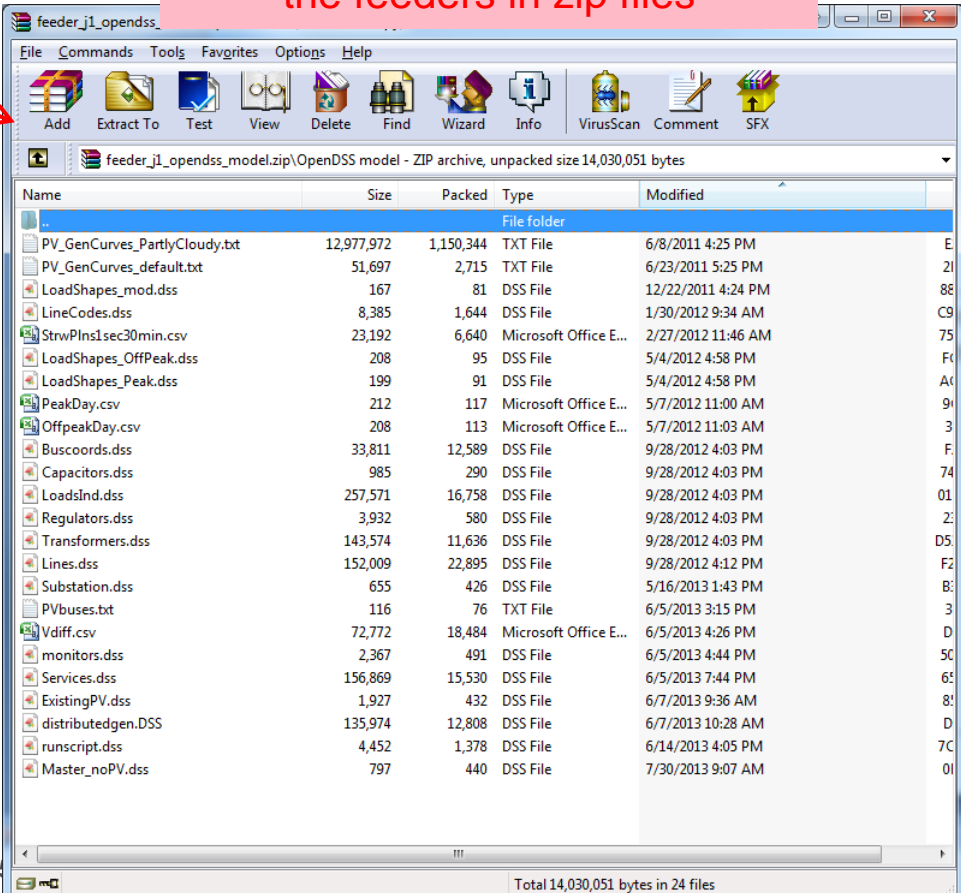
Measurement Data  
**Feeder Models**

### Feeder Models

Use the links below to download the feeder models.

- Feeder J1 OpenDSS model**
- Feeder K1 OpenDSS model
- Feeder M1 OpenDSS model

Links allow the user to download the feeders in zip files



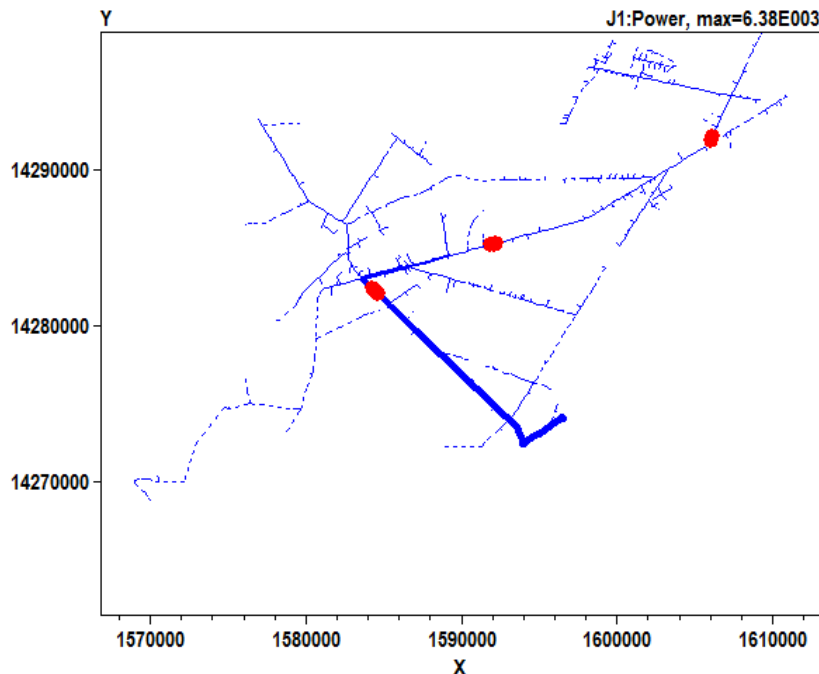
# Included in the Feeder Model

- The complete model is included for each feeder
- The Master\_noPV.dss is the top level file that pulls in all feeder information without PV
- Existing or future PV must be added to the master file to simulate the impact
- An example script is included in the J1 feeder model for basic OpenDSS usage

# Example Script for Feeder J1

```
C:\Projects\PV\OpenDSS model\runscript.dss
Font...
!-----
! Sample Script files from EPRI's OpenDSS Training, June 7, 2013, Charlotte, NC.
! ~ Jeff Smith, EPRI
compile "C:\Projects\PV\OpenDSS model\master_nopv.dss"
solve
!-----
!Plot Circuit Power flow
set markercode=24
set markregulators=yes
plot circuit power 1ph=3
```

- Open script in the DSS software
- Modify the data path to the location of the file
- Execute the first few lines of code
  - Highlight lines
  - Press Ctrl+D



# Plotting Voltages on Feeder Layout

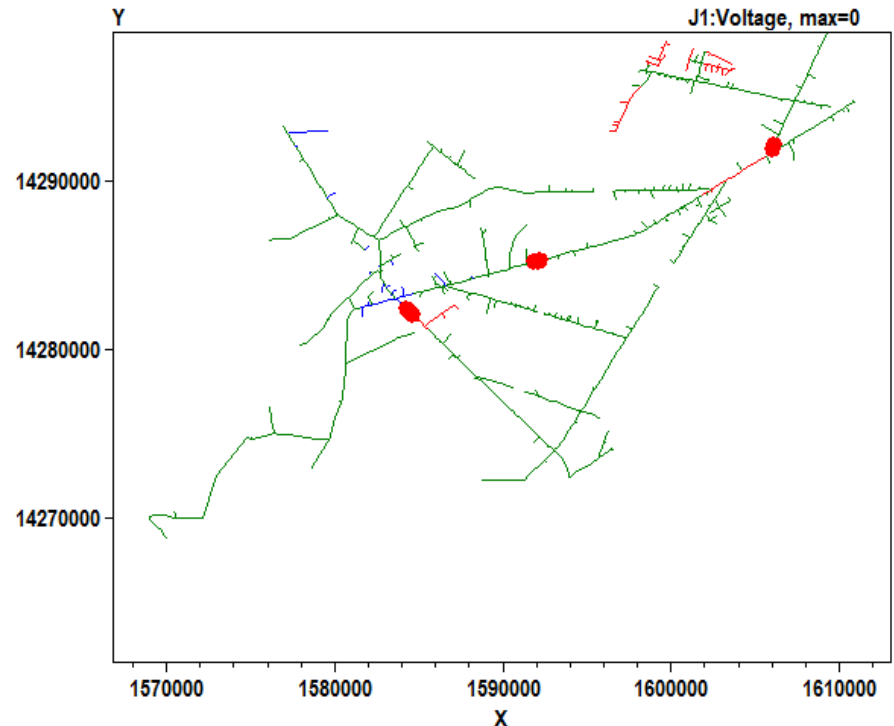
```
!-----  
! Sample Script files from EPRI's OpenDSS Training, June 7, 2013, Charlotte, NC.  
! ~ Jeff Smith, EPRI  
compile "C:\Projects\PV\OpenDSS model\master_nopv.dss"  
solve
```

```
!-----  
!Plot Circuit Power flow  
set markercode=24  
set markregulators=yes  
plot circuit power 1ph=3
```

```
!plot voltages  
set emergyminput=1.0  
set normvminpu=1.035  
plot circuit voltage
```

```
!plot profile  
set normvminpu=0.95  
plot profile phases = primary  
plot profile phases = all
```

```
!Minimum load case (approximate)  
set loadmult=.1  
solve  
plot profile phases = all
```





# Plotting Voltages as a Function of Distance

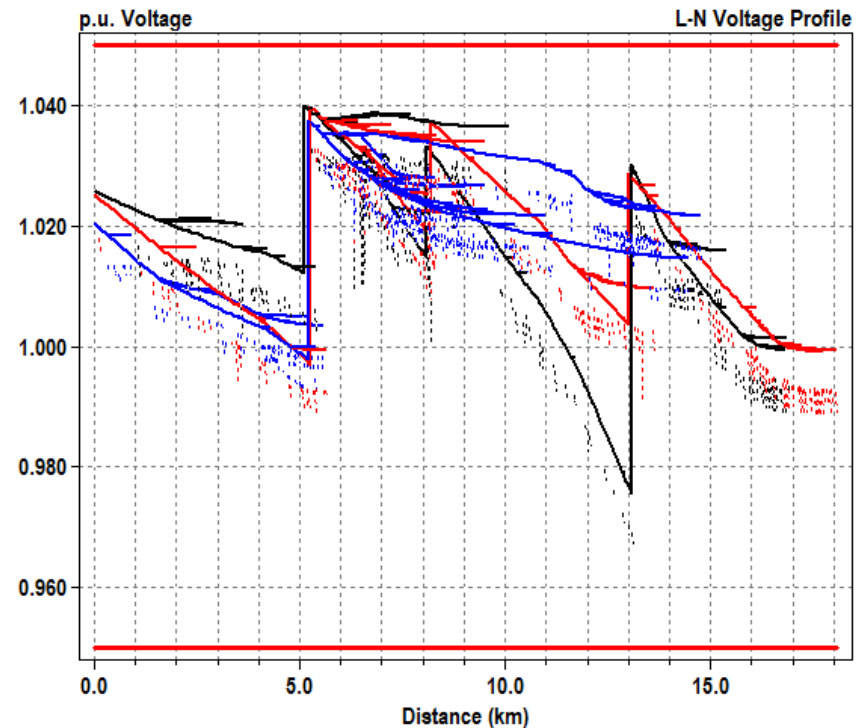
```
!-----  
! Sample Script files from EPRI's OpenDSS Training, June 7, 2013, Charlo  
! ~ Jeff Smith, EPRI  
compile "C:\Projects\PV\OpenDSS model\master_nopv.dss"  
solve
```

```
!-----  
!Plot Circuit Power flow  
set markercode=24  
set markregulators=yes  
plot circuit power 1ph=3
```

```
!plot voltages  
set emergyminput=1.0  
set normvminpu=1.035  
plot circuit voltage
```

```
!plot profile  
set normvminpu=0.95  
plot profile phases = primary  
plot profile phases = all
```

```
!Minimum load case (approximate)  
set loadmult=.1  
solve  
plot profile phases = all
```



# Adding PV to Model

```
!-----
! Sample Script files from EPRI's OpenDSS Training, June 7, 2013, Charlo
! ~ Jeff Smith, EPRI
compile "C:\Projects\PV\OpenDSS model\master_nopv.dss"
solve
```

```
!-----
!Plot Circuit Power flow
set markercode=24
set markregulators=yes
plot circuit power 1ph=3
```

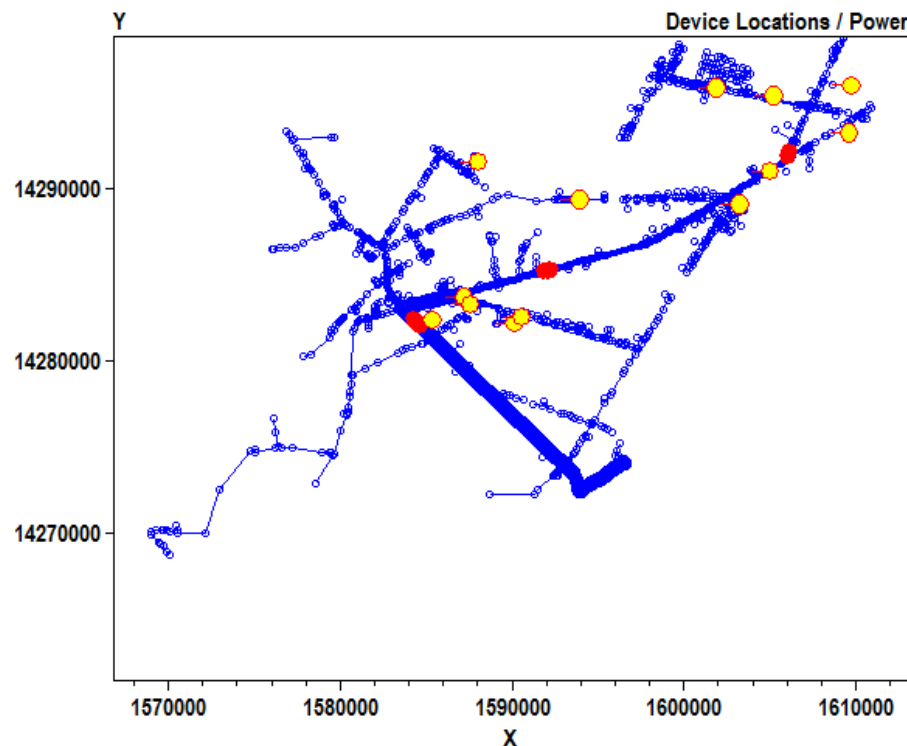
```
!plot voltages
set emergvminpu=1.0
set normvminpu=1.035
plot circuit voltage
```

```
!plot profile
set normvminpu=0.95
plot profile phases = primary
plot profile phases = all
```

```
!Minimum load case (approximate)
set loadmult=.1
solve
plot profile phases = all
```

```
!-Add PV to Circuit Model-----
Compile "C:\Projects\PV\OpenDSS model\master_nopv.dss"
solve
```

```
!Add PV
Redirect ExistingPV.dss
Set DaisySize=2.5
set markregulators=yes
plot daisy power max=2000 dots=y buslist={file=pvbuses.txt }
solve
plot profile phases = all
```

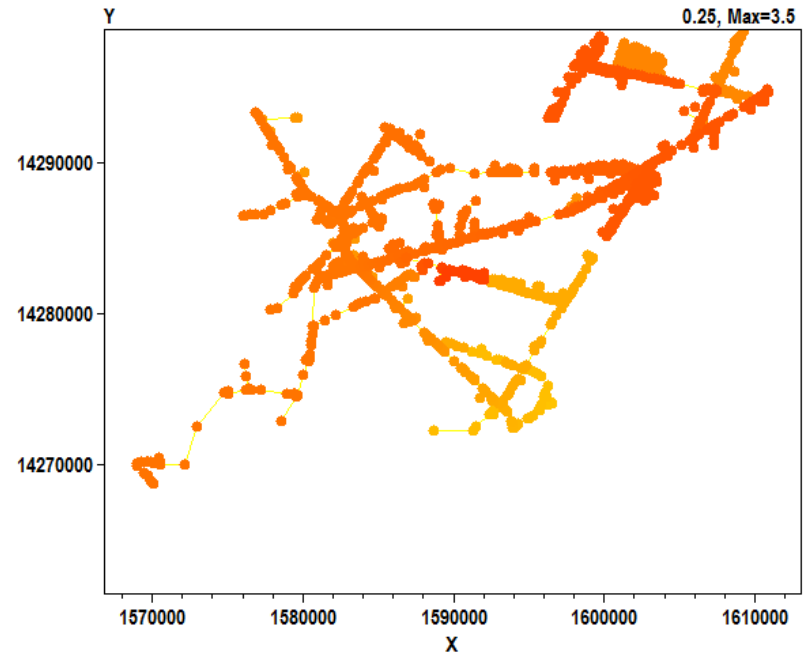
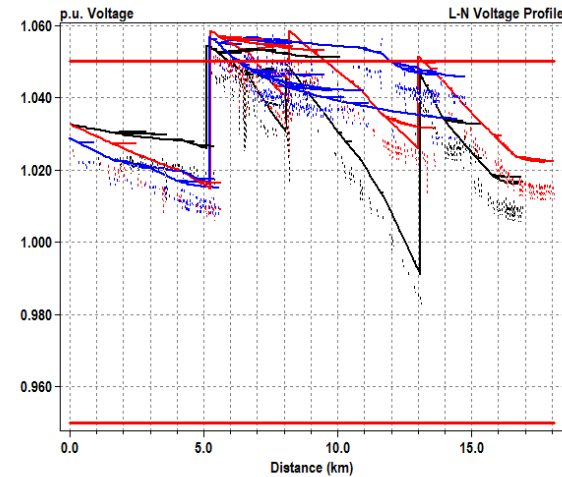


- Yellow dots indicate the existing PV on the feeder

# Voltage Change Test Impact from Existing PV

```
!-----Voltage Change Test-----  
compile "C:\Projects\PV\OpenDSS model\master_nopv.dss"  
solve  
save voltages  
Redirect ExistingPV.dss  
!Disable all controls  
set controlmode=off  
solve  
plot profile phases = all  
  
! Compare saved voltages to current case solved  
vdiff !creates voltage difference file  
set markercode=24 nodewidth=2.5  
!Plot difference in voltage between no-PV and with-PV cases  
plot general quantity=1 max=3.5 min=0.0 dots=y labels=n object=vdiff.csv
```

- Base case is executed
- Existing PV is added
- Controls are locked
- PV case is executed
- Voltage change is calculated



# Time Series Analysis

```
!----- Run Time Series Analysis-----
compile "C:\Projects\PV\OpenDSS model\master_nopv.dss"
Redirect ExistingPV.dss
solve
! - define PV curve
new loadshape.mypv npts=1800 sinterval=1 csvfile=strwplns1sec30min.csv
new monitor.PVSite4VI element=PVSystem.3P_ExistingSite4 terminal=1 mode=0
new monitor.PVSite4PQ element = Line.Site4_PV terminal=2 mode=65 ppolar=no
!Assign same PV curve to all PV systems (single curve used for demo only)
batchedit pvsystem.* daily=mypv

!- change solution mode
solve mode=daily stepsize=1s number=1800

batchedit pvsystem.* pf=-0.98

!-----Plotting-----
Export monitors pvsite4vi
Plot monitor object= pvsite4vi channels=(1 )
Export monitors pvsite4pq
Plot monitor object= pvsite4pq channels=(1 )
```

- PV generation curve follows measurement data
- Solution is for 30 minute period
- Voltage and Power are displayed

