

June 19, 2023

Dear Customer,

We are pleased to release Version 31 of our software suite, with the new features and improvements summarised below.

Besides the new features described below, we have invested several thousand additional hours of talent into the on-going effort to internally re-write/re-structure our programs to ensure their stability, longevity, and maintainability well into the future. GT PRO/GT MASTER and STEAM PRO/STEAM MASTER have been the major beneficiaries of these efforts over the past fifteen months, and the next release (Version 32) will incorporate these developments.

New features since Version 30 are summarized below, inclusive of those that had been released as revisions to Version 30, optionally downloaded from our online Service Center.

ELINK

ELINK was entirely rewritten to be compatible with both 32-bit and 64-bit versions of Microsoft Excel. ELINK no longer relies on Microsoft’s ‘ActiveX technology’ so it will ease system configuration efforts needed to ensure ELINK functions properly. ELINK maintains ability to update old ELINK worksheets, so you can use existing linked models with this new version.

The previous ELINK tab was renamed ‘ELINK (Legacy)’. It will continue to work for old versions of ThermoFlow’s suite, assuming you continue to use 32-bit Excel. ELINK (Legacy) will not support Version 31 or later models.

Changes Affecting Multiple Programs

Gas Turbine Database – The gas turbine database was updated as shown below. Some of these engine models were included in revisions to TFLOW30 available from our online Service Center.

Engines added to the Database

756: SGT5-9000HL	763: SGT-100-1S (5.4MW, no VIGV, no Bleed)	769: SGT-400 (10.5MW, no Bleed)
757: GE LM9000 50Hz (Prelim)	764: SGT-100-1S (5.4MW, VIGV, no Bleed)	770: SGT-400 (10.5MW, Bleed)
758: SGT6-9000HL	765: SGT-100-1S (5.4MW, VIGV & Bleed)	771: SGT-400 (12.9MW, no Bleed)
759: SGT5-4000F	766: SGT-300-1S (7.9MW, no VIGV, no Bleed)	772: SGT-400 (12.9MW, Bleed)
760: SGT-400 12.9MW	767: SGT-300-1S (7.9MW, VIGV, no Bleed)	773: SGT-400 (14.4MW, no Bleed)
761: SGT-100-1S (5.05MW, no VIGV)	768: SGT-300-1S (7.9MW, VIGV & Bleed)	774: SGT-400 (14.4MW Bleed)
762: SGT-100-1S (5.05MW, VIGV)		

Electrolyzer Database – The electrolyzer database was updated with the following additional units. Some of these units were included in revisions to TFLOW30 available from our online Service Center.

5: H-Tec ME450	12: Nel A150	21: Kyros Type 50
	13: Nel A300	22: Kyros Type 100
6: ITM HGas1SP	14: Nel A485	23: Kyros Type 200
7: ITM HGas2SP	15: Nel A1000	24: Kyros Type 300
8: ITM HGas3SP	16: Nel A3880	25: Kyros Type 400
9: ITM HGasXMW	17: Nel M2000	26: Kyros Type 450
	18: Nel M3000	27: Kyros Type 600
10: ThyssenKrupp AG 10MW	19: Nel M40000	28: Kyros Type 1000
11: ThyssenKrupp AG 20MW	20: Nel M5000	29: Kyros Type 2000

Wind Turbine Database – The wind turbine database was updated to include the following additional turbines.

117 Eno Energy ENO114- 4.0MW	118 Eno Energy ENO114-4.8MW	119 Eno Energy ENO140-4.2MW
120 Eno Energy ENO152-5.6MW	121 Suzlon S133-2.6MW	122 Suzlon S133-3.0MW
123 Suzlon S144-3.xMW	124 Vensys VENSYS62-1.5MW	125 Doosan WinDS3000
126 Doosan WinDS3300	127 Doosan WinDS5500	128 Enercon E-175EP5
129 Enercon E-138EP3E3	130 Vestas V136-4.5MW	131 Vestas V150-4.5MW
132 Vestas V155-3.6MW	133 Vestas V163-4.5MW	134 Siemens Gamesa SG 2.9-129

Wind Turbine Database –the following turbines were modified to reflect current performance specs.

135 Enercon E-160EP5E3	136 Eno Energy Eno160-6MW	137 Vensys VENSYS126-3.8MW
138 Vensys VENSYS126-3.5MW	139 Vensys VENSYS115-4.1MW	

Chemical CO₂ Capture

The chemical CO₂ capture model was revised to ensure default design parameters better reflect current technology. Cost estimates were revised in light of recent reports.

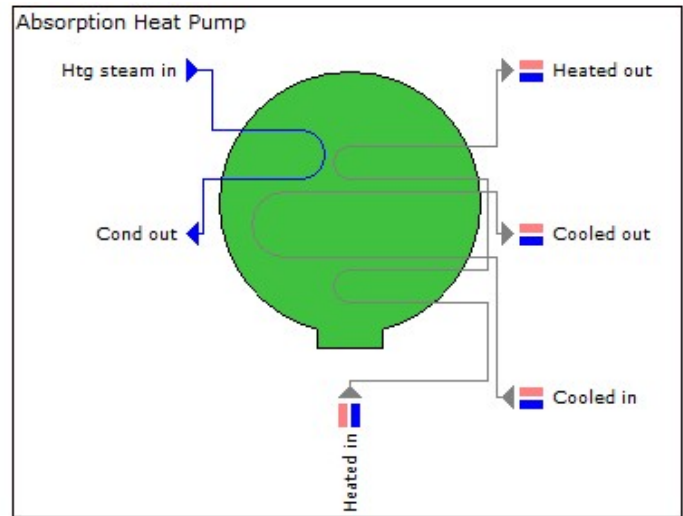
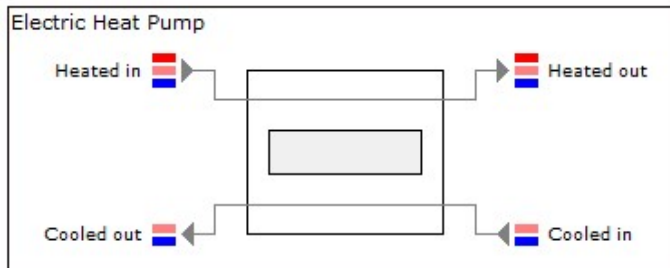
GT PRO & GT MASTER

CO₂ Capture system can now be included in plants using salt water for cooling.

An option to operate gas turbine with desired fuel flow as another way to control engine load is now available.

THERMOFLEX

New Heat Pump Components

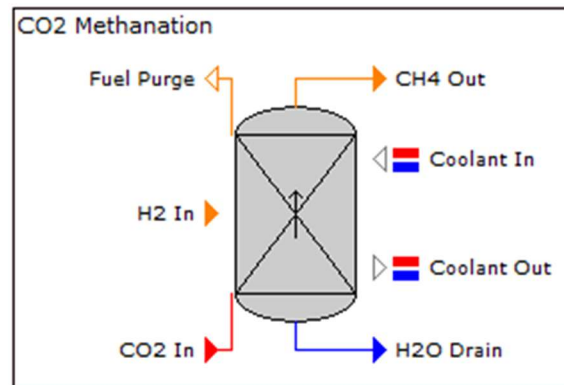


New electric and absorption heat pump components were added to the [General] tab of the Icon Selector, between the Wind Farm and Electric Chiller icons. Akin to the electric and absorption chillers, these components are available with a PEACE license.

The Electric Heat Pump icon represents a heat pump based on a vapor-compression refrigeration cycle, driven by an electric motor intrinsic to the icon. It has four ports; two for the cooled stream flowing in and out, and two for the heated stream, which carries away the energy extracted from the cooled stream together with the electrical energy running the heat pump. Heated streams may be water, air/gas (red stream), or heat transfer fluid (pink stream). The cooled stream can be water or heat transfer fluid (pink streams).

The Absorption Heat Pump is driven by heat from a steam or hot water stream, delivered at suitable temperature. The icon has six ports, two for the heating stream supply/return, two for the cooled stream supply/return, and two for the heated stream supply/return. Heated and cooled streams may be either water (blue) or heat transfer fluid (pink).

New CO2 Methanation Process Component



A new icon to model the Methanation process was added to the [Other Fluids] tab of the Icon Selector. This component implements a black-box model of a process to produce methane from carbon dioxide or carbon monoxide by an

endothermic reaction in the presence of a catalyst. Sample file '(S5-31) Wind Power to Methane.tfx' illustrates use of this component.

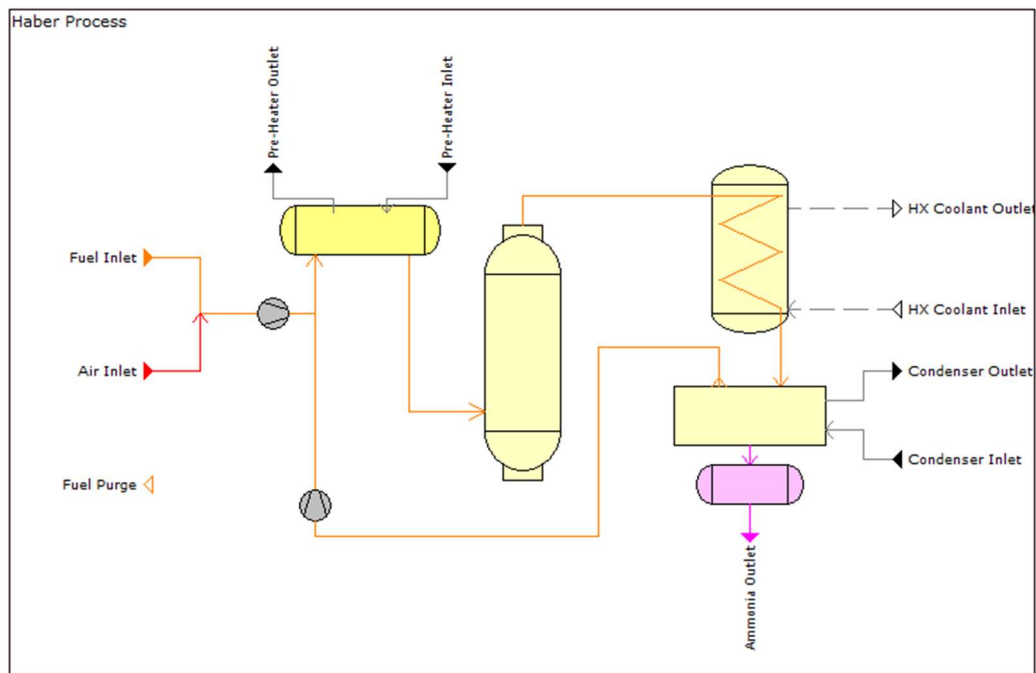
Enhanced Fuel Cell Component

The Fuel Cell, available on the [Gas/Air] tab of the Icon Selector, was revised. It now has ability to burn hydrogen or natural gas and reports estimated size, weight, cost, and includes a site layout diagram. The built-in library was expanded to include fourteen units available from a variety of manufacturers, in addition to the ability to model a User-defined Fuel Cell.

The built-in library includes the units listed below.

1: NedStack PAG CHP-FCP-500 (hydrogen)	8: Doosan PureCell Model 400 Hydrogen
2: NedStack CHP-FCPS-1000 (hydrogen)	11: Doosan PureCell model 400 (natural gas)
3: NedStack CHP-FCPS-500 (hydrogen)	9: Bloom Energy Hydrogen Fuel Cell
4: NedStack CHP-FCPS-100 (hydrogen)	10: Toshiba H2Rex (hydrogen)
5: Fuji Electric Global FP-100iH (hydrogen)	9: Bloom Energy Hydrogen Fuel Cell (hydrogen)
14: Fuji Electric Global FP-100i (natural gas)	12: FuelCell Energy SureSource1500 (natural gas)
6: Ballard FCwave (hydrogen)	13: FuelCell Energy SureSource3000 (natural gas)
7: Ballard ClearGen (hydrogen)	

New Haber-Bosch Process Component



A new icon to model the Haber-Bosch process was added to the [Other Fluids] tab of the Icon Selector. This component implements a grey-box model of the Haber-Bosch process which produces ammonia from hydrogen and nitrogen. This process may play a role in the 'hydrogen economy' by producing a more readily transportable and storable product

stream from hydrogen gas produced by electrolysis. Sample file '(S6-20) Integrated SMR and Haber System.tfx' illustrates use of this component.

Phase Change Fuels (previously called LNG) Database

The following fuels were added to the Phase Change Fuels database. Country-specific entries are typical but do not represent an exhaustive listing.

Ammonia (NH3)	Norway Natura Gas #1
Australia Natura Gas #1	Norway Natura Gas #1
Australia Natura Gas #2	Oman Natura Gas
German Natural Gas	Qatar Natura Gas #1
Malaysia Natura Gas	Qatar Natura Gas #2
Nigeria Natura Gas	Russian Natural Gas
North Sea Natural Gas	Trinidad & Tobago Natura Gas

Refrigerant Database

The refrigerant database was expanded by adding Chlorine, listed as “[REFPROP] Chlorine - Cl2” to the selection list.

Others

CO Capture system can now be included in plants using salt water for cooling.

NOVO PRO

Firm & Flexible H2 Production

Firm & Flexible H2 Production: In MicroGrid mode, Electrolyzers have a user-selectable Loading Strategy with three choices.

- **Flexible** - run electrolyzer using only excess electricity generated above Demand.
- **Firm – no import allowed** - run electrolyzer at the user-specified load when the System has sufficient self-generation capacity, i.e. without import from grid. When System capacity falls short, Demand is satisfied as first priority, and electrolyzer load satisfied as second priority.
- **Firm – import allowed** - run the electrolyzer at the user-specified load, Import used when System capacity falls short.

NOVO PRO computes and reports break-even hydrogen export price (aka levelised cost of hydrogen) on the Financial Summary report.

Others

User-Defined Solar Irradiance - Solar irradiance may be defined directly to allow use of data from third-party sources. The [Irradiance] tab includes an option to edit, or more likely paste data into, a table of 8760 hourly values shown below.

Main Inputs		Configuration		Irradiance		PEACE Inputs					
Irradiance Method <input type="radio"/> Estimated with specified cloud cover factor <input type="radio"/> Use database <input type="radio"/> User-defined monthly insolation data <input checked="" type="radio"/> User-defined hourly insolation data				User-defined Hourly Irradiance Station Information: Name: BAKERSFIELD MEADOWS FIELD State / Region: CA Timezone (from UTC): -8 hr Elevation (asl): 45.42 m Latitude: 35.43 degrees Longitude: -119 degrees Albedo of surroundings: 0.2 Threshold solar altitude for beam irradiance: 0 degrees							
Hours of year ->		31	32	33	34	35	36	37	38	39	40
GHI	W/sq.m.	0	42	105	279	261	431	397	272	301	87
DNI	W/sq.m.	0	21	97	349	83	243	284	149	264	22

Electrolyzer Water Accounting - Price for water imported to feed the electrolyzers is now available on the 'Main Inputs' tab of the [Economics] topic. Annual water consumed by the electrolyzers, and its effect on plant financial performance, is now reported in the outputs.

Windfarm O&M - A built-in model for windfarm O&M was added to augment the user-defined O&M feature that's always been available.

PEACE

Cost multipliers were revised, mostly upwards, relative to Version 30. Gas turbine pricing was revised to reflect market activity in the small engine (<100 MW) range along as well as the inflationary trends affecting all industrial equipment. Changes to estimated costs will depend on the particular plant configuration, EPC prices for gas turbine plants from simple cycle peakers to GT+WHB CHP plants to baseload F-class reheat GTCC with and without CO2 capture will be anywhere from 7 to 20% higher in Version 31 relative to Version 30. EPC estimate for steam plants will be approximately 7 to 9% higher in Version 31.

Reference currency exchange rates, relative to the USD, and regional cost multipliers were revised.