GT New Horizons

Large Steam Turbine

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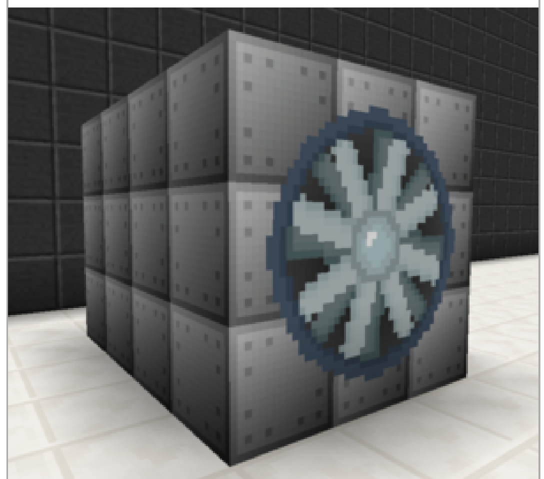
	
Mod	GregTech
Type	Tile Entity
Relevant Quest	We Need Big Toys
Tier	HV
Size	4x3x3 (LxWxH)

The **Large Steam Turbine** (LST) is an HV tier multiblock for generating power from steam. The LST is a major upgrade from the singleblock steam turbines which have poor fuel efficiency and low power output. A turbine must be placed inside the GUI of the controller for the machine to run. Turbines come in four different sizes and many different materials each with their own efficiency bonus and optimal flow rate (L/t of steam). Power is extracted through a *buffered* dynamo hatch on the back of the machine as steam condensates into distilled water in the output hatch. Do not exceed the dynamo hatch's maximum EU/t output or else it will explode. Save on fuel by automatically enabling/disabling the LST with an RS-latch connected to a Lapotronic Supercapacitor.

Later on, the player can upgrade to the XL Turbo Steam Turbine which runs as fast as 16 LST, but only occupies the space of 12. There is also the Large HP Steam Turbine which generates power from *superheated* steam and outputs regular steam, as well as the Large Supercritical Steam Turbine which generates power from *supercritical* steam and outputs superheated steam. Superheated and supercritical steam both have 2x the EU value as regular steam.

Spreadsheet: Large Turbine Calculator (https://docs.google.com/spreadsheets/d/1oyNyHwPdkognPs7-r5HSxdy9RB0WgvbiZcpFTMOZLjM/edit?gid=655714366#gid=655714366)

Construction

The dynamo hatch must replace the center turbine casing on the back of the structure, opposite the controller. Multi-amp and laser energy hatches are NOT accepted, but *buffered* dynamo hatches can output up to 4A and are highly recommended. The remaining hatches can replace any turbine casing on the LST except the 8 blocks surrounding the controller. There is NO muffler hatch so do not make the mistake of including one or else the structure will not form. The inside of the structure and the 9 blocks directly in front are also mandatory air. Use the Multiblock Structure Hologram Projector to visualize/build the structure.

The turbine housing is unique to large turbines and automatically replaces the turbine inside the controller once it breaks. It is not necessary, but recommended to maximize runtime and reduce the probability of power failing a base.

Requires:

- 1 Large Steam Turbine (controller)
- 8-31 Turbine Casing
- 1 Maintenance Hatch (any turbine casing, except front)
- 1 Dynamo Hatch (back center turbine casing)
- 0+ Input Hatch (any turbine casing, except front)
- 0+ Output Hatch (any turbine casing, except front)
- 0+ Turbine Housing (any turbine casing, except front)

Wallsharing

LSTs can wallshare each of their sides to save on space, casings, and hatches. However, do NOT share the input hatch because the fuel is not split evenly between the LSTs--one consumes everything and the other receives nothing.

Usage

The LST has two operating modes, listed below, but see the spreadsheet linked at the top for the quantifiable differences between them. The former is better in the early to mid game when steam production is low and the latter is better in the late game when power output is more important than efficiency. Switch modes by using a screwdriver on the controller.

- *Tight Fitting Mode*: High efficiency, Low optimal flow rate (power).
- *Loose Fitting Mode*: Low efficiency, High optimal flow rate (power).

As steam enters the LST through an input hatch, the speed of the turbine increases linearly up to 100%. Speed is directly proportional to the power output of the machine and takes 50 seconds to reach its maximum value regardless of the turbine size/material. Speed only decays when the turbine is removed, the structure is broken, or the LST runs out of fuel. Disabling the LST does NOT reset the speed. View the current speed of the turbine by using a Portable Scanner on the controller or looking at the "efficiency" value in WAILA.

Optimal Flow Rate (L/t)

The rate at which steam enters the LST is extremely important. Too little steam and only a fraction of the potential power is generated; too much steam and a tremendous of fuel is wasted. Ideally, steam enters the LST at the optimal flow rate of the turbine which changes significantly with size/material and the operating mode of the machine. Although visible in NEI, the optimal flow rate (FR) in L/t is calculated with the following equations where k is a multiplier associated with each material, size is a constant between 1=small and 4=huge, and η is the efficiency of the turbine.

- *Tight Fitting Mode:* $FR_{opt} = k * size * 50$
- *Loose Fitting Mode:* $FR_{opt} = k * size * 150 * 1.1^{20(\eta_{base} - 0.8)}$

Due to the low energy of Steam (0.5 EU/L), the optimal flow rates of some turbines are incredibly high--especially if the LST is in loose mode. The player may need to upgrade their fluid regulator or add a second input hatch to meet the increased demand. Eventually it becomes necessary to switch to AE2 fluid P2P tunnels which effectively have no transfer limit and no regard for temperature or heat capacity.

Overflow & Power

Exceeding the optimal flow rate generates additional power with diminishing returns based on the overflow efficiency of the turbine (visible in NEI). Overflow efficiency is a discrete value separated into three different tiers, listed below. A higher overflow efficiency means the EU/L of steam decreases at a slower rate and the overall maximum flow rate is higher. For both tight and loose fitting mode, the maximum flow rate is calculated by multiplying the optimal flow rate by the overflow efficiency.

- T1 Overflow Efficiency = 150%
- T2 Overflow Efficiency = 200%
- T3 Overflow Efficiency = 250%

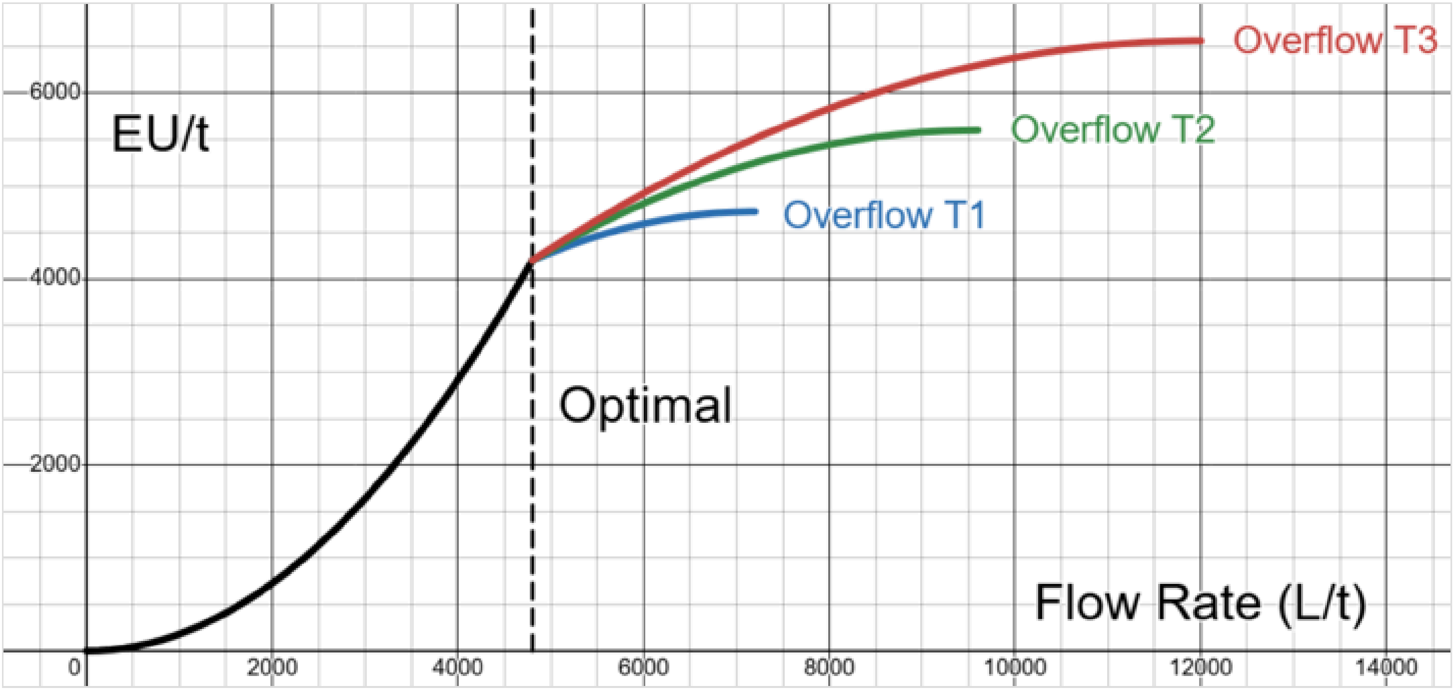
Power is extracted from the LST via the *buffered* dynamo hatch on the back of the structure. Do not exceed the maximum EU/t of the dynamo hatch and do not break it while the machine is running, or else the LST will **explode**. Exceeding the total EU in the dynamo's buffer, however, is perfectly safe; the LST will not explode if an attached battery buffer or Lapotronic Supercapacitor (LSC) is full and there is nowhere for the EU to go. Any additional EU is simply voided. It is highly recommended to automatically enable/disable the LST with a redstone RS-latch to avoid wasting fuel--see the LSC page for a guide on setting that up.

$$EU/t = FR * \left(1 - \frac{|FR - FR_{opt}|}{FR_{opt} * (1 + OF_{tier})}\right) * 0.50 * \eta$$

Although visible in WAILA, the power output is calculated with the above equation where FR is the flow rate in L/t, OF is the overflow efficiency TIER, and η is the turbine efficiency. This equation applies to both tight and loose fitting modes. Let OF = 0 for any flow rates less than the optimal flow rate. The 0.50 is the EU/L or energy value of steam.

Example

Consider the following graph which relates power output (EU/t) to the flow rate of steam (L/t) for an LST with a large HSS-E turbine in tight fitting mode. The efficiency of the turbine is 175%, the optimal flow rate is 4,800 L/t, and the overflow efficiency is Tier 3. This means the maximum flow rate is 2.5 * 4,800 L/t = 12,000 L/t and the LST follows the top line in red. The lower overflow efficiency tiers are only visible for comparison purposes. Notice how quickly the EU/t increases as the flow rate approaches the optimal value and then how quickly the turbine loses efficiency afterwards. Loose fitting mode and every other turbine follows a very similar pattern.



Power curve for an LST with a large HSS-E turbine in tight fitting mode.

Turbines

A turbine must be placed inside the GUI of the controller for the machine to run. Turbines come in four different sizes and many different materials each with their own efficiency bonus and optimal flow rate. The tier of a turbine means absolutely nothing. There are too many different permutations to list them all here, but the spreadsheet linked at the top has all the relevant information and even a calculator for determining the power output and lifespan of any turbine with any fuel.

- Small turbines are crafted with long magnalium rods // available as early as LV.
- Normal turbines are crafted with long titanium rods // available at the end of HV after traveling to the moon.
- Large turbines are crafted with long tungstensteel rods // available in IV after the tungsten processing line.
- Huge turbines are crafted with long americium rods // available in ZPM after building a Fusion Reactor Mk-II.

Durability

Turbines slowly lose durability as power is generated. The total durability of a turbine depends on the material and instantly voids once it reaches 0%. Turbines cannot be inserted or extracted from the controller, but turbine housing buses can automatically replace turbines after they break. By default, turbine housings check if the controller is empty once every 1200 ticks (60 seconds). Use a screwdriver on the bus to decrease that interval as necessary. Turbine housings do NOT re-enable the LST if the machine is ever disabled from a "missing rotor" error--use a machine controller cover for that.

The following equation is for calculating the lifespan of a turbine (in hours) from the power output of an LST. Note that loose fitting mode has a 33% durability bonus to compensate for the reduced lifespan of a higher power output. Turbines generally have lifespans of several hundred hours (or more) so they should not need to be replaced very often.

$$Lifespan = \frac{Durability}{36 * min\left(0.2 * EU/t, (EU/t)^{0.6}\right)} * 1.33_{loose}$$

Recommended Progression

The following are the best available turbines for the LST as the player progresses. It is very common to skip a few of these because the cost of replacing healthy turbines may not be worth a slight boost in performance. The power and lifespan of the turbines are strictly based on the optimal flow rate and varies with any deviations. Note that this list is slightly different from the other large turbines and even the XL Turbo Steam Turbine because different fuels have different energy values and the LST is very limited by the size of the dynamo hatch.

Tier	Material	Size	Efficiency	Mode	Fuel	Optimal Flow Rate	Power	Dynamo	Lifespan
HV	Vibrant Alloy	Small	95%	Tight	Steam	900 L/t	427 EU/t	Buffered MV	296.7 h
HV	Manyullyn	Small	104%	Tight	Steam	1,250 L/t	656 EU/t	Buffered HV	116.1 h
HV	Shadow Metal	Small	95%	Tight	Steam	1,600 L/t	760 EU/t	Buffered HV	425.2 h
EV	Shadow Metal	Normal	120%	Tight	Steam	3,200 L/t	1,920 EU/t	Buffered HV	487.7 h
EV	Terrasteel	Normal	130%	Tight	Steam	3,200 L/t	2,080 EU/t	Buffered EV	488.9 h
EV	Oriharukon	Normal	130%	Tight	Steam	3,200 L/t	2,080 EU/t	Buffered EV	488.9 h
IV	Oriharukon	Large	155%	Tight	Steam	4,800 L/t	3,720 EU/t	Buffered EV	614.9 h
IV	HSS-E	Large	175%	Tight	Steam	4,800 L/t	4,200 EU/t	Buffered EV	571.7 h
IV	HSS-S	Large	185%	Tight	Steam	4,800 L/t	4,440 EU/t	Buffered EV	553.0 h
IV	MAR-Ce-M200 Steel	Large	145%	Tight	Steam	22,500 L/t	16,313 EU/t	Buffered IV	5,065.7 h
IV	Ichorium	Large	225%	Tight	Steam	28,800 L/t	32,400 EU/t	Buffered IV	13,928.7 h
LuV	Duranium	Large	215%	Tight	Steam	76,800 L/t	82,560 EU/t	Buffered LuV	382.9 h
ZPM	Duranium	Huge	240%	Tight	Steam	102,400 L/t	122,880 EU/t	Buffered LuV	402.2 h
ZPM	Adamantium	Huge	158%	Loose	Steam	335,029 L/t	265,343 EU/t	Buffered ZPM	67.6 h
ZPM	Gaia Spirit	Huge	174%	Loose	Steam	490,515 L/t	426,013 EU/t	Buffered ZPM	5,277.9 h
UV	Trinium	Huge	142%	Loose	Steam	915,316 L/t	654,909 EU/t	Buffered UV	245.6 h
UV	Ext. Unst. Naquadah	Huge	165%	Loose	Steam	1,266,827 L/t	1,048,932 EU/t	Buffered UV	651.7 h
UV	Cosmic Neutronium	Huge	174%	Loose	Steam	1,471,546 L/t	1,278,038 EU/t	Buffered UV	526.3 h
UV	Chrysotile	Huge	160%	Tight	Steam	1,792,000 L/t	1,433,600 EU/t	Buffered UV	23.0 h
UHV	Duranium	Huge	166%	Loose	Steam	6,486,152 L/t	5,370,534 EU/t	Buffered UHV	55.6 h