F-Chart Software

No. 51, Fall 2026

EESy Solutions

Engineering Equation Solver Newsletter

Inside this issue:

Welcome	1
AI Skill and Launcher	1
Features of the AI Skill and Launcher	2
Example of AI-Assisted Calculation w/EES	2
The EES_COOLPROP Interface	4
EES_COOLPROP Interface Example	6
Selected Recent Changes to EES	8
Instant Update and Technical Service	8

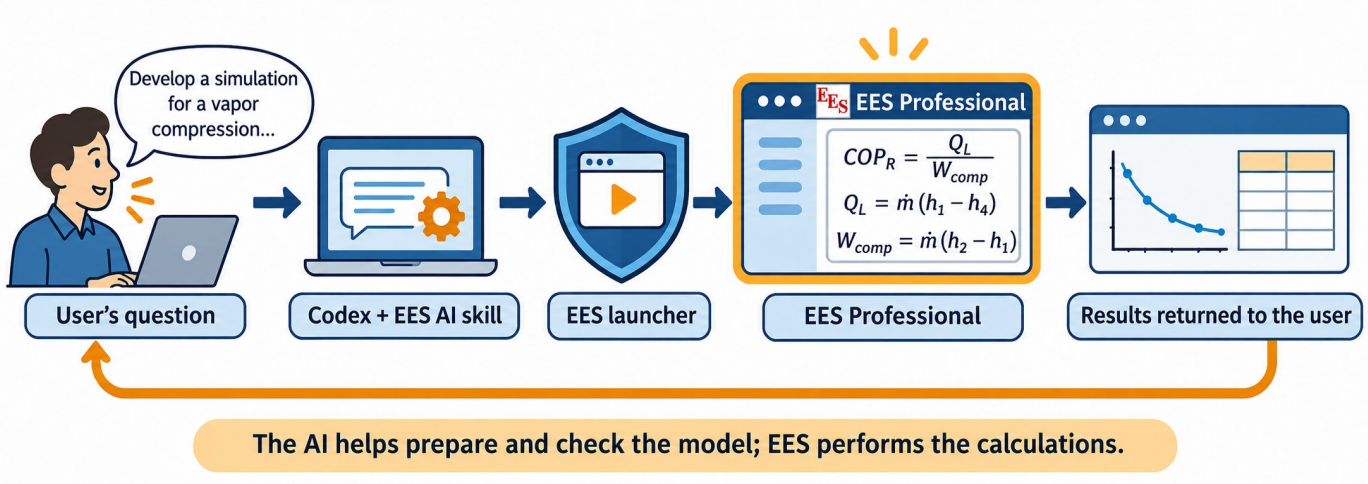
Welcome

This is the 51st issue of EESy Solutions, a newsletter that provides news, tips, and other updates for users of the Engineering Equation Solver software. This issue describes some of the recently added features, updates, and improvements to the program. These include a new skill that allows EES to be run agentically using AI. The skill was developed specifically for Codex but is adaptable to other AI models. An EES-to-CoolProp interface (EES_COOLPROP) has also been developed that facilitates calling the property routine CoolProp from within EES.

EES has been commercially available for almost three decades and during that time it has been continuously maintained and improved. Previous issues of EESy Solutions can be downloaded from: https://fchartsoftware.com.

AI Skill and Launcher

An EES AI skill and launcher is available that allows Codex in the ChatGPT desktop app to work directly with EES. Examination of the skill should allow other AI models to also work more efficiently with EES. A user can describe an engineering problem in ordinary language, and the skill helps the AI find appropriate EES functions, prepare the equations, run the model, and review the results. The launcher provides a controlled connection between the AI and the copy of EES installed on the user's computer. EES remains the calculation engine, so a licensed copy of EES Professional is required.



Instructions to download and use the AI Skill and Launcher are provided at:

https://fchartsoftware.com/ees/ees_codex/

and a video showing how to install and use it can be accessed at: https://youtu.be/c3npJXIA0jE

Features of the AI Skill and Launcher

An AI tool with access to your computer can open and run a licensed copy of EES without the EES Skill or Launcher. However, the Skill and Launcher make this process more reliable, consistent, and secure.

- The **EES Skill** teaches the AI about EES syntax, units, library functions, model construction, and results checking.
- The **Launcher** provides a tested way to send a model to EES, solve it, return the results (including plots), and capture any warning or error messages.
- Models and results are kept in a defined workspace, making calculations easier to reproduce and inspect.
- Built-in checks reduce common problems involving incorrect commands, missing output, stalled calculations, and inappropriate file access.

EES still performs all of the calculations; the Skill and Launcher simply help the AI use it correctly. The EES Skill and Launcher can reduce AI token use by several-fold compared with using an ad hoc approach and by approximately an order of magnitude compared with having AI control EES directly through the graphical interface.

Example of AI-Assisted Calculations with EES

Once the skill and launcher have been installed and verified, as described here, it's possible to use them to carry out AI-assisted engineering design using EES.

As an example, let's ask Codex to design a 100 kW CO2/ammonia cascade refrigeration cycle. This can show how the AI turns a written design request into an EES model and runs a design sweep through the EES launcher. The AI is able to include additional design considerations. For example it can reject designs that violate a compressor-temperature limit and select the best feasible design. EES performs the property and equation calculations; the AI prepares, runs, inspects, and explains the model and interprets the results. Further prompts can ask the AI to provide details of the cycle or refine the model through the use of more detailed models of the components that are involved. It can also build property plots, carry out parametric studies, etc.

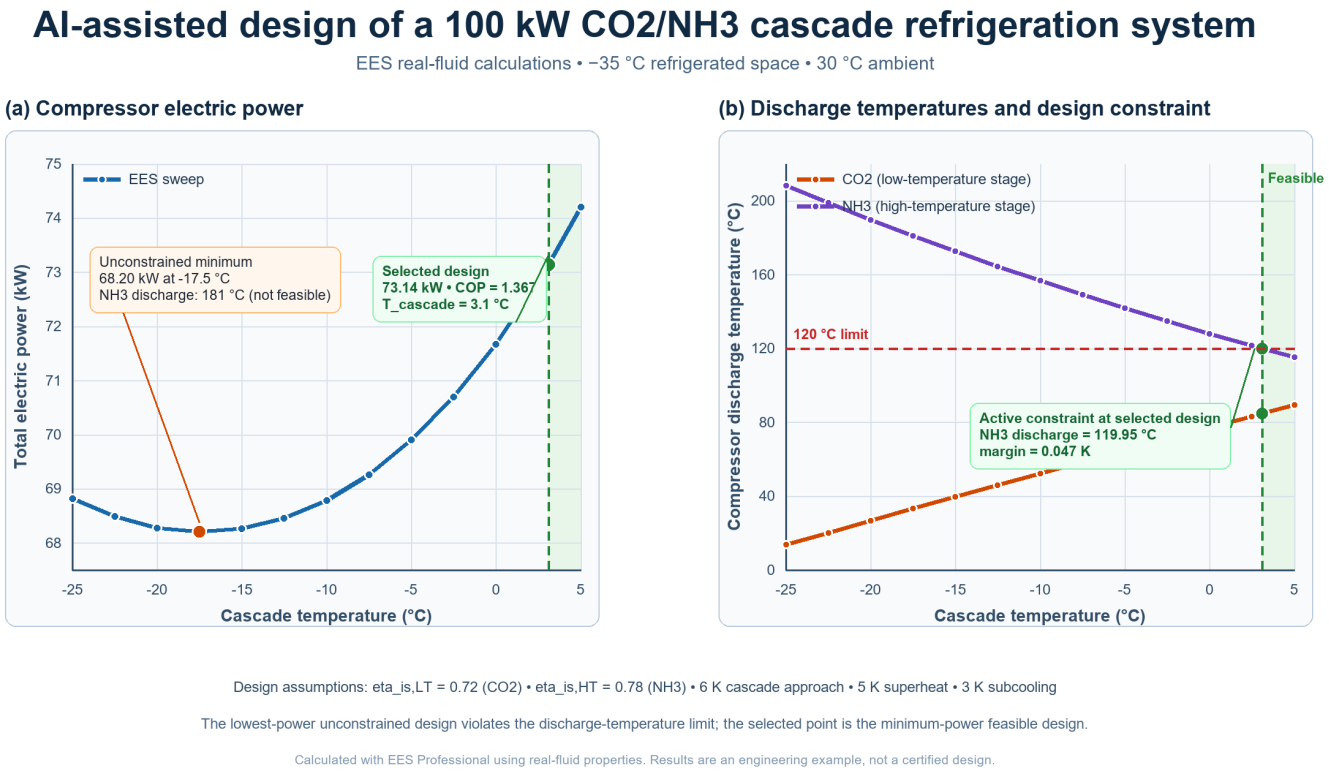
> Use EES to design a cascade refrigeration system that provides 100 kW of cooling to a -35°C refrigerated space and rejects heat to 30°C ambient air. Use carbon dioxide in the low-temperature circuit and ammonia in the high-temperature circuit. Assume a 5 K evaporator approach, a 10 K condenser approach, a 6 K cascade heat-exchanger approach, 5 K of superheat, and 3 K of subcooling in both circuits. Use compressor isentropic efficiencies of 72% and 78%, for the low temperature and high temperature compressors, respectively. Assume both compressors are driven by a motor with efficiency of 95%. Assume that the volumetric efficiencies of the low temperature and high temperature compressors are 75% and 80%, respectively. Find the cascade temperature that minimizes electrical power between -25°C and 5°C. Make sure that both compressors have a discharge temperature that is at or below 120°C. Determine the refrigerant mass flow rates and the compressor displacement rates, report the COP of the system. Be sure to include energy-balance residuals in order to verify the result.

Example of AI-Assisted Calculations with EES (continued)

AI Output:

I built and ran a two-refrigerant EES model using real-fluid property functions. The unconstrained minimum electrical input occurs near a cascade midpoint temperature of -17.5°C, but that design would produce an ammonia discharge temperature of about 181°C. It therefore fails the 120°C limit.

I refined the search near the feasible boundary. The 3.0°C design still fails by 0.207 K, whereas the 3.1°C design passes by 0.047 K. Since electrical input rises as the cascade temperature is increased in this region, 3.1°C is the lowest-power feasible point on the 0.1°C search grid. The plots below show total electrical power vs cascade temperature (a) and compressor discharge temperatures as a function of cascade temperature (b).

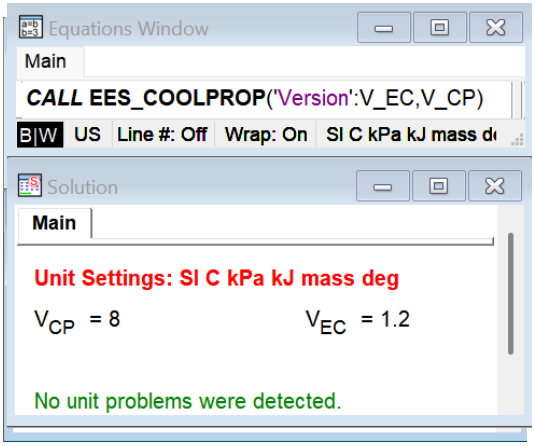


The plot shows why the selected design differs from the unconstrained minimum:

- *Unconstrained minimum: 68.20 kW at −17.5°C, but NH3 discharge reaches 181°C.*
- *Feasible design: 73.14 kW at 3.1°C.*
- *COP: 1.367.*
- *NH3 discharge: 119.95°C, just below the 120°C limit.*
- *Energy-balance residuals are effectively zero.*

The EES_COOLPROP Interface

COOLPROP is a public domain properties program that provides high-quality property data for pure fluids and mixtures. Most of the fluids in COOLPROP also exist natively in EES; however, the advantage of COOLPROP is that it allows the user to specify the composition of a mixture. An interface, called EES_COOLPROP, is now available for Professional 32 and 64-bit EES licenses. The interface allows COOLPROP to be called from within an EES program. The interface and COOLPROP can both be downloaded from https://fchartsoftware.com/ees/add-ons.php.



Once the setup_ees_coolprop.exe program is downloaded, double-click on the file to install both the CoolProp.dll and the EES_Coolprop.fdl programs into the folder /EES_COOLPROP in your /Userlib directory. You can validate the installation and determine the version of EES_COOLPROP Interface (V_EC) and the version of the COOLPROP.dll (V_CP) by calling EES_COOLPROP using the argument 'Version'. The current version is 1.2 using CoolProp version 8.0.

There is a compiled help file that is placed in the EES_COOLPROP folder that provides guidance relative to using the interface. The most typical format of an EES_COOLPROP property call is:

Call ***EES_COOLPROP***(F$, MF[1],..MF[N-1], MODE, Input1, Input2 : Output1, Output2, ...)

The first input (F$) is the name of the fluid or mixture. This string can consist of a single pure fluid or set of components separated by a plus (+) with no spaces (e.g., 'Ethane+Methane'). The list of fluids included in COOLPROP can be found in the EES_COOLPROP help file or at the COOLPROP web site. The next set of inputs (MF[1],…, MF[N-1]) are the mole fractions of each component (except the last one, which is internally calculated). These are entered in the order that the fluids are specified in the F$ string.

The next input (MODE) specifies what properties are used to fix the state (e.g., temperature and pressure) and the arguments following MODE are the values of these two properties. Each mode is indicated with an integer value; these are mapped to more intuitive variable names using a text file that can optionally be included with your EES code using the $Include directive. The text files is found in the /COOLPROP/ directory. For example, the code below uses temperature (320 K) and pressure (200 kPa) to set the state of a mixture of 20% methane with the balance ethane (by mole). This corresponds to MODE = 12; this mode has been mapped to the variable TP in the file EES_COOLPROP.txt.

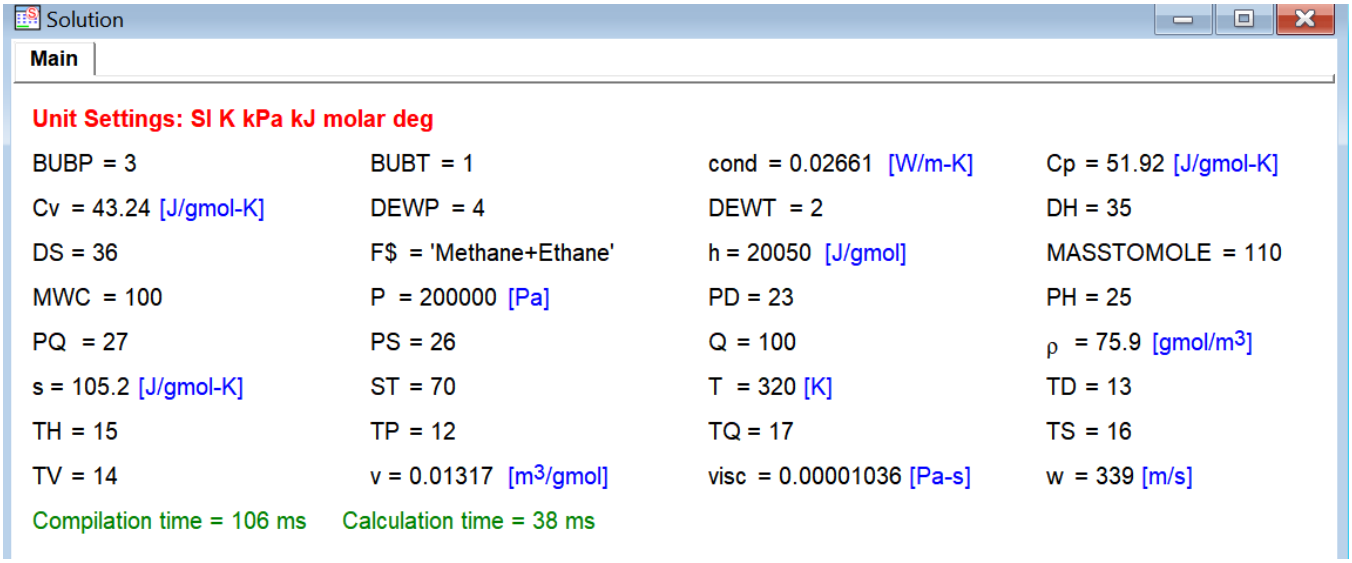
```
Main
$Include c:\ees32\userlib\EES_COOLPROP\EES_COOLPROP.txt
$VarInfo rho units=gmol/m^3
$VarInfo v units =m^3/gmol
$VarInfo h units=J/gmol
$VarInfo s, Cv, Cp  units=J/gmol-K
$VarInfo w units=m/s
$VarInfo visc units=Pa-s
$VarInfo cond units=W/m-K
F$='Methane+Ethane'
T=320 [K]
P=200 [kPa]*Convert(kPa,Pa)
CALL EES_COOLPROP(F$,0.2,TP,T,P:,,rho,v,h,s,Q,Cv,Cp,w,visc,cond)
```

The EES_COOLPROP Interface (continued)

The outputs include, in order:

Out1 = Temperature in K
Out2 = Pressure in Pa
Out3 = Density in gmol/m3
Out4 = Specific volume in m3/gmol
Out5 = Specific enthalpy in J/gmol
Out6 = Specific entropy in J/K-gmol
Out7 = Quality (molar basis) (<0 for subcooled liquid, >1 for superheated vapor)
Out8 = Specific heat at constant volume (Cv) in J/K-gmol
Out9 = Specific heat at constant pressure (Cp) in J/K-gmol
Out10 = Speed of sound in m/sec
Out11 = Viscosity in Pa-s
Out12 = Conductivity in W/m-K

Note that the units used by the EES_COOLPROP interface are those used by COOLPROP itself and cannot be changed. These units are mole specific and can be seen in the output list above. Also note that outputs that are not needed can be skipped by providing a space in place of a variable. Running the code on the previous page will lead to the solution provided below.

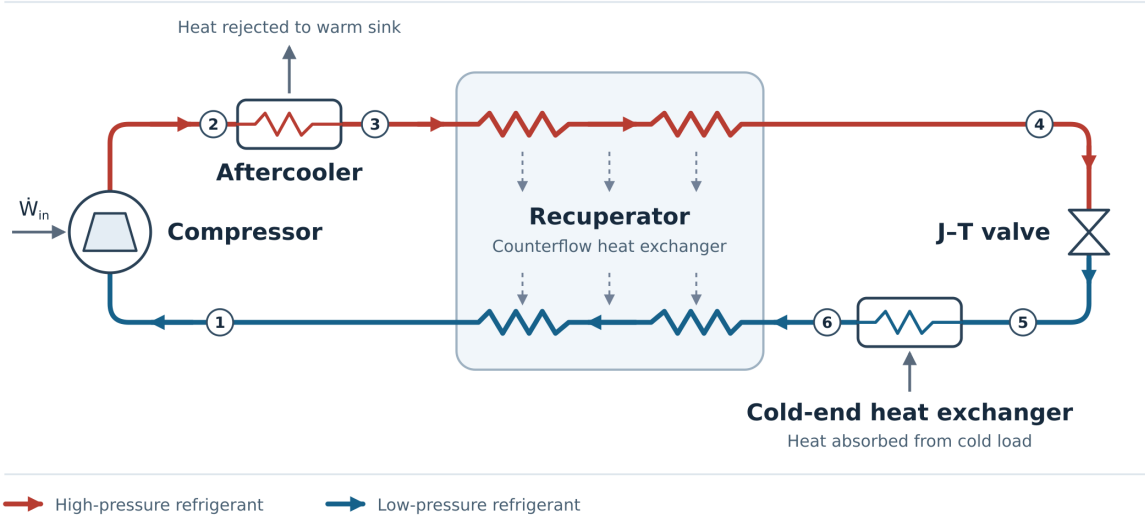


There are several special modes that are useful. For example, if MODE = 1 (BUBT) then the bubble point pressure and other properties are provided at a given temperature. This call will also provide the composition of the vapor phase at the bubble point. Similar modes are provided for the dew point. Finally, if MODE = 100 (MWC) then the critical properties and molar mass are returned.

MODE = 110 (MASSTOMOLE) is useful for converting from mass fractions (which might be known) to mole fractions (which must be used in the EES_COOLPROP interface).

EES_COOLPROP Interface Example

The main advantage of using the EES_COOLPROP interface is that you can vary the composition of a mixture that you are analyzing from within EES. One application where this is particularly useful is the design of mixed gas Joule Thomson (MGJT) systems.



In a single stage, simple design of this type of system, the ideal or maximum amount of refrigeration that can obtained per mole of mixture is related to the isothermal, pressure-driven enthalpy difference (i.e., the difference between the enthalpy at the lower pressure and the enthalpy at the higher pressure at a given temperature):

$$\Delta h(T) = h(T, P_{low}) - h(T, P_{high})$$

The maximum amount of refrigeration that can be obtained from a mixture is equal to the minimum value of the isothermal, pressure-driven enthalpy difference over the temperature span of the device:

$$\left(\frac{\dot{Q}}{\dot{n}}\right)_{max} = MIN\left[\Delta h(T)\right] \text{ over } T_{min} < T < T_{max}$$

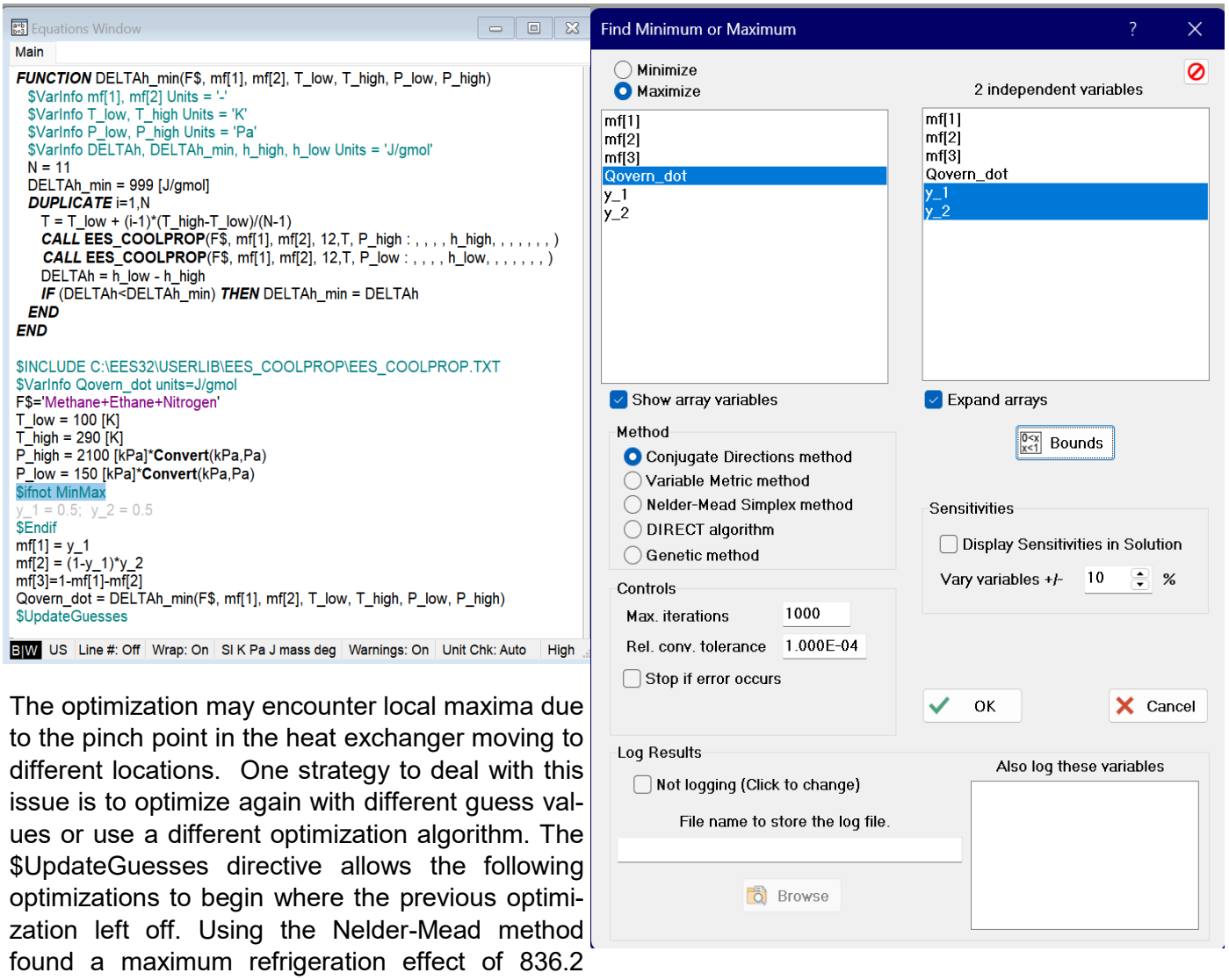
First we will develop a function (DELTAh_min) that can provide the minimum value of the isothermal, pressure-driven enthalpy difference for a specified 3-component mixture of arbitrary composition and given values of high and low pressures and minimum and maximum temperatures. This is done by evaluating the pressure-driven temperature change over the entire temperature range and then picking out the minimum value. Each temperature requires two calls to the EES_COOLPROP interface, one at the high pressure and the other at the low pressure.

Then we will optimize a mixture of methane, ethane and nitrogen such that it has the maximum possible refrigeration potential over the range from 100 K to 290 K operating between 150 kPa and 2100 kPa. The optimization variables are y_1 and y_2 where the mole fraction of constituent 1 (mf[1], methane) is equal to y_1 and the mole fraction of constituent 2 (mf[2], ethane) is (1-mf[1])*y_2. In this way, the limits of the optimization variables are naturally 0<y_1<1 and 0<y_2<1.

EES_COOLPROP Interface Example (continued)

The optimization proceeds by selecting Min/Max from the Calculate menu and indicating that you want to maximize the value of the refrigeration potential by varying y_1 and y_2. The Conjugate Directions method was chosen for this optimization by clicking the Bounds button and entering guess values of 0.5 and bounds of 0.01 and 0.99 for y_1 and y_2.

The result of the optimization with the Conjugate Directions method is a mixture that consists of 6.9 mole% methane, 65.5% ethane with the balance being nitrogen (27.6%). This mixture produces a maximum refrigeration effect of 777.3 J/gmol.



The optimization may encounter local maxima due to the pinch point in the heat exchanger moving to different locations. One strategy to deal with this issue is to optimize again with different guess values or use a different optimization algorithm. The $UpdateGuesses directive allows the following optimizations to begin where the previous optimization left off. Using the Nelder-Mead method found a maximum refrigeration effect of 836.2 J/gmol with a mixture of 8.8% methane, 68.5% ethane.

Selected Recent Changes to EES

- If line numbers are enabled in the Equations window, they will also appear in the Formatted Equations Window.
- The Search Menu provides a Go To Line Number option to allow easier navigation of large EES programs. This menu item works in both the Equations window and the Formatted Equations Window.
- Two new menu items (Go To Line Number and Show Formatted Equation) have been added to the popup menu that appears when you right-click the mouse in the Equations window. The Show Formatted Equation will display the equation that is selected in the Equations window in the Formatted Equations window.
- Data for the melting (fusion) and sublimation lines have been added for many of the real fluids.
- The help and figures for all of the routines in the Heat Transfer Library have been revised.
- Thermodynamic and transport property data are provided for Perfluorobutane, Perfluoropentane, Perfluorohexane (FC72), MD3M (dodecamethylpentasiloxane), R444B, R441a, R245ca, R430a, R499a, R464a, R477a and NitrogenTrifluoride.
- The DELTAV_fusion function has been added, which returns the volume change of fusion at the triple point. The volume of the solid phase for temperatures at or above the triple point can be estimated using this function.
- Correlations for the pressure at which a substance melts at a given temperature have been added for many of the pure fluids and can be accessed with the P_melting function.
- Thermodynamic property data for Helium have been updated.
- An improved correlation for the viscosity of Helium-3 has been added.
- The $LaTexPDF directive will create a .pdf document using the Latex processor.
- The Engineering Tools Dialog in the Options menu provides a searchable index of all of the engineering tool functions available in EES.
- The $CopyParametricToLookup directive copies the contents of a specified Parametric table to a Lookup table.
- Functions MinIntegral and MaxIntegral have been added to identify the extreme values of an integral.
- The LiquidMixtureDensity function returns the density of a mixture of up to 6 fluids in the liquid phase.
- A Temperature function is now available for Solutions (brines). This function allows the temperature of a solution to be determined given its density, enthalpy, or internal energy.
- The Preferences Dialog provides a control at the bottom right of the dialog to allow easier selection of the tabs.

F-Chart Software

PO Box 44042
Madison, WI, 53744

Phone: 608-274-4262
Internet: http://fchartsoftware.com
E-mail: info@fchart.com

Instant Update & Technical Service

EES uses a different model for updating than most other programs. Each time that there is a change in the EES program, either to correct a problem or to add a new feature, the version number is incremented by 0.001 and the latest version of EES is placed on our website. EES is very robust and stable. There have been many new versions of EES released with new capabilities since the last EESy Solutions was distributed.

Any user who has a current subscription to our Instant Update & Technical Service (IUTS) or Academic Update Service (AUS) can download the current version. All new Commercial and Professional licenses of EES are provided with a one year subscription of this service. The cost to continue IUTS or AUS after the first year is ~20% of the current cost of the program per year, provided that it is renewed within 12 months after expiration. Contact us if you wish to re-subscribe to IUTS or AUS.