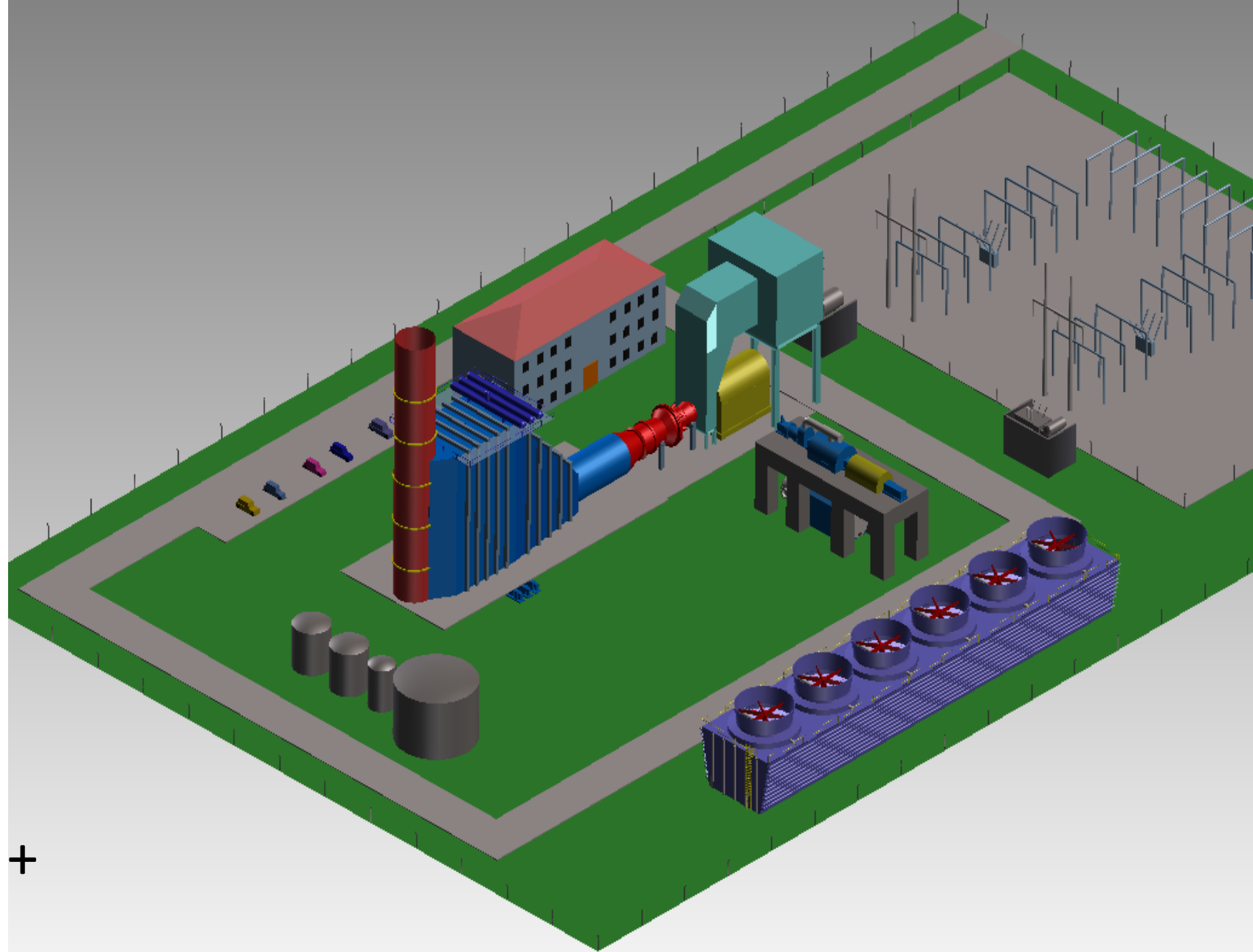


# Hypothetical Hybrid Plant Arizona / USA

300MW PV + 300MW Wind  
+ Gas Fired Thermal  
(Backup) Plant



## NOVO PRO® Sample 1:

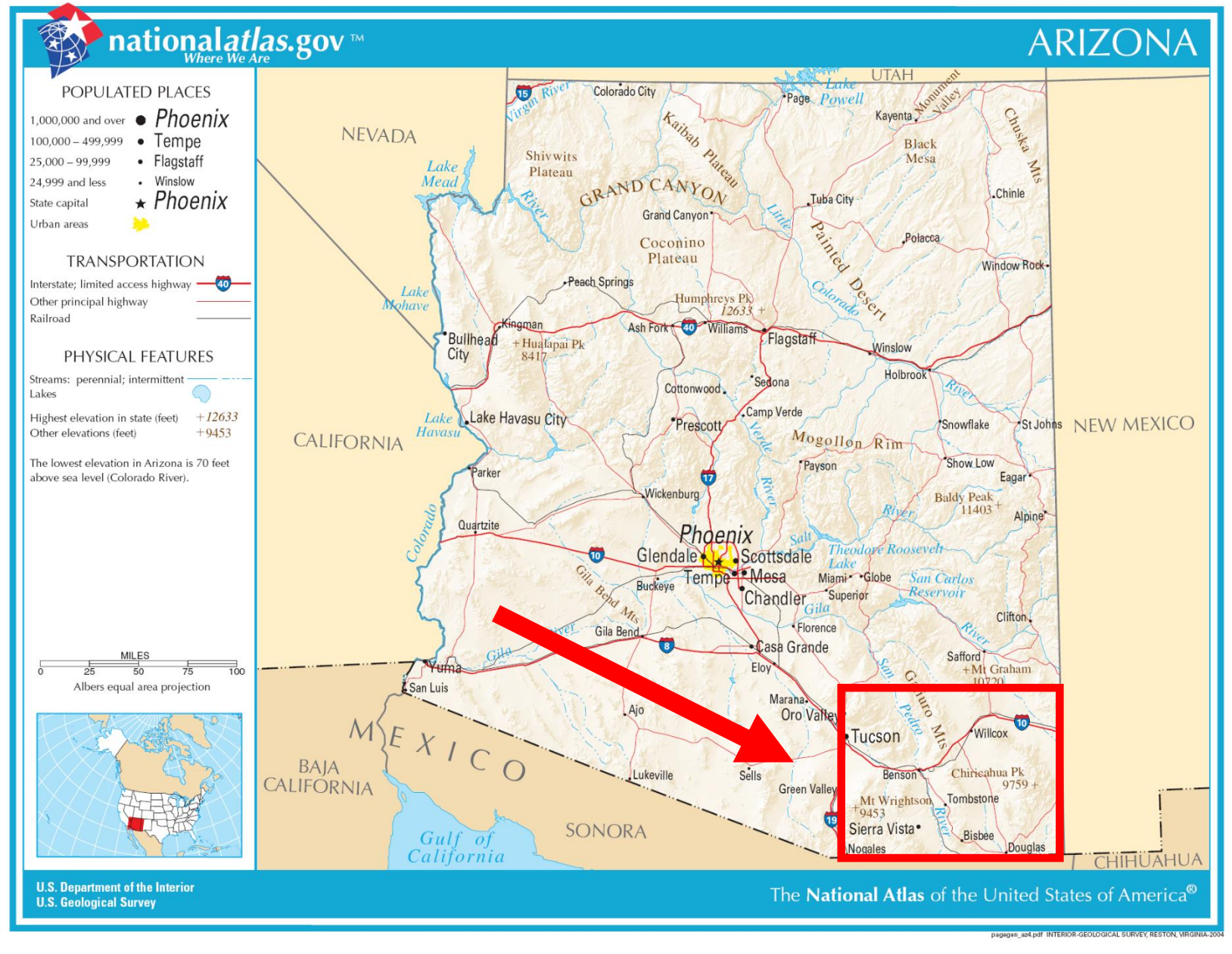
Introductory (get started): Hybrid Plant in Arizona / USA

What can I expect from the NOVO PRO Introduction:

- Which inputs are needed to get started ?
- How to setup to site conditions, economical parameters and power demand ?
- How to setup renewable systems: PV Plant and Wind Farm ?
- How to setup a "customized" thermal Power Plant in GT PRO®/GT MASTER®/ THERMOFLEX® and how to import it to NOVO PRO ?
- How to use the NOVO PRO Outputs to analyze and optimize the Hybrid Plant ?

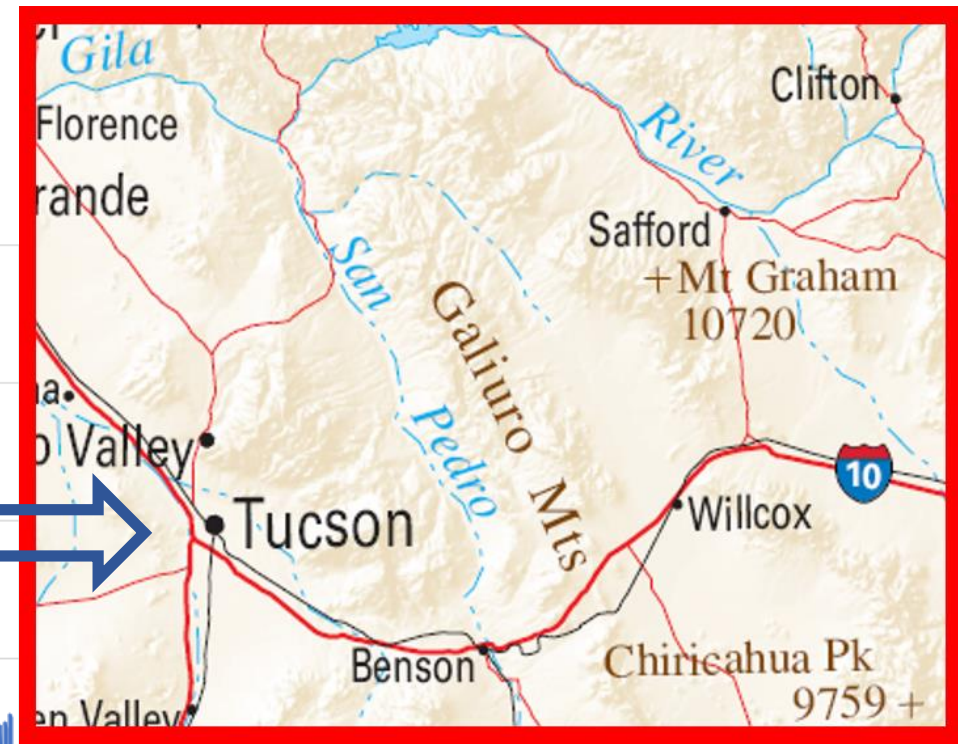
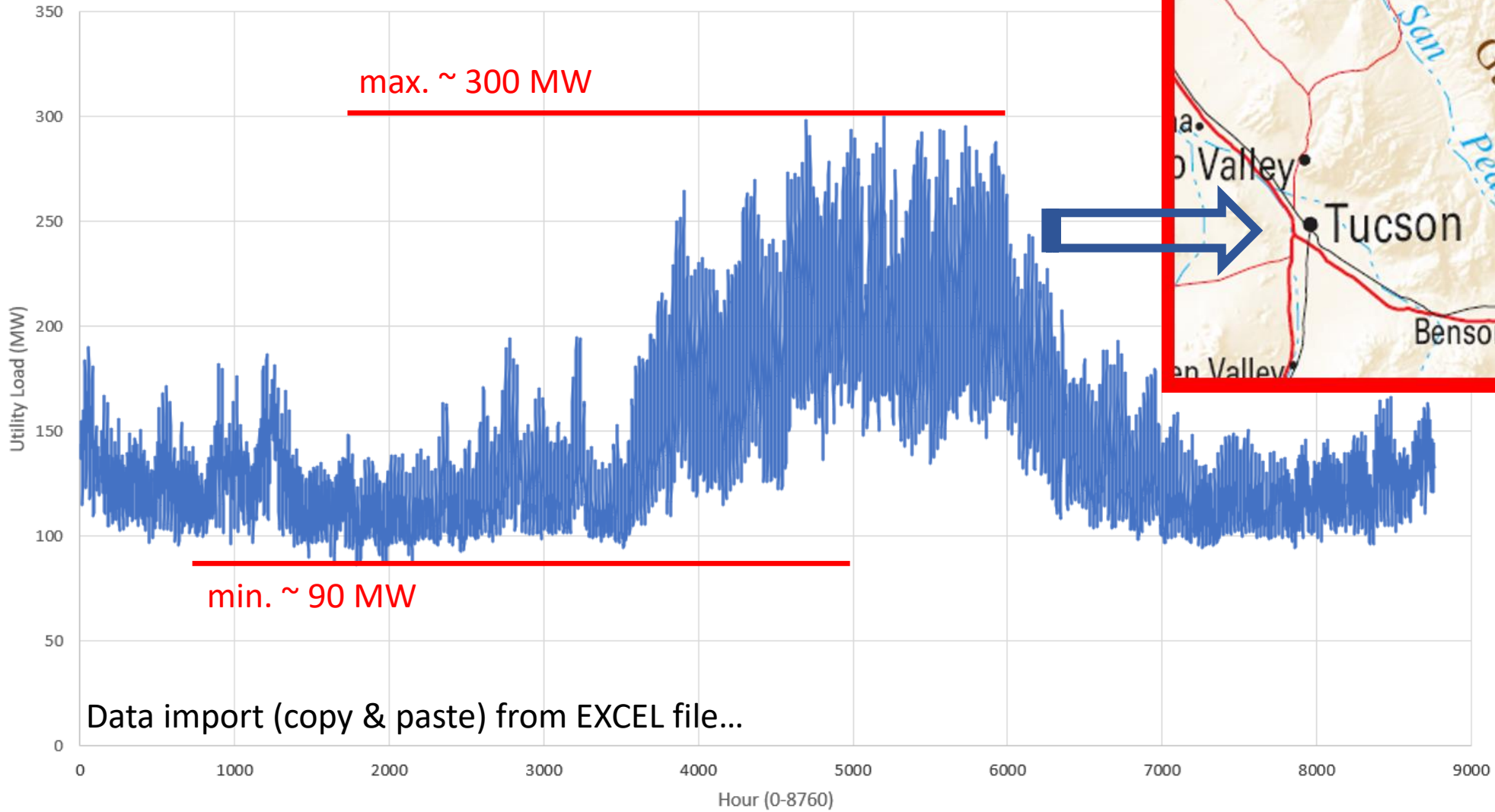
# Location:

Tucson area,  
Arizona, USA



# Power Demand

Scaled Load for Hypothetical Utility





# Ambient Conditions, Wind Resource Data & Solar Irradiation

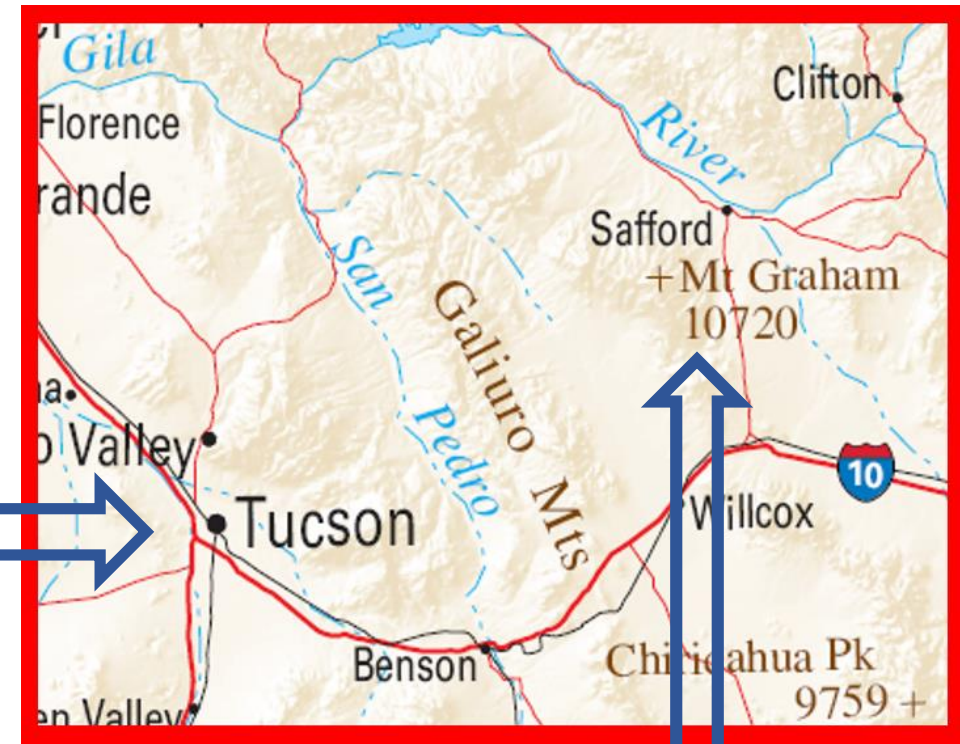
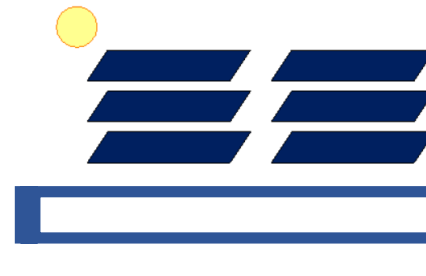
## PV Solar Irradiation Data from: TMY = Typical Meteorological Year

Typical Meteorological Year (TMY): is a set of meteorological data with hourly values in a year for a given location. The data are selected from hourly data in a longer time period (normally 10 years or more). For each month in the year the data have been selected from the year that was considered most "typical" for that month.

### Available data in Thermoflow:

- US NREL TMY3 Data
- Environment Canada CWEC Data
- EnergyPlus US/DOE

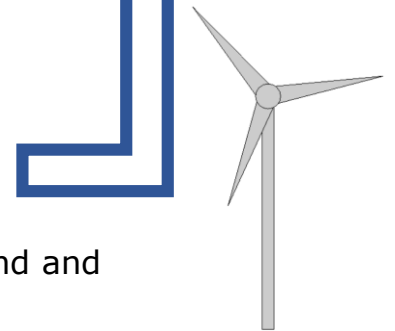
### [Google Earth - PV](#)



## Wind Resource Data from: built-in ERA5 database

ERA5 / European Copernicus Project – [www.Copernicus.eu](http://www.Copernicus.eu) : provides hourly estimates of a large number of atmospheric, land and oceanic climate data.

### [Google Earth - Wind](#)



## Economic Inputs










Demand Power Price:	60 USD / MWh
Surplus Power Price:	0 USD / MWh
Import Power Price:	no power import
Gas Fuel Price:	3 USD / GJ

## Scenarios

- (1) Large F-Class GTCC, 3pRH, 1-1-1 Config., Wet Cooling Tower
- (2) Reciprocating Gas Engines (open cycle), approx. 10-20 units
  
- (3) Scenario (1) + 300MW PV
- (4) Scenario (2) + 300MW PV
  
- (5) Scenario (1) + 300MW PV + 300MW Wind
- (6) Scenario (2) + 300MW PV + 300MW Wind

# New MAN Reciprocating Gas Engine Specifications

Courtesy of  **MAN Energy Solutions**  
Future in the making

<b>35/44G</b> Single staged/ two-staged	 7,368 – 12,800 kW <sub>mech</sub>  $> 51,3 \%^*$ <sub>mech</sub>  NG, biogas, H <sub>2</sub> < 20%, MN60-100
<b>51/60G</b> Single staged/ two-staged	 18,900 – 20,700 kW <sub>mech</sub>  $> 51,8 \%^*$ <sub>mech</sub>  NG, biogas, H <sub>2</sub> < 20%, MN60-100
<b>51/60DF</b> Single staged/ two-staged	 6,300 – 18,900 kW <sub>mech</sub>  $> 51,8 \%^*$ <sub>mech</sub>  NG, biogas, liquid biofuels, MGO/ MDO, HFO

\*Reference according ISO 3046-1 & ISO 15550, 5% tol.

GT PRO / GT MASTER database:

ID	Manufacturer & Model
<b>MAN Energy Solutions - Combustion Engines</b>	
734	MAN 12V35/44G TS - 60Hz (**)
733	MAN 12V35/44G TS - 50Hz (**)
732	MAN 20V35/44G - 60Hz (**)
731	MAN 20V35/44G - 50Hz (**)
736	MAN 20V35/44G TS - 60Hz (**)
735	MAN 20V35/44G TS - 50Hz (**)
737	MAN 18V51/60G High Efficiency (**)
739	MAN 18V51/60G TS High Efficiency (**)



# New MAN Reciprocating Gas Engine Specifications

NOVO PRO and THERMOFLEX database:

Engine Selection Filter

Smallest power  kW Largest power  kW

Sort

Manufacturer  Smallest to largest power  Largest to smallest power

Show 50 Hz engines  Show 60 Hz engines  
 Show gas engines  Show Diesel engines

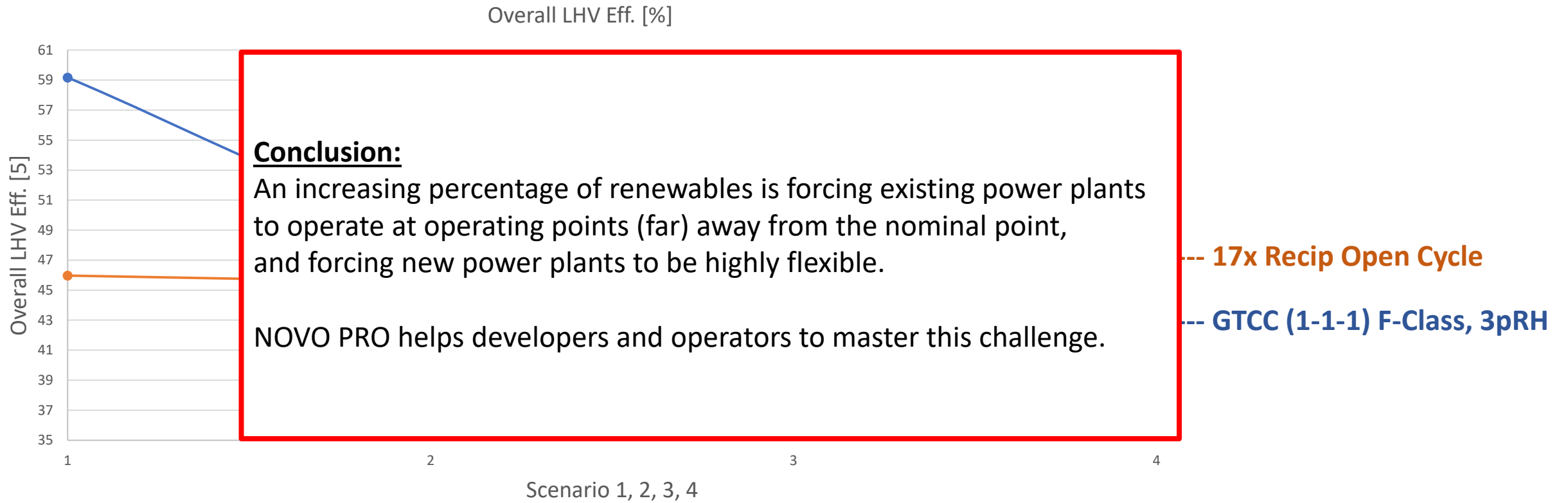
ID	Model	Fuel	Aspiration	Mode	RPM	Freq.	Power	Texh	Exh. flow	Elec. Eff.
						Hz	kW	C	t/h	%
446	MAN 20V35/44G	G	TA	C	750	50	10420	302	64,76	46,4
447	MAN 20V35/44G	G	TA	C	720	60	10027	302	62,32	46,4
448	MAN 18V51/60G	G	TA	C	500	50	18654	327	109,31	47,4
449	MAN 18V51/60G	G	TA	C	514	60	18654	327	109,31	47,4
451	MAN 12V35/44G TS	G	TA	C	750	50	7534	289	43,00	47,9
452	MAN 12V35/44G TS	G	TA	C	720	60	7228	289	41,30	47,9
453	MAN 20V35/44G TS	G	TA	C	750	50	12582	289	71,70	48,0
454	MAN 20V35/44G TS	G	TA	C	720	60	12071	289	68,80	48,0
457	MAN 18V51/60G TS	G	TA	C	500	50	18654	304	112,50	48,3
458	MAN 18V51/60G TS	G	TA	C	514	60	18654	304	112,50	48,3
461	MAN 6L51/60DF	G	TA	C	500	50	6180	334	37,90	46,3
462	MAN 6L51/60DF	G	TA	C	514	60	6180	334	37,90	46,3
465	MAN 6L51/60DF	G	TA	C	500	50	6180	364	37,60	45,3
466	MAN 6L51/60DF	G	TA	C	514	60	6180	364	37,60	45,3
469	MAN 6L51/60DF	G	TA	C	500	50	6769	324	47,10	44,6
470	MAN 6L51/60DF	G	TA	C	514	60	6769	324	47,10	44,6
473	MAN 12V51/60DF	G	TA	C	500	50	12411	334	75,80	47,2
474	MAN 12V51/60DF	G	TA	C	514	60	12411	334	75,80	47,2
477	MAN 12V51/60DF	G	TA	C	500	50	12411	364	75,30	45,8
478	MAN 12V51/60DF	G	TA	C	514	60	12411	364	75,30	45,8
481	MAN 12V51/60DF	G	TA	C	500	50	13593	315	94,30	45,0
482	MAN 12V51/60DF	G	TA	C	514	60	13593	315	94,30	45,0
485	MAN 18V51/60DF	G	TA	C	500	50	18654	334	113,70	47,3
486	MAN 18V51/60DF	G	TA	C	514	60	18654	334	113,70	47,3
489	MAN 18V51/60DF	G	TA	C	500	50	18654	364	112,90	45,9
490	MAN 18V51/60DF	G	TA	C	514	60	18654	364	112,90	45,9
497	MAN 18V51/60DFTS	G	TA	C	500	50	18654	315	116,50	48,8
498	MAN 18V51/60DFTS	G	TA	C	514	60	18654	315	116,50	48,8

# Summary NOVO PRO Outputs

		Nominal		Thermal only		Thermal + 300MW PV		Thermal + 300MW PV + 300MW Wind	
		GTCC	Recips	GTCC	Recips	GTCC	Recips	GTCC	Recips
Gross Power	[MW]	374	317.118						
Net Power	[MW]	364	307.644						
Net El. Eff.	[%]	59,17	45,97						
Capacity Factor	[%]			41,00	46,98	27,43	31,45	24,15	27,18
Overall LHV Eff.	[%]			49,03	45,53	45,44	45,1	44,26	44,94
Fuel Consumption	[GJ]			9.373.851	10.011.260	6.766.298	6.765.180	6.126.693	5.867.830
CO <sub>2</sub> production	t/year			513.841	550.086	370.904	371.724	335.843	322.418
Total Owner's Costs	[USD]	300.000.000	220.000.000	300.000.000	220.000.000	656.000.000	576.000.000	1.107.000.000	1.027.000.000

**Capacity Factor** describes the relative power output for the power plant compared to a theoretical output where the plant operates at rated output for the same number of hours.

# Summary NOVO PRO Outputs



- 1: Nominal / Design Point Performance
- 2: Thermal Power Plant only
- 3: Thermal Power Plant + 300MW PV
- 4: Thermal Power Plant + 300MW PV + 300MW Wind

# Thank you!

Questions? Email us: [info@thermoflow.com](mailto:info@thermoflow.com)