COURSE CONTENT FOR TRANSIT TRAINING

1.1 INTRODUCTION TO BASIC NEPLAN FUNCTIONS - LOAD FLOW AND CONTROL OF DISTRIBUTED GENERATORS

1.1.1 Introduction

The electric power sector is currently experiencing a significant shift in its paradigm. The primary challenge lies in establishing a sustainable (carbon-free) and market-based framework for the sector, while still ensuring affordability. Global environmental awareness has led policymakers to craft initiatives centered around renewable and sustainable energy. Traditionally, power plants were located away from consumers, with electric power transmitted over long distances through high-voltage lines to consumption centers. Subsequently, the power was stepped down to lower voltage levels (medium and low voltage) before distribution to consumers.

Presently, there is a notable departure from this conventional structure. The integration of generation at medium and low voltage levels is on the rise, occurring within utility networks and behind-the-meter. This includes not only wind and solar photovoltaic (PV) sources but also small hydro, gas turbines, steam turbines, and microturbines. This form of generation is referred to as distributed generation (DG). Consequently, the distribution grid is transforming from a passive to an active system. Power flow is no longer unidirectional solely from the transmission grid to the distribution grid; it is bidirectional, changing direction at specific points in time and locations within the grid.

DG, alongside other energy vectors like gas and heat, as well as additional units such as thermal and electricity storage and controllable loads (demand response), collectively constitute distributed energy resources (DERs). DERs are expected to play a crucial techno-economic role in the future. Local generation and consumption of heat and electricity are anticipated to enhance energy efficiency, reduce carbon footprints, and bolster the reliability of electricity supply by minimizing line losses. Furthermore, DERs can maximize existing potential and delay the need for grid expansion.

However, the widespread adoption of numerous DERs presents new challenges in planning, operating, and controlling the grid safely, stably, and efficiently. Consequently, there is a growing demand for skills in modeling distribution grids and distribution generators using professional software. This is essential for analyzing how DG can be effectively controlled and utilized to improve the conditions of the electric power system in terms of voltage and power.

Throughout this training session, the utilization of NEPLAN software will be showcased in the demonstration of load flow and the control of distributed generators.

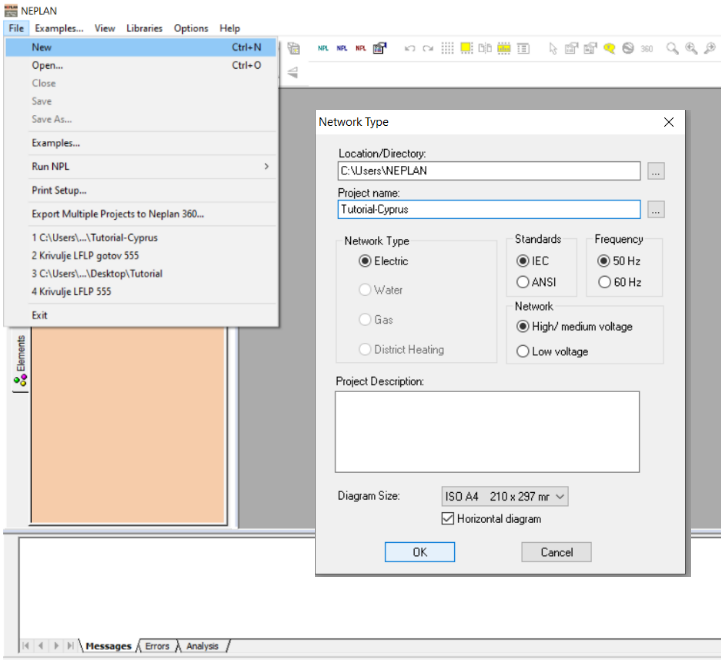
Funded by the European Union
Funded by UK Research and Innovation

1.1.2 Training description

In this exercise, the modeling of a section of the distribution grid will be conducted using NEPLAN software. The grid comprises voltage levels of 110 kV, 35 kV, 10 kV, and 0.4 kV, along with associated elements such as transformers, busbars, lines, loads, and distributed generators. The demonstration will begin by guiding the readers through the steps within NEPLAN to construct an electrical network. Subsequently, it will be illustrated how photovoltaic (PV) elements can contribute to a reduction in power losses within the grid. Finally, the training will cover methods for controlling PV elements, focusing on the management of both active and reactive power.

1.1.3 NEPLAN elements

To initiate a new project in the program, begin by clicking on the "File – New" menu after launching the application (Figure 1). Specify the location or directory where you want to save the project and enter the desired project name. Next, select the network type from options such as Electric, Water, or Gas. Optionally, you can provide a project description for reference. Customize the diagram size and choose the page orientation according to your preferences. Once these details are configured, proceed by pressing the OK button to confirm and create the new project, setting the foundation for your work within the software.



Network Type

Location/Directory: C:\Users\NEPLAN

Project name: Tutorial-Cyprus

Network Type: ● Electric ○ Water ○ Gas ○ District Heating

Standards: ● IEC ○ ANSI

Frequency: ● 50 Hz ○ 60 Hz

Network: ● High/ medium voltage ○ Low voltage

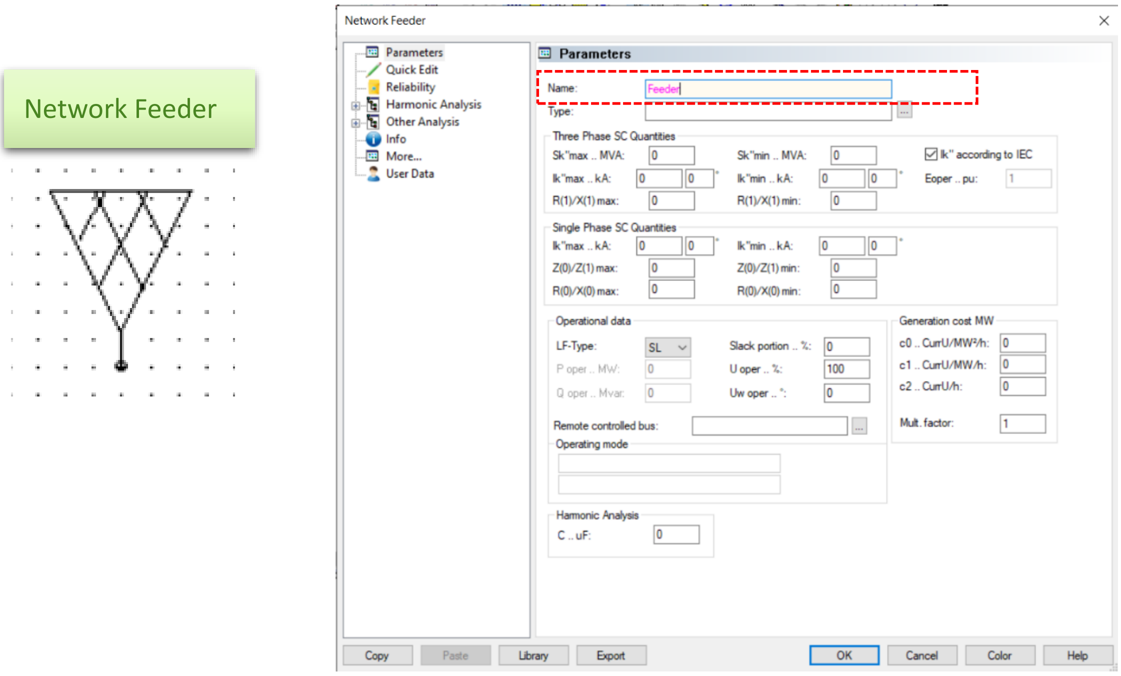
Project Description:

Diagram Size: ISO A4 210 x 297 mr

☑ Horizontal diagram

Figure 1. Create a new project

To add an element, utilize the "drag and drop" feature from the Elements toolbar situated in the right-side column. The initial required element is the "Network feeder" (Figure 2), serving as a representation of the entire Electric Power System (EPS). Generally, it symbolizes unlimited power and stable voltage, requiring only the entry of its name for load flow simulations.



Parameters

Name: Feeder
Type:

Three Phase SC Quantities
Sk"max .. MVA: 0
Sk"min .. MVA: 0
☑ Ik" according to IEC
Ik"max .. kA: 0 0 °
Ik"min .. kA: 0 0 °
Eoper .. pu: 1
R(1)/X(1) max: 0
R(1)/X(1) min: 0

Single Phase SC Quantities
Ik"max .. kA: 0 0 °
Ik"min .. kA: 0 0 °
Z(0)/Z(1) max: 0
Z(0)/Z(1) min: 0
R(0)/X(0) max: 0
R(0)/X(0) min: 0

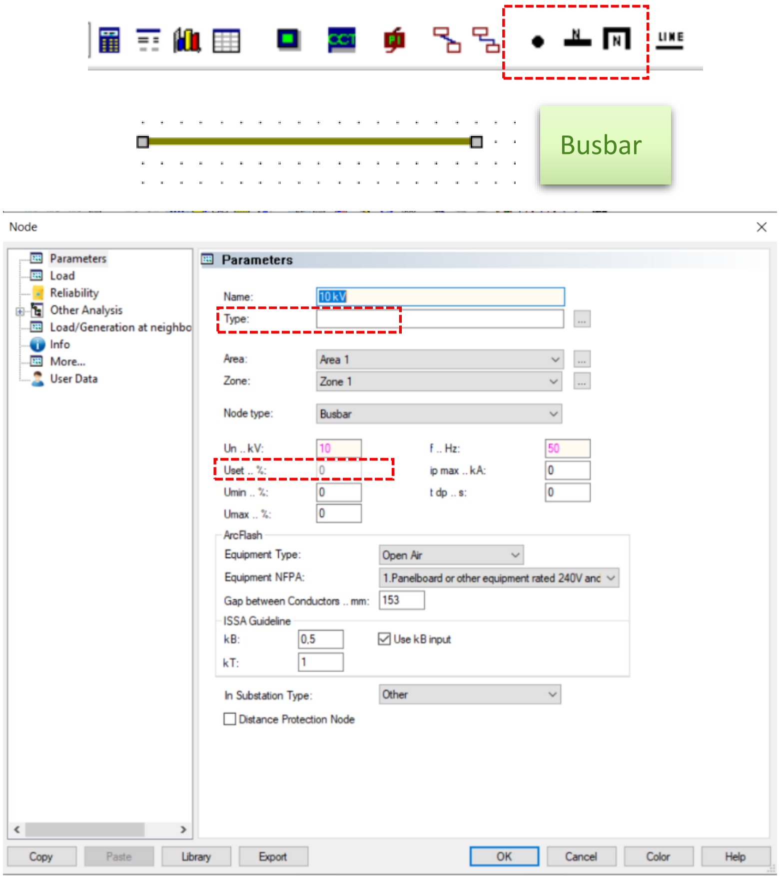
Operational data
LF-Type: SL
Slack portion .. %: 0
P oper .. MW: 0
U oper .. %: 100
Q oper .. Mvar: 0
Uw oper .. °: 0
Remote controlled bus:
Operating mode

Generation cost MW
c0 .. CurrU/MW²/h: 0
c1 .. CurrU/MW/h: 0
c2 .. CurrU/h: 0
Mult. factor: 1

Harmonic Analysis
C .. uF: 0

Figure 2. The Network feeder element (left) and parameters window (right)

Connect the Network feeder to the 35 kV busbar. The busbar element can be directly inserted from the toolbar (Figure 3), with parameters requiring only the definition of the name and nominal voltage.



Parameters

Name: 10 kV
Type:
Area: Area 1
Zone: Zone 1
Node type: Busbar
Un .. kV: 10
f .. Hz: 50
Uset .. %: 0
ip max .. kA: 0
Umin .. %: 0
t dp .. s: 0
Umax .. %: 0

ArcFlash
Equipment Type: Open Air
Equipment NFPA: 1.Panelboard or other equipment rated 240V anc
Gap between Conductors .. mm: 153

ISSA Guideline
kB: 0,5
☑ Use kB input
kT: 1

In Substation Type: Other
☐ Distance Protection Node

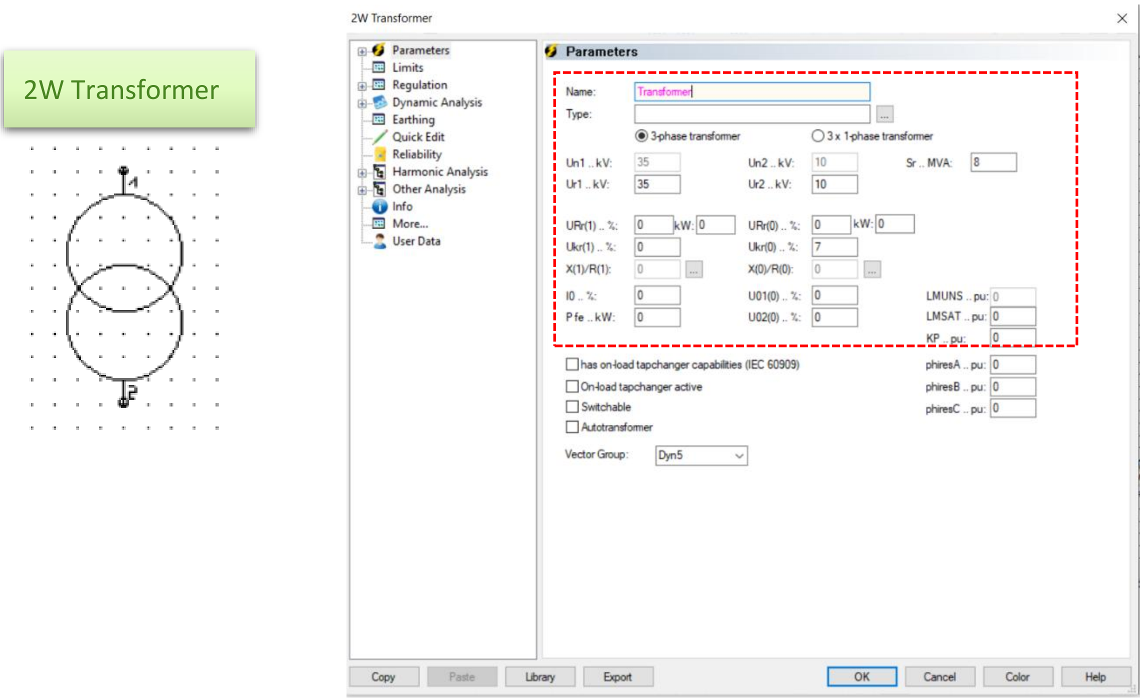
Figure 3. The toolbar (up), the busbar element (middle), and parameters window (down)

Funded by the European Union
Funded by UK Research and Innovation

To interconnect elements with elements or nodes, use the links from the toolbar (Figure 4).

Figure 4. Interconnectors

For stepping down the voltage from 35 kV to 10 kV, transformers are essential. The transformer element is of the two-port type, requiring the definition of parameters such as nominal voltages, power, resistance, and inductance in load flow simulations, in addition to the name (Figure 5). These parameters can be set manually or automatically using a library element.



Parameters

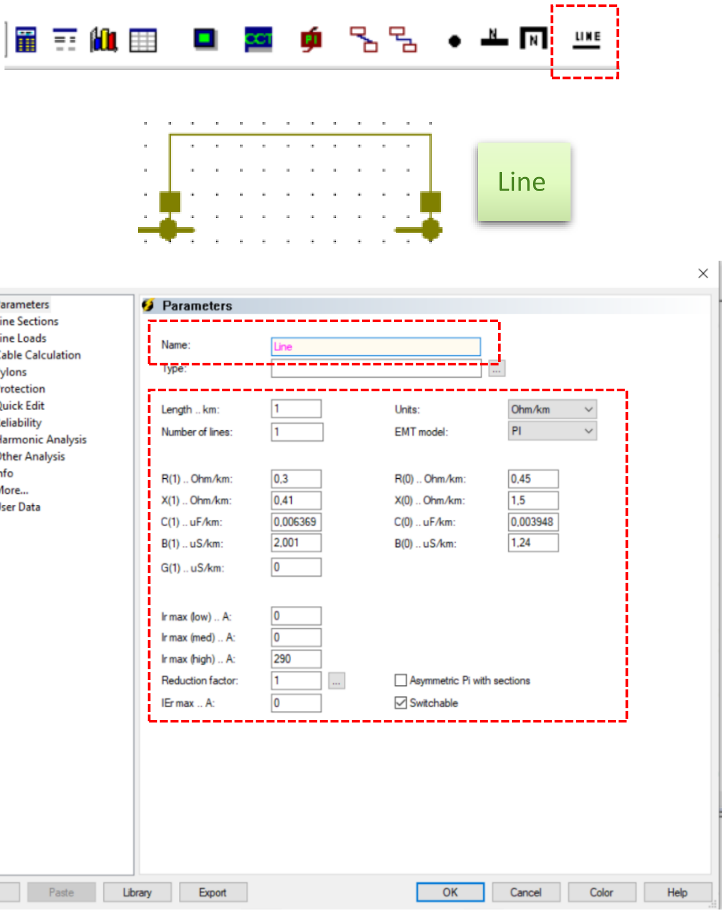
Name: Transformer
Type:
● 3-phase transformer ○ 3 x 1-phase transformer
Un1 .. kV: 35 Un2 .. kV: 10 Sr .. MVA: 8
Ur1 .. kV: 35 Ur2 .. kV: 10
URr(1) .. %: 0 kW: 0 URr(0) .. %: 0 kW: 0
Ukr(1) .. %: 0 Ukr(0) .. %: 7
X(1)/R(1): 0 X(0)/R(0): 0
I0 .. %: 0 U01(0) .. %: 0 LMUNS .. pu: 0
P fe .. kW: 0 U02(0) .. %: 0 LMSAT .. pu: 0
KP .. pu: 0
☐ has on-load tapchanger capabilities (IEC 60909) phiresA .. pu: 0
☐ On-load tapchanger active phiresB .. pu: 0
☐ Switchable phiresC .. pu: 0
☐ Autotransformer
Vector Group: Dyn5

Figure 5. The 2W Transformer element (left) and parameters window (right)

Connect the second port of the transformers to the 10 kV busbar. You can either insert a new busbar (Figure 3) or copy-paste an existing one, ensuring its nominal voltage is changed to 10 kV.

The modeled grid section so far represents a typical transformer substation. As these substations are often distant from consumers, the line element must be inserted to connect transformer substations with those closer to consumers. Note that both elements must be inserted before the line can be used. Repeat the aforementioned steps to create a 10/0.4 kV transformer substation. Once the second substation is established, connect the two substations with a line. The line element can be inserted from the toolbar (Figure 6), requiring the definition of the name, length, resistance, inductance, and capacitance for load flow simulations.

Finally, the last element to be inserted is the load element, a one-port element. In load flow simulations, define the name and nominal power (Figure 7). Ensure the loads are connected to the 0.4 kV busbars.



Line

Parameters

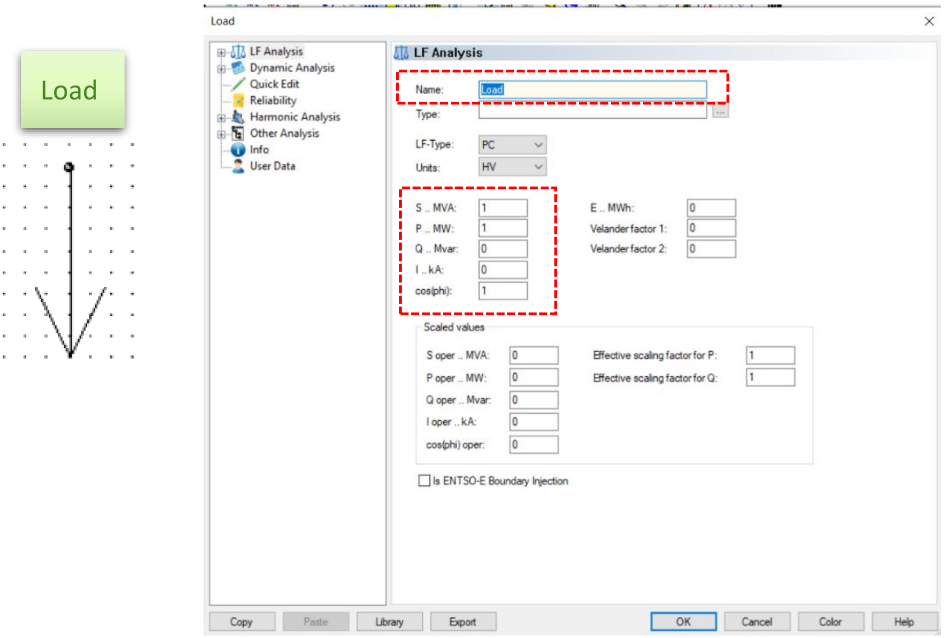
Name: Line
Type:

Length .. km: 1
Number of lines: 1
Units: Ohm/km
EMT model: PI

R(1) .. Ohm/km: 0,3
X(1) .. Ohm/km: 0,41
C(1) .. uF/km: 0,006369
B(1) .. uS/km: 2,001
G(1) .. uS/km: 0
R(0) .. Ohm/km: 0,45
X(0) .. Ohm/km: 1,5
C(0) .. uF/km: 0,003948
B(0) .. uS/km: 1,24

Ir max (low) .. A: 0
Ir max (med) .. A: 0
Ir max (high) .. A: 290
Reduction factor: 1
IEr max .. A: 0
☐ Asymmetric Pi with sections
☑ Switchable

Figure 6. The toolbar (up), the line element (middle), and parameters window (down)



Load

LF Analysis

Name: Load
Type:
LF-Type: PC
Units: HV

S .. MVA: 1
P .. MW: 1
Q .. Mvar: 0
I .. kA: 0
cos(phi): 1
E .. MWh: 0
Velander factor 1: 0
Velander factor 2: 0

Scaled values

S oper .. MVA: 0
P oper .. MW: 0
Q oper .. Mvar: 0
I oper .. kA: 0
cos(phi) oper: 0
Effective scaling factor for P: 1
Effective scaling factor for Q: 1

☐ Is ENTSO-E Boundary Injection

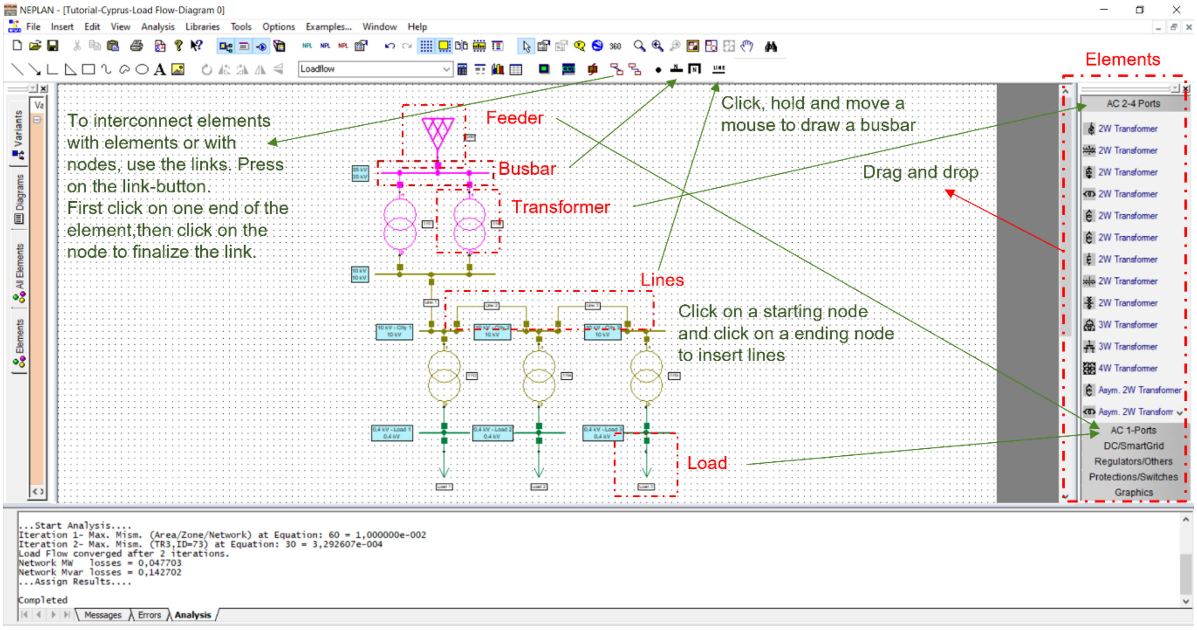
Figure 7. The load element (left) and parameters window (right)

Funded by the European Union

Funded by UK Research and Innovation

1.1.4 Grid Model

By following the procedure described above, one can now construct a complete distribution electrical grid, as illustrated in Figure 8, where all the steps are visible simultaneously.



To interconnect elements with elements or with nodes, use the links. Press on the link-button. First click on one end of the element,then click on the node to finalize the link.

Click, hold and move a mouse to draw a busbar

Drag and drop

Click on a starting node and click on a ending node to insert lines

```
...Start Analysis....
Iteration 1- Max. Mism. (Area/Zone/Network) at Equation: 60 = 1,000000e-002
Iteration 2- Max. Mism. (TR3,ID=73) at Equation: 30 = 3,292607e-004
Load Flow converged after 2 iterations.
Network MW   losses = 0,047703
Network Mvar losses = 0,142702
...Assign Results....

Completed
```

Figure 8. Comprehensive construction of a distribution electrical grid

Once the grid is constructed, the calculation process can be initiated. The commencement of calculation and the adjustment of calculation parameters are functionalities available on the toolbar (Figure 9). For basic load flow analyses, there's generally no need to modify parameters, but users have the option to make adjustments if they wish to modify settings, such as the calculation method.

Figure 9. Calculation and calculation parameters in the toolbar

Upon error-free completion of the calculation, results in terms of electrical quantities become available. To select and display specific results, right-click and navigate to diagram properties, then opt for load flow. Here, users can decide which variables to showcase, specify the units, determine the number of decimals, and make similar adjustments (Figure 10). Typically, the preferred variables for display in electrical grid analysis include the absolute values of voltage, current, active power, and element loading.

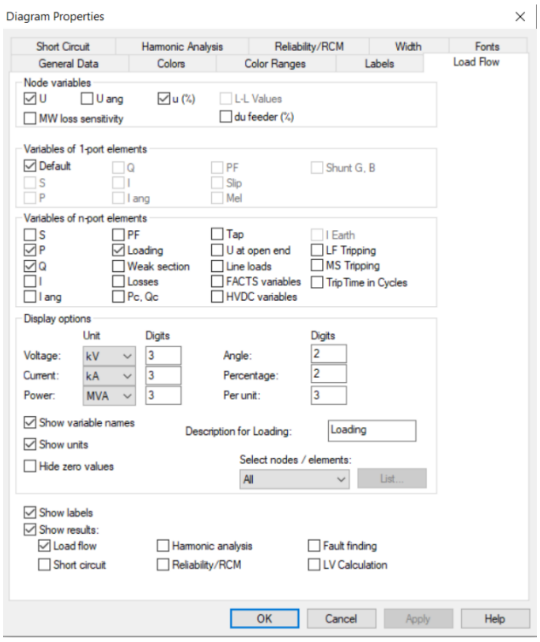


Diagram Properties

Short Circuit | Harmonic Analysis | Reliability/RCM | Width | Fonts
General Data | Colors | Color Ranges | Labels | Load Flow

Node variables
☑ U ☐ U ang ☑ u (%) ☐ L-L Values
☐ MW loss sensitivity ☐ du feeder (%)

Variables of 1-port elements
☑ Default ☐ Q ☐ PF ☐ Shunt G, B
☐ S ☐ I ☐ Slip
☐ P ☐ I ang ☐ Mel

Variables of n-port elements
☐ S ☐ PF ☐ Tap ☐ I Earth
☑ P ☑ Loading ☐ U at open end ☐ LF Tripping
☑ Q ☐ Weak section ☐ Line loads ☐ MS Tripping
☐ I ☐ Losses ☐ FACTS variables ☐ Trip Time in Cycles
☐ I ang ☐ Pc, Qc ☐ HVDC variables

Display options

	Unit	Digits		Digits
Voltage:	kV	3	Angle:	2
Current:	kA	3	Percentage:	2
Power:	MVA	3	Per unit:	3

☑ Show variable names
Description for Loading: Loading
☑ Show units
☐ Hide zero values
Select nodes / elements: All

☑ Show labels
☑ Show results:
☑ Load flow ☐ Harmonic analysis ☐ Fault finding
☐ Short circuit ☐ Reliability/RCM ☐ LV Calculation

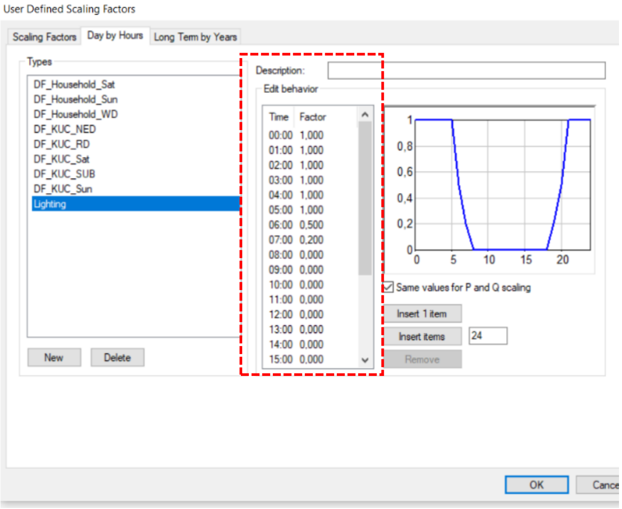
Figure 10. Result properties

Funded by the European Union
Funded by UK Research and Innovation

1.1.5 Load flow with load profiles

Load Flow is employed when the focus is on determining power output at a specific moment. However, for scenarios where the variability of consumption throughout a day or week needs to be considered, the Load Flow with Load Profiles option in NEPLAN becomes essential. It offers a series of power flow calculations, yielding comprehensive results such as energy, voltage, current, and power ranges within the considered timeframe. Additionally, it provides time diagrams for various parameters like voltage, currents, and loadings. To execute Load Flow with Load Profiles (LFLP), users must input the start and end of the observed interval along with the desired time step, such as 15 minutes. Additionally, in order to carry out Load Flow with Load Profiles (LFLP), users are required to assign load curves to consumers.

The load curve can be configured within the NEPLAN GUI by utilizing the "CTRL+G" shortcut and navigating to the "Day by Hours" tab. Here, users can shape the load curve by specifying power in per unit (Factor) for each timestamp, as illustrated in Figure 11. Following this, the created curves must be associated with specific days of the week, a task accomplished in the "Scaling Factors" tab, as depicted in Figure 12. Lastly, the defined curves need to be assigned to either loads or generators. This allocation can be executed through the properties of the respective element, accessing the "Scaling Factors" tab under LF Analysis.



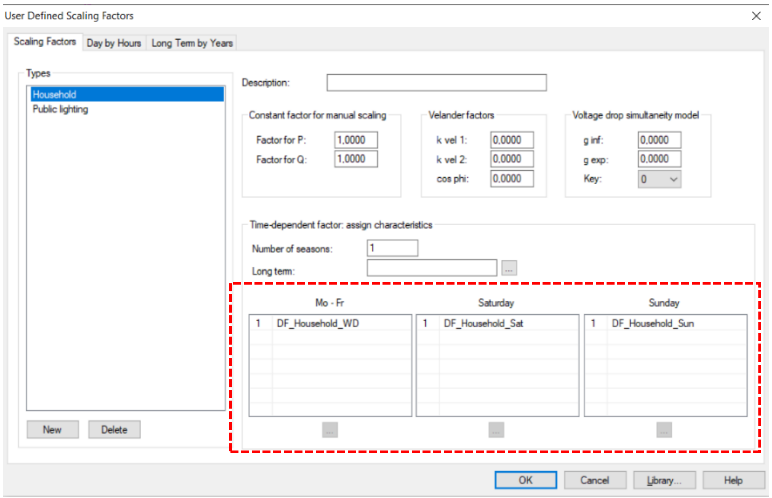
Types:
- DF_Household_Sat
- DF_Household_Sun
- DF_Household_WD
- DF_KUC_NED
- DF_KUC_RD
- DF_KUC_Sat
- DF_KUC_SUB
- DF_KUC_Sun
- Lighting

Time	Factor
00:00	1,000
01:00	1,000
02:00	1,000
03:00	1,000
04:00	1,000
05:00	1,000
06:00	0,500
07:00	0,200
08:00	0,000
09:00	0,000
10:00	0,000
11:00	0,000
12:00	0,000
13:00	0,000
14:00	0,000
15:00	0,000

☑ Same values for P and Q scaling

Insert items: 24

Figure 11. Load curve configuration



Types:
- Household
- Public lighting

Factor for P: 1,0000
Factor for Q: 1,0000
k vel 1: 0,0000
k vel 2: 0,0000
cos phi: 0,0000
g inf: 0,0000
g exp: 0,0000
Key: 0
Number of seasons: 1
Long term:

Mo - Fr	Saturday	Sunday
1 DF_Household_WD	1 DF_Household_Sat	1 DF_Household_Sun

Figure 12. Assigning the load curve to the days of the week

Accessing LFLP parameters is achieved through the toolbar, as illustrated in Figure 13. It is imperative to specify the time simulation duration, such as one week, as depicted in Figure 14a. Additionally, users should opt for "Combine constant and time-dependent scaling factors" (Figure 14b) and define the number of seasons along with the commencement date (Figure 14c).

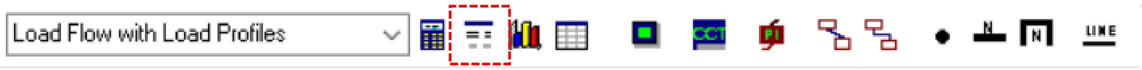
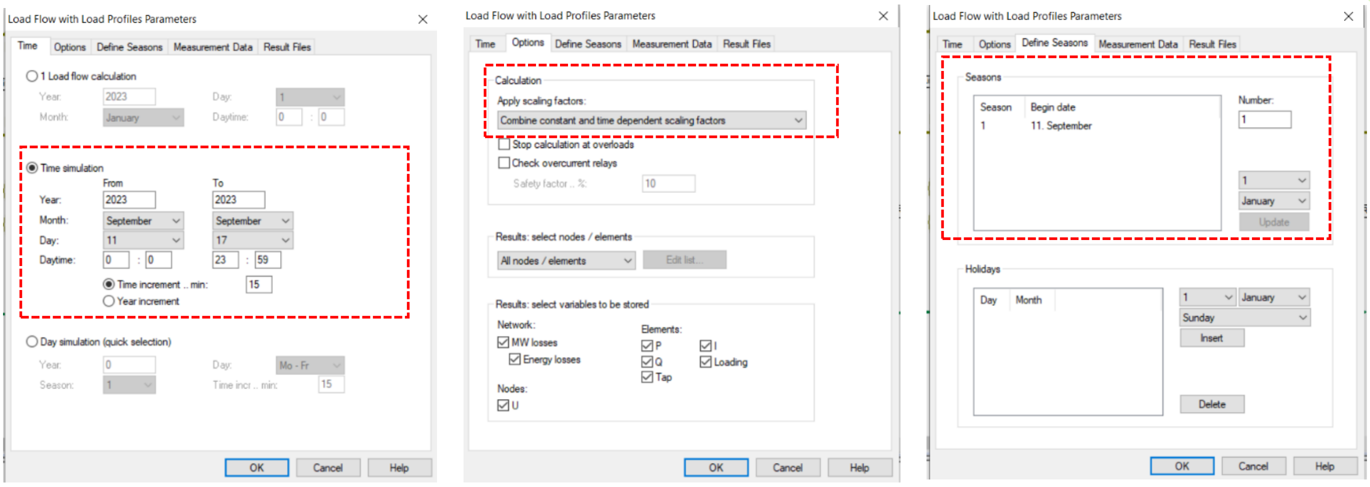

Load Flow with Load Profiles

Figure 13. LFLP parameters in the toolbar

Funded by the European Union
Funded by UK Research and Innovation



a) Time tab:

○ 1 Load flow calculation
Year: 2023 Month: January Day: 1 Daytime: 0 : 0

● Time simulation
From Year: 2023 Month: September Day: 11 Daytime: 0 : 0
To Year: 2023 Month: September Day: 17 Daytime: 23 : 59
● Time increment .. min: 15
○ Year increment

○ Day simulation (quick selection)
Year: 0 Season: 1 Day: Mo - Fr Time incr .. min: 15

b) Options tab:

Calculation
Apply scaling factors: Combine constant and time dependent scaling factors
☐ Stop calculation at overloads
☐ Check overcurrent relays
Safety factor .. %: 10

Results: select nodes / elements
All nodes / elements — Edit list...

Results: select variables to be stored
Network: ☑ MW losses ☑ Energy losses
Nodes: ☑ U
Elements: ☑ P ☑ Q ☑ Tap ☑ I ☑ Loading

c) Define Seasons tab:

Seasons

Season	Begin date
1	11. September

Number: 1
1 — January — Update

Holidays

Day	Month

1 — January — Sunday — Insert — Delete

Figure 14. LFLP parameters: a) Time simulation, b) Type of scaling factors, c) Defining seasons.

Now, all preparations are complete for the calculation. Initiating the calculation and displaying the results can be performed through the toolbar, as depicted in Figure 15. Within the chart settings, users have the flexibility to define various preferences, including element type, variable, units, and axes settings, among others, as showcased in Figure 16.

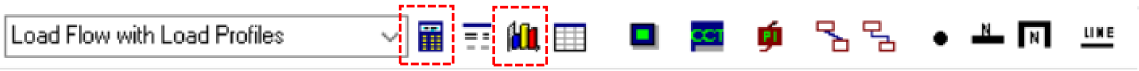
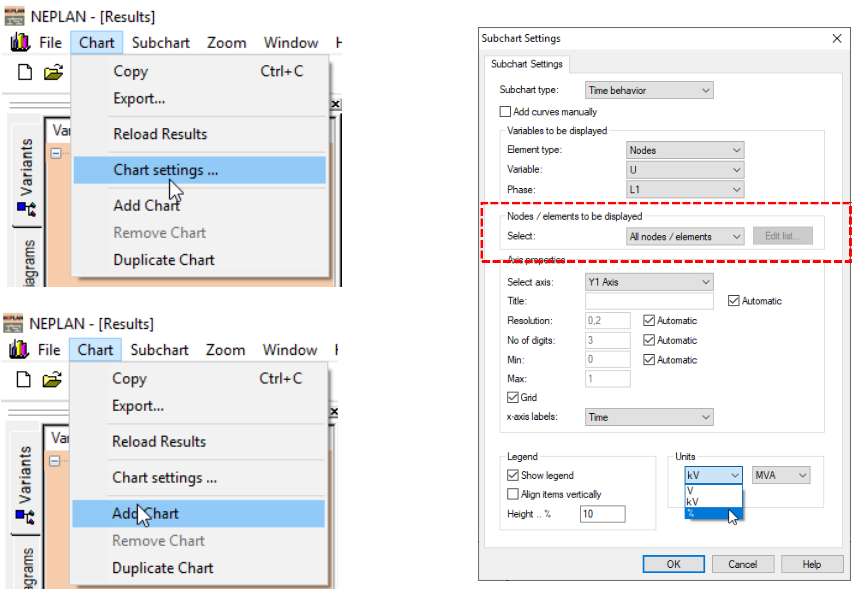


Figure 15. LFLP Calculation and Chart Settings



Subchart Settings

Subchart type: Time behavior
☐ Add curves manually

Variables to be displayed
Element type: Nodes
Variable: U
Phase: L1

Nodes / elements to be displayed
Select: All nodes / elements — Edit list...

Axis properties
Select axis: Y1 Axis
Title: ☑ Automatic
Resolution: 0,2 ☑ Automatic
No of digits: 3 ☑ Automatic
Min: 0 ☑ Automatic
Max: 1
☑ Grid
x-axis labels: Time

Legend
☑ Show legend
☐ Align items vertically
Height .. %: 10

Units
kV (V, kV, %) — MVA

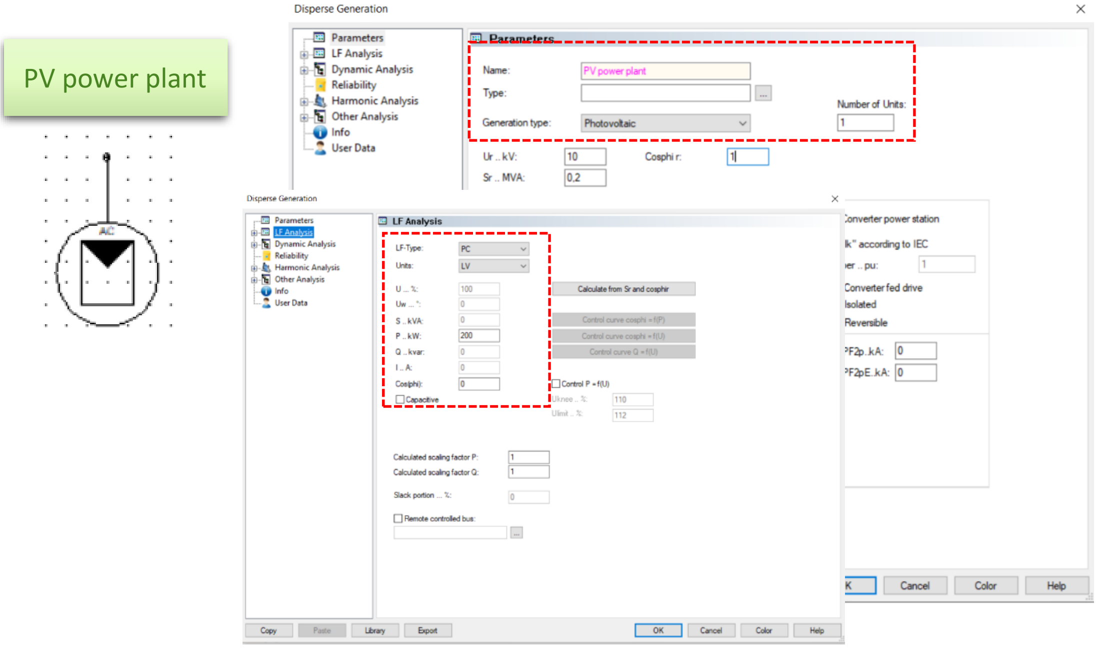
Figure 16. Chart Settings

Funded by the European Union
Funded by UK Research and Innovation

1.1.6 Control of distributed generators

In the realm of distributed power generation, control mechanisms play a key role in ensuring efficient and reliable operation. Particularly for power plants connected via power electronics, precise control methods are essential to optimize their performance. One critical aspect of control involves the management of reactive power, which is contingent upon voltage variations. In addition to reactive power, the control of active power is equally significant, with various strategies employed to modulate its output. In NEPLAN, these strategies include active power control dependent on voltage (P=f(U)), as well as several approaches to reactive power control, such as power factor as a function of active power (cos(ϕ) = f(P)) or direct correlation with voltage (Q = f(U)). Such control techniques are fundamental in regulating distributed generators to meet operational requirements and grid stability mandates.

To incorporate a photovoltaic (PV) power plant into the system, locate a dispersed generation element. Within the properties of this element, users can specify the generation type as photovoltaic. In load flow simulations, it is essential to define the name, nominal power, and nominal voltage for the PV power plant, as illustrated in Figure 17.



Parameters

Name: PV power plant
Type:
Generation type: Photovoltaic
Number of Units: 1
Ur .. kV: 10
Cosphi r: 1
Sr .. MVA: 0,2

LF Analysis

LF-Type: PC
Units: LV
U ... %: 100
Uw ... °: 0
S .. kVA: 0
P .. kW: 200
Q .. kvar: 0
I .. A: 0
Cos(phi): 0
☐ Capacitive
☐ Control P = f(U)
Uknee .. %: 110
Ulimit .. %: 112
Calculated scaling factor P: 1
Calculated scaling factor Q: 1
Slack portion ... %: 0
☐ Remote controlled bus:
er .. pu: 1
PF2p..kA: 0
PF2pE..kA: 0

Figure 17. The PV power plant element (left) and parameters window (right)

To configure the PV element effectively, users need to generate and assign a typical generation curve. This process involves following the steps outlined in Figures 11 and 12.

When the PV element is connected to the farthest busbar in the grid shown in Figure 8, a comparison of power losses can be made between scenarios with and without the PV power plant. Figure 18 illustrates the comparison of power losses, highlighting a noticeable reduction during daylight hours. This reduction is attributed to the PV power plant generating power exclusively during daylight, resulting in lower losses. Conversely, power losses remain consistent during nighttime hours when the PV power plant is not producing power.

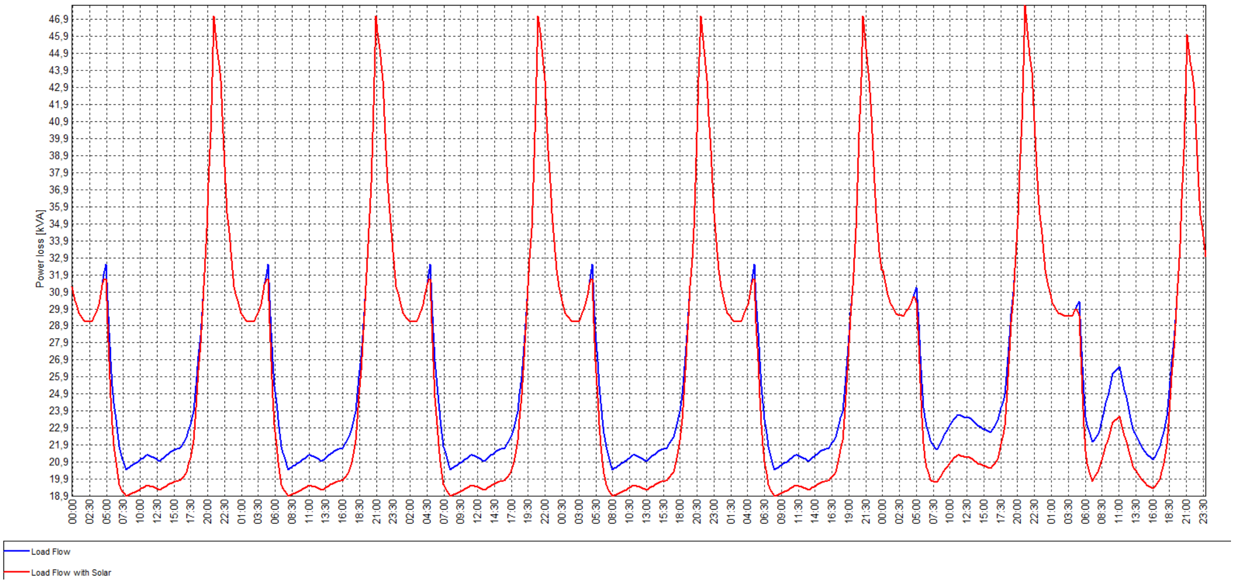
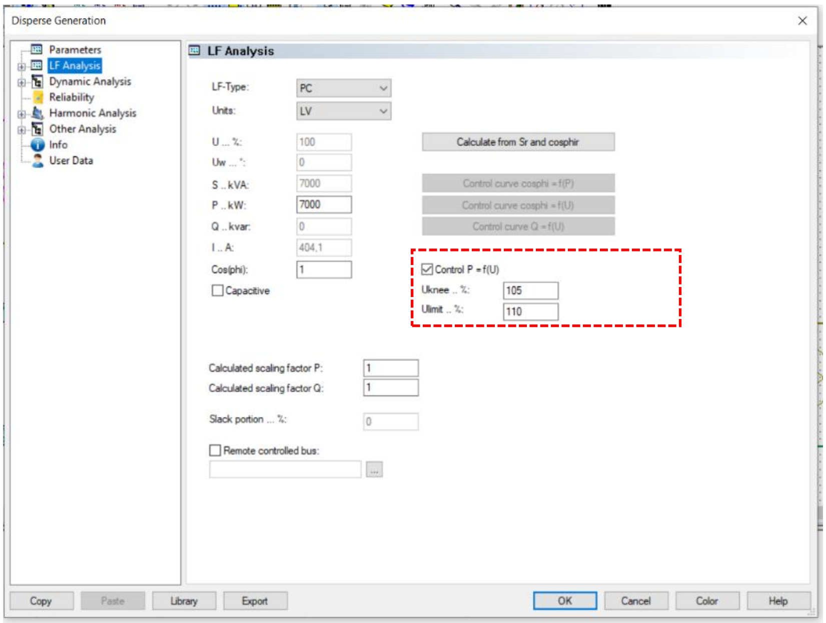


Figure 18. Comparison of grid power losses with and without the PV power plant



LF Analysis

LF-Type: PC
Units: LV
U ... %: 100
Uw ... °: 0
S .. kVA: 7000
P .. kW: 7000
Q .. kvar: 0
I .. A: 404,1
Cos(phi): 1
☐ Capacitive
☑ Control P = f(U)
Uknee .. %: 105
Ulimit .. %: 110
Calculated scaling factor P: 1
Calculated scaling factor Q: 1
Slack portion ... %: 0
☐ Remote controlled bus:

Figure 19. *P*=*f*(*U*) settings

In managing active power in relation to voltage, two critical parameters must be specified, as illustrated in Figure 19. The first parameter is *Uknee*, representing the voltage up to which the power plant produces without limitations. The second parameter is *Ulimit*, denoting the voltage at which the power plant ceases production. The decline between these two voltage points follows a linear pattern. As an example, when the voltage reaches 109% of the nominal voltage (Un), the power plant will generate 20% of its rated power (Sn), as indicated in the initial screen displaying these parameters. This approach is particularly relevant when dealing with production curves, such as those associated with solar power, where the reduction in power output signifies the upper limit of the system's capability.

The example illustrated in Figure 20 demonstrates a notable reduction in the maximum PV power from 8 MW (nominal power) to approximately 4.2 MW, attributed to the preventive measures against high voltage conditions. The implemented control mechanism i.e. *P*=*f*(*U*) ensures that power reduction initiates when the voltage surpasses 105%. Consequently, the voltage stabilizes at 107%, aligning with stability conditions, as most grid codes permit a 10% allowable increase in voltage. This control strategy effectively prevents voltage levels from reaching critical thresholds, promoting stability within the electrical grid.

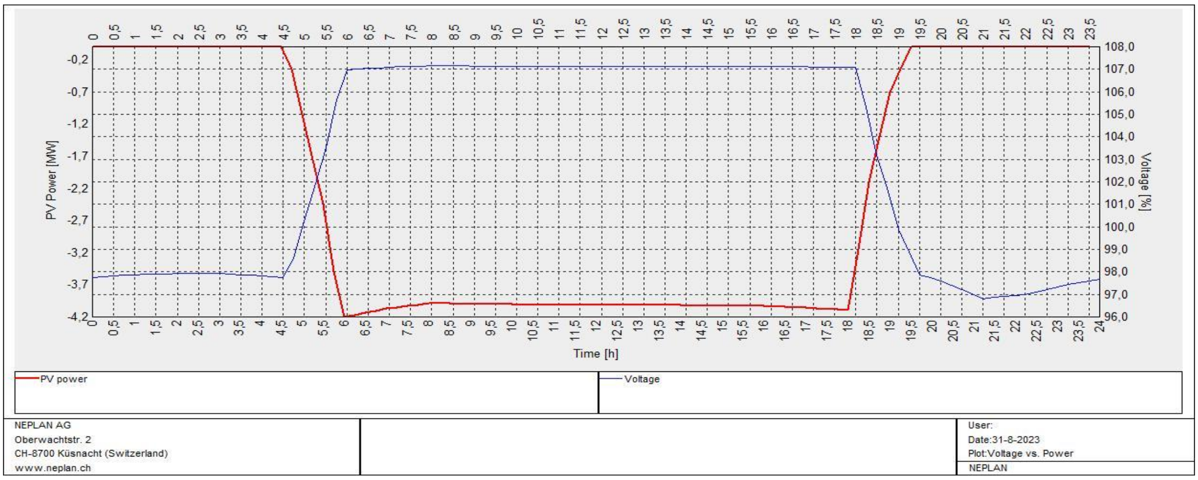
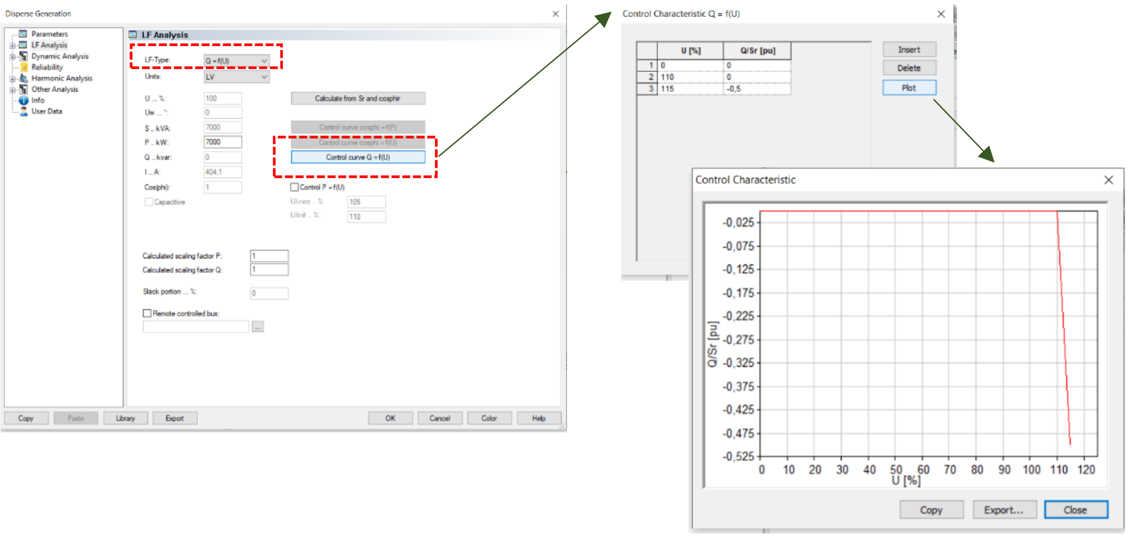


Figure 21. PV power plant active power as a function of voltage

Concerning reactive power control, power plants connected through power electronics, such as inverters or converters, present a diverse range of options. While active power is constrained by the primary energy source, the control of reactive power is only limited by the inverter's topology. Typically, reactive power control follows the relationship $Q=f(U)$. Notably, the power plant can adjust reactive power without necessitating a change in active power. However, within NEPLAN, for this control to be effectively implemented, a minimum active power value is mandatory (Figure 11, “Factor” needs to be at least 0.001).

The configuration of reactive power control can be established within LF analysis, specifically within the Dispersed Generation element properties, as demonstrated in Figure 22. For this specific control method, it is imperative to adjust the control characteristic, essentially defined by Q graphs in dependence on voltage U. In the presented case in Figure 22, the reactive power consumption remains at 0 until the voltage reaches 110%, after which it initiates a linear increase in reactive power consumption up to 115%. This modification allows for precise management of reactive power behavior in response to voltage fluctuations within the electrical grid. Put differently, under conditions of either low or high voltage, the PV element possesses the capability to generate or absorb reactive power, effectively mitigating and counteracting voltage fluctuations within the system. In Figure 23, the graphical representation displays the reactive power generated by the PV element and the corresponding busbar voltage where the PV is interconnected. The noticeable trend indicates that the PV element begins absorbing reactive power (depicted by the blue line) once the voltage (represented by the red line) reaches the predefined threshold of 110%. Through this reactive power absorption, the voltage stabilizes at 110%, preventing any further increase.

Funded by the European Union
Funded by UK Research and Innovation



Disperse Generation

LF Analysis

LF-Type: Q = f(U)

Units: LV

U ... %: 100

Uw ... °: 0

S .. kVA: 7000

P .. kW: 7000

Q .. kvar: 0

I .. A: 404,1

Cos(phi): 1

☐ Capacitive

☐ Control P = f(U)

Uknee .. %: 105

Ulimit .. %: 110

Calculated scaling factor P: 1

Calculated scaling factor Q: 1

Slack portion ... %: 0

☐ Remote controlled bus:

Control Characteristic Q = f(U)

	U [%]	Q/Sr [pu]
1	0	0
2	110	0
3	115	-0,5

Figure 22. *Q*=*f*(*U*) settings

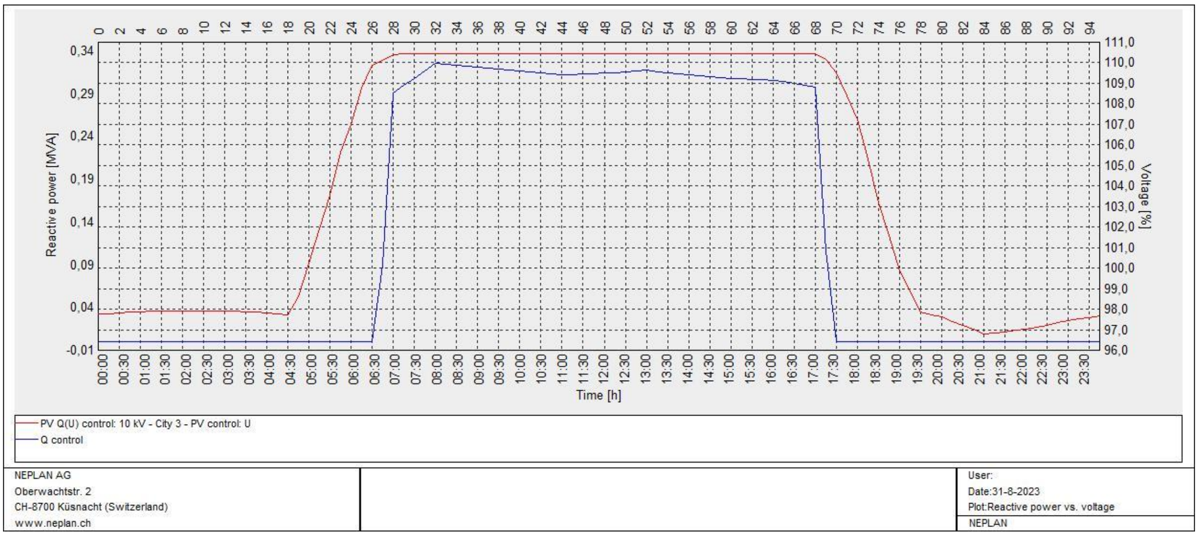


Figure 23. PV power plant reactive power as a function of voltage

1.1.7 Contribution to development of low carbon technologies, sustainability, and circularity

This topic holds significant importance in advancing the development and utilization of low carbon technologies, promoting sustainability within the energy sector. By delving into load flow analysis and the control of distributed generators, NEPLAN empowers users to model, simulate, and optimize electrical distribution grids. This capability is pivotal in the integration of renewable energy sources, such as photovoltaic (PV) power plants, into the grid. Furthermore, the control features for distributed generators, especially in managing reactive power, contribute to grid stability and resilience. The ability to modulate reactive power in response to voltage fluctuations aids in maintaining optimal operating conditions and preventing grid instabilities. This is particularly

Funded by
the European Union

Funded by
UK Research
and Innovation

relevant in the context of low carbon technologies, as it ensures the reliable integration of renewable energy sources, contributing to the reduction of greenhouse gas emissions.

1.1.8 Highlight on application in industry

The knowledge elaborated in the materials regarding load flow analysis and the control of distributed generators using NEPLAN offers numerous possibilities for application in the industry. Industries can use NEPLAN to assess the impact of integrating renewable energy sources into their grids, optimize their operation, and manage grid stability with the fluctuating output of these sources. By analyzing load profiles and understanding energy consumption patterns, industries can implement demand response strategies to adjust their electricity usage in response to grid conditions or price signals, contributing to grid stability and reducing energy costs. In addition, the ability to analyze control of distributed generators, especially with a focus on reactive power and load profiles, is crucial for the seamless integration of renewable energy sources. Industries can leverage this knowledge to optimize the use of solar, wind, and other distributed energy resources, reducing dependency on traditional power sources and contributing to sustainability goals.

In conclusion, applying the knowledge gained from load flow analysis and distributed generator control using NEPLAN is versatile. From optimizing energy usage to ensuring grid stability and compliance with sustainability goals, these capabilities offer valuable insights and tools for industries to succeed in an increasingly dynamic and sustainable energy landscape.

1.1.9 Contribution to development of skills and competences

The training on load flow analysis and the control of distributed generators using NEPLAN significantly contributes to the development of skills and competencies for employees in the industry and other stakeholders. The training on load flow analysis and the control of distributed generators using NEPLAN plays a key role in promoting the professional development of industry employees and other stakeholders. Through hands-on experience with NEPLAN software, participants gain technical proficiency, grid optimization skills, and expertise in integrating renewable energy sources, thereby contributing to sustainable energy initiatives. The training forms problem-solving abilities in addressing challenges related to grid stability, reactive power control, and voltage fluctuations, empowering professionals in real-world industrial settings. Participants are equipped with insights into smart grid technologies and how they can be used to improve system conditions within the distribution grid.