



# The Steam Machine

Energy Recovery from “The Most Powerful Machine in the World”<sup>(1)</sup>



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Langson Energy's Steam Machine is an economically viable solution to improving energy efficiency and recovering energy from waste heat and waste steam. It works with various types of steam and waste heat in many different industrial processes – especially those with saturated steam. It utilizes helical screw technology, which has been an integral part of the compressor business for over 100 years. By investing years of research and true entrepreneurial and inventive spirit, Mr. Richard Langson has developed another method for converting wasted energy into low cost power. This advanced Steam Machine will dramatically improve the economics of green energy opportunities.

The Steam Machine has significantly lower capital costs than other steam turbines. By integrating Langson Energy technology with components that have a proven history of reliable, robust, low-maintenance performance, Langson has solved the challenges of expensive steam turbine solutions to generating power. Traditional turbines have been the accepted method for generating power from steam pressure for many years. However, their high capital costs and difficulty in handling fluctuations in pressures and flow rates as well as problems with wet steam have proven to be significant hurdles to running sources with inconsistent conditions, saturated, contaminated steam, two-phase fluids and geothermal brine.

## I. Introduction

It was the steam machines that propelled the Industrial Revolution in the early 1800's. Today, steam-electric power plants produce about 86% of all electricity worldwide.<sup>2</sup> Yet the electric efficiency of a conventional steam-electric power plant is typically 33 to 48% efficient<sup>3</sup>. It is the economic recovery of lost energy from turbines, stack heat, biomass & biogas boilers, geothermal or most sources of waste heat and waste steam for which Langson Energy's Steam Machine offers significant benefits to improve energy efficiency.

The ideal match of a prime mover compatible with a liquid has been historically absent. It has been necessary to produce a dry vapor to drive a turbine, either by flashing part of the liquid to steam and separating the water out, or by boiling a secondary fluid in a heat exchanger. In the steam-flashing process, much energy is lost in the waste fluid which flows from the steam separators, and the throttling step itself is inherently inefficient. Similarly, in the process involving a secondary fluid, substantial energy losses are associated with the temperature difference necessary to drive the heat exchanger and with the power demands for pumping the secondary fluid. In addition, supplementary process equipment, especially heat exchangers, condensers and cooling towers are expensive.<sup>3</sup>

## II. Langson Energy's Solution

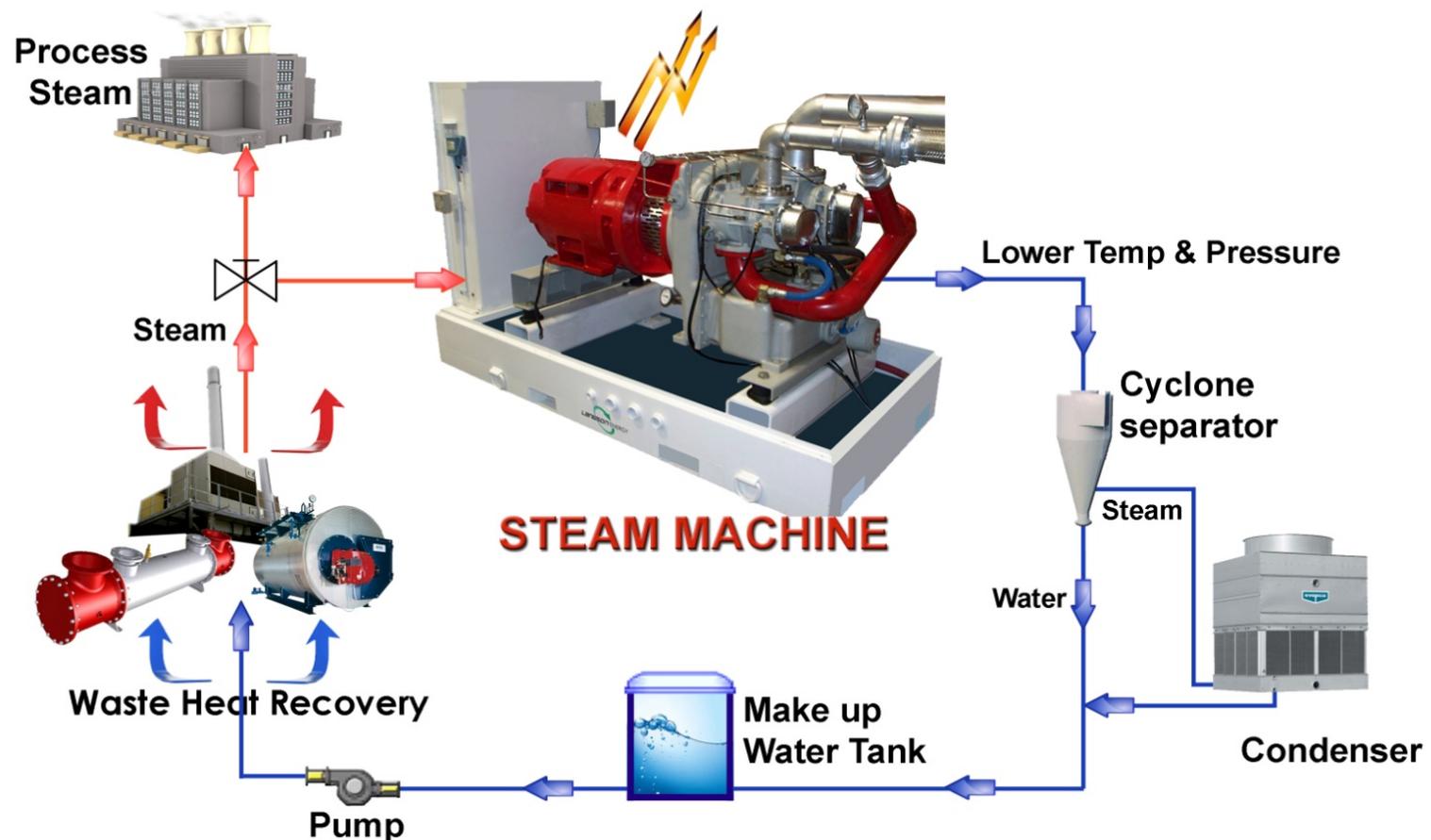
Langson Energy has developed an exceptional Steam Machine that solves the problems inherent in running wet steam in traditional steam turbines. The helical screw expander is a unique positive displacement machine, which bridges the gap between centrifugal or axial flow type aerodynamic machines and reciprocating positive displacement machines. By utilizing a robust, helical screw expander, total flow generators add efficiencies to countless applications that have, until now, been very challenging. It runs at a slower speed without the high radial loads, tip speeds and balance problems characteristic of turbines. As a saturated steam prime mover, the helical screw expander is a total flow machine, which can expand directly the fluid that is continuously being produced from the hot saturated liquid as it decreases in pressure during its passage through the expander. The effect is that of an infinite series of stages of steam flashers, all within the prime mover. Thus, the mass flow of vapor increases continuously as the pressure drops throughout the expansion process,



and the total fluid is carried all the way to the lowest expansion pressure. The process approximates an isentropic expansion from the saturated liquid line for the total flow<sup>3</sup>.

By utilizing helical screws, the Steam Machine can recover waste heat to generate power without the combustion of any fuel beyond what is needed to run the gas turbine. It can be used with saturated or low-quality steam, waste steam, geothermal brine, two-phase fluids, letdown steam PRVs, and also dry, superheated steam, etc. to generate clean electricity. They can handle moisture that would cause serious damage to turbines.

## STEAM MACHINE Heat Recovery "CHP"



**Capital Costs** – The installed capital cost of the Steam Machine is significantly less than other energy efficiency solutions. Langson modifies readily-available and proven components. This holds the capital investment in a Steam Machine to a fraction of what would be required for a steam turbine installation. Helical screw technology has a proven track record of literally millions of hours of operation and tens of thousands of installations worldwide.



**Operating Costs** – The operating costs of the Steam Machine are estimated to be significantly less than alternative environmentally friendly systems. Routine maintenance is simply lubricating oil changes twice a year and generator lubrication. Bearing and seal replacement is done every 50,000 hours (or 5 years of continuous operation) providing the customer with a very favorable value proposition.

**Base-Load and Distributed Power** – One of the challenges facing the expansion of green energy generation is that methods such as wind and solar provide intermittent power generation and require backup power facilities in order to maintain an adequate base-load power supply. Costly transmission lines normally need to be run from remote sites to be grid connected. Langson's Steam Machine can operate 24 hours a day, 7 days a week providing reliable on-site power or distributed power closer to the existing transmission capabilities.

**Blackstart, Stand Alone and Off Grid Capability** – The Steam Machine can be effectively used as the prime mover, i.e., without the accompanying steam turbine. For example, in new geothermal fields when a few wells have been drilled but the main power plant is under design or construction, the Steam Machine can be hooked up to a well or a set of wells to begin generating power immediately. This electricity can help power the drilling operations, being of critical importance particularly in remote sites. Moreover, owing to the compact, skid-mounted design of the Steam Machine, it can be readily moved around the field as wells are connected to the main plant and new wells continue to be drilled, or moved new fields.

**Emission Reduction** – Since the Steam Machine uses waste heat, saturated steam or otherwise under-utilized energy to generate electricity, the necessity to generate the same power by using fossil fuels, coal or nuclear fuel sources is eliminated and improvement in the average emissions per kilowatt is realized. This is revealed as a significant increase in the thermal efficiency of the combined cycle. For example, the U.S. Environmental Protection Agency (EPA) states that the average emission rates in the United States from natural gas power plants is 4,971 Tons of CO<sub>2</sub> per MW each year<sup>5</sup> In 2012 natural gas plants generated 1,230,708 gigawatt hours of electricity in the USA.<sup>6</sup> Thus, CO<sub>2</sub> from natural gas plants emitted exceeded 6 trillion tons. If only 10% of the electricity generated by these gas-fired plants utilized a Steam Machine to improve its efficiency by 10%<sup>9</sup>, over 90 billion tons of CO<sub>2</sub> would be reduced each year in the US alone.

**Redundancy Capability** – Lower capital investment and the Steam Machine's modular, compact design allow for the ability to create parallel, serial, expandable and redundant power generation capabilities on a distributed basis. On sites with sufficient flows and pressures to warrant multiple units, a serial or parallel combination can be deployed.

**Efficiencies** – Typically, expanders have demonstrated overall adiabatic efficiencies well in excess of 60% over a wide operating range and have reached efficiencies as high as 85%.



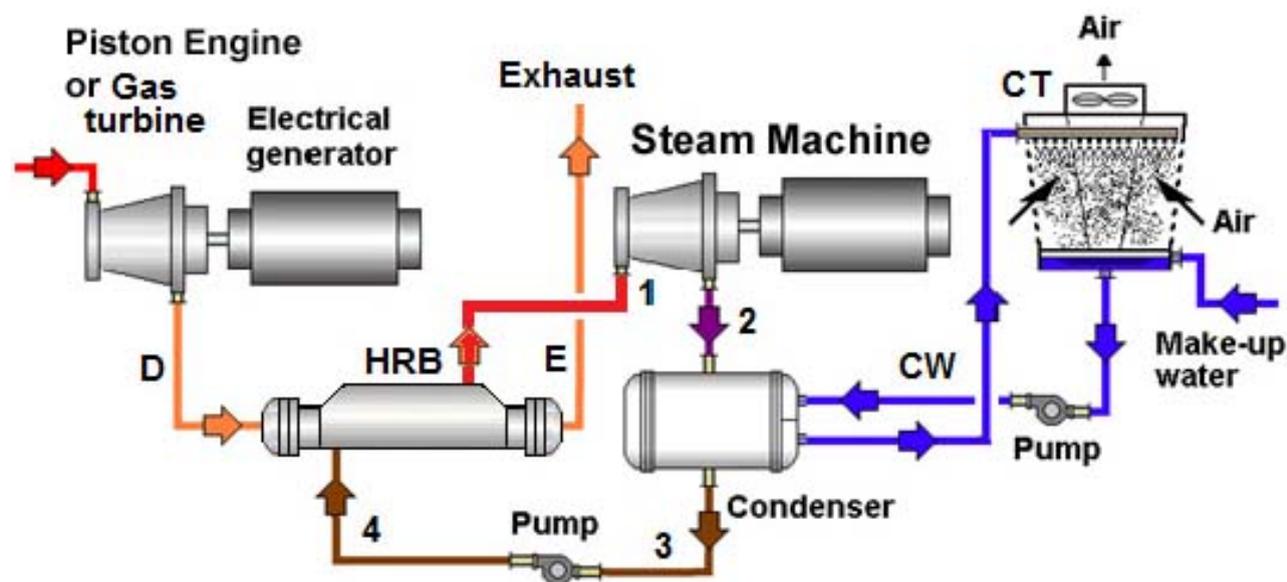
### III. Turbines

Turbines are well-known throughout the power generation industry. They are rotary engines that extract energy from a fluid flow, whether that is gas, steam or combustion (e.g. jet engines). They efficiently use the energy in the fluid and are widely utilized for power generation. However, the complexity of turbines causes them to have relatively high capital costs and operating costs.

### IV. Sample Applications



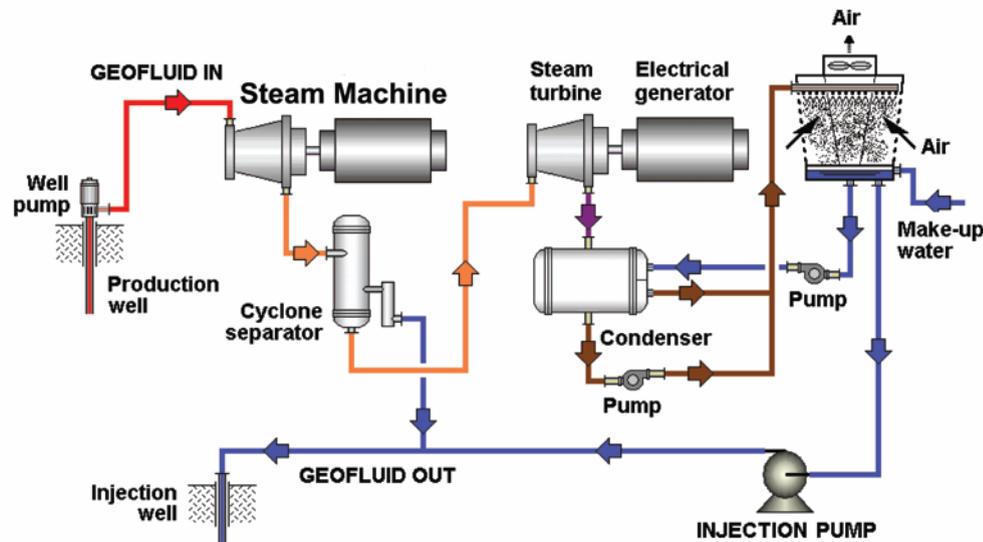
### Gas Turbines and Piston Engines



The Steam Machine has the capability to perform well in conjunction with gas turbines and piston engines (reciprocating engines) by utilizing the waste energy stored in the exhaust to generate power without the combustion of any fuel beyond what is needed for the gas turbine or engine. By generating electricity without the need for any external input energy, the average emissions per kilowatt are reduced.

Gas turbines, used to provide stand-alone electric power generation for utilities and large industrial users and to provide shaft power to drive gas compressors along the many gas pipelines, can be fired with distillate, usually the fuel of choice is natural gas, especially when used at natural gas compressor stations where they operate continuously. When gas turbines are used in conjunction with waste heat boilers and steam turbines, the resulting combined cycle has the highest thermal efficiency of any electric power plant, which is about 60-65%. The Steam Machine may be considered as a device for replacing the steam turbine in combined cycle applications. The specific benefits of using the Steam Machine as part of a combined cycle depend on the technical characteristics of the gas turbine or piston engine since the downstream system must be compatible with the exhaust conditions available.<sup>9</sup>

## Topping Units



When used as a topping unit, the Steam Machine improves the total electrical output and thus increases the efficiency of a power plant. In this diagram, the Steam Machine is incorporated within an integrated geothermal power system where the Steam Machine essentially replaces the standard cyclone separator in a typical flash-steam power plant.

## Steam Blowdown

The Steam Machine can utilize steam pressure from any boiler with continuous blowdown exceeding around 5% of the steam rate. Larger energy savings can occur with high-pressure boilers. The table to the right shows the potential for heat recovery from boiler blowdown. Another benefit is the cooling that helps to comply with local codes limiting the discharge of high-temperature liquids into the sewage system.<sup>8</sup>

Recoverable Heat from Boiler Blowdown

| Blowdown Rate, % Boiler Feedwater | Heat Recovered, Million Btu per hour (MMBtu/hr) |     |      |      |      |
|-----------------------------------|---|-----|------|------|------|
|                                   | Steam Pressure, psig                            |     |      |      |      |
|                                   | 50  | 100 | 150  | 250  | 300  |
| 2                                 | 0.45  | 0.5 | 0.55 | 0.65 | 0.65 |
| 4                                 | 0.9   | 1.0 | 1.1  | 1.3  | 1.3  |
| 6                                 | 1.3   | 1.5 | 1.7  | 1.9  | 2.0  |
| 8                                 | 1.7   | 2.0 | 2.2  | 2.6  | 2.7  |
| 10                                | 2.2   | 2.5 | 2.8  | 3.2  | 3.3  |
| 20                                | 4.4   | 5.0 | 5.6  | 6.4  | 6.6  |

Based on a steam production rate of 100,000 pounds per hour, 60°F makeup water, and 90% heat recovery.

## Process Steam

Heating applications for positive pressure steam can be found in food processing factories, oil & gas refineries, plants for chemicals, petrochemicals, plastics, pharmaceuticals, fiberglass, adhesives, glues iron, steel, automotive, rubber, tire, ceramic, glass, printing, textile, water, garbage and sewage processing, data centers, hospitals or hotels to name a few. Excess process steam is typically saturated steam that can be used by the Steam Machine to improve efficiencies and generate clean, low cost, electricity. Since saturated steam has a much higher useful heat content than superheated steam, it is used in such processes where heating and sterilization are needed.<sup>12</sup>

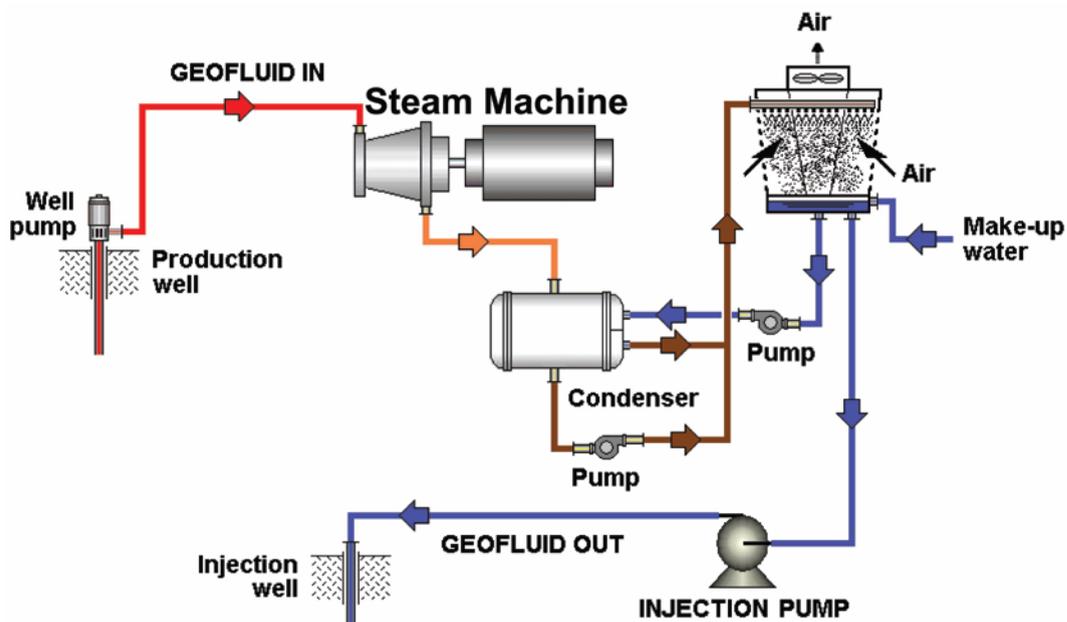
Electricity can also be generated during “idle” boiler times when a wide range of steam demands leads to periods where optimum use of the boiler is not achieved. On Jan. 31, 2013 the US EPA submitted MACT standards that require an estimated 14,136 boilers and process heaters in the USA to reduce their emissions by 2016 and all new boilers and process heaters must meet these standards.<sup>11</sup> The Steam Machine can help in many instances. See diagram on page 3.

## Geothermal

As a Total Flow Generator, the Steam Machine can accept geofluid directly from the well pumps. The technical challenges of the Steam Machine working with geothermal brine are minor compared to technical challenges faced by existing turbine and ORC technologies. In fact, some brine deposits on the rotors increase the isentropic efficiency of the Steam Machine. The advantages of the Steam Machine lie in its simplicity, lower capital cost, ease of installation, reliable operation, lower cost of electricity, and ability to operate on lower-temperature reservoirs when compared to either flash-steam or binary systems.<sup>7</sup>

Hot water is usually produced from wells by means of downhole pumps. The Steam Machine could capture some exergy before the fluid enters the heat exchangers. In some cases, 2-phase mixtures are present and the Steam Machine could be more effectively used here than sending steam to heat exchangers, as is done at some existing plants. Given the prevalence of binary plants, both in operation and under development, this is an ideal application<sup>10</sup>

Per the diagram to the right, water cooling towers are used in conjunction with the Steam Machine, which will be thermodynamically superior to competing binary plants. In addition, such plants will be less expensive to install, lending an economic advantage over typical installations. Another advantage of water cooling towers is that the net power over the course of a year will be more uniform than installations utilizing air-cooled condensers that are very sensitive to variations in air temperature.<sup>7</sup>



## Geo Pressure



The Steam Machine is an excellent means of converting energy which is being wasted with the hot water that is separated from oil and gas wells. It is far simpler than the binary plants being tested and more efficient, assuming 65% - 75% isentropic efficiency.<sup>10</sup>

### **Solar Thermal Heating Plants**

The Steam Machine provides a means to generate power from lower-temperature collectors.<sup>10</sup>

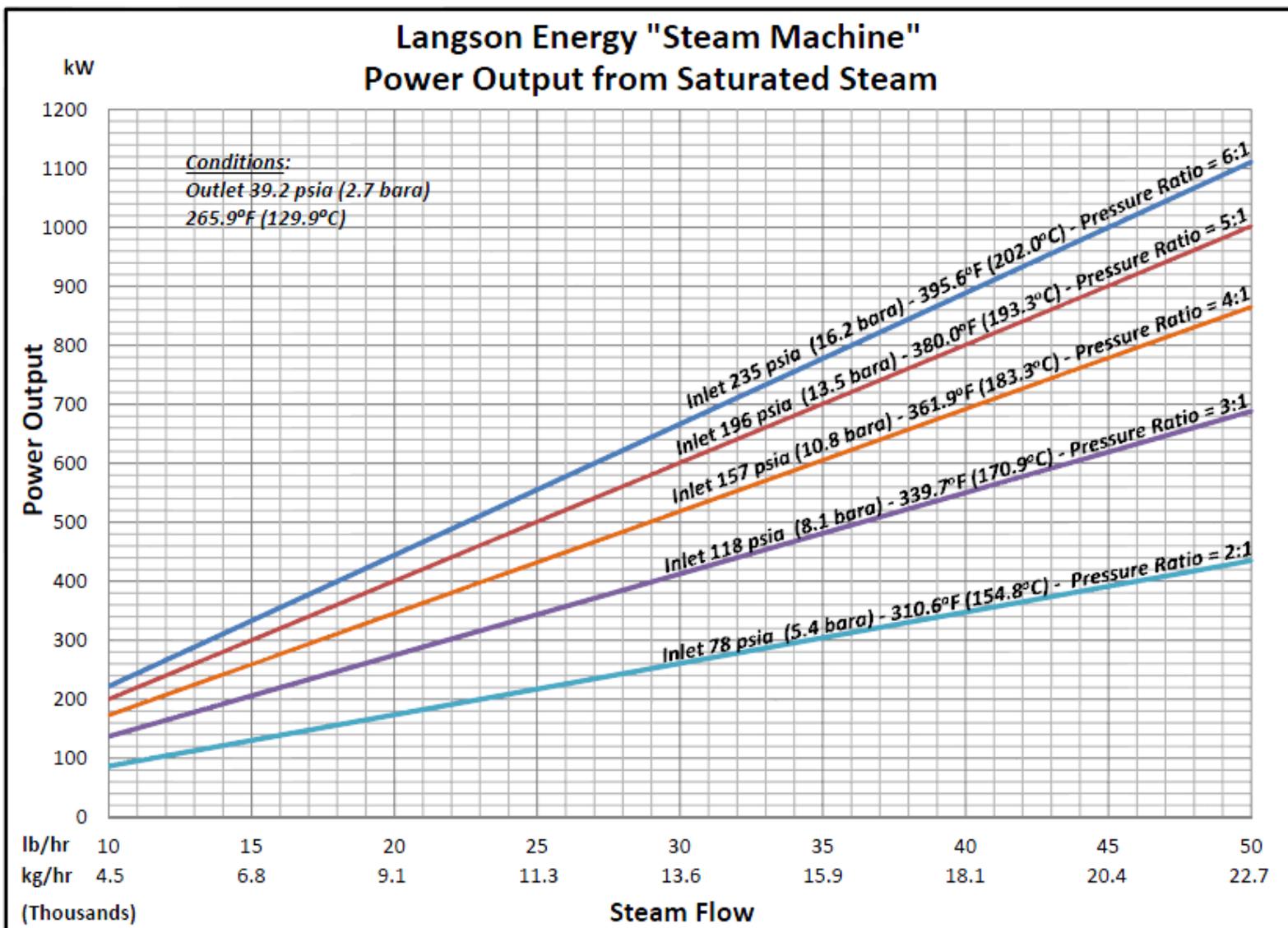
### **V. Sample Power Outputs for the Steam Machine**

The following graph and table can be used to get an idea of how much electricity one Steam Machine can generate based on typical inlet and outlet temperature, pressure, and flow rates.

It is very important to note that since the Steam Machines can be installed in parallel or in series, the potential for power output is only limited by the amount of waste energy available for recovery from any particular process system.

## V. Summary

Langson Energy's Steam Machine solves the challenges of utilizing renewable energy and wasted energy from low-grade or saturated steam. It improves energy efficiency and avoids emissions. Countless opportunities to make carbon free, base load green power are now re-opened. This new technology warrants a re-examination of the potential of those installations with a new paradigm, the Langson Energy Steam Machine.





### **References:**

- <sup>1</sup> The Most Powerful Idea in the World – A Story of Steam, Industry, and Invention” by William Rosen, 2010
- <sup>2</sup> [http://en.wikipedia.org/wiki/Steam-electric\\_power\\_station](http://en.wikipedia.org/wiki/Steam-electric_power_station)
- <sup>3</sup> JPL Report, Helical Rotary Screw Expander Power System
- <sup>4</sup> Water and Steam Applications of the Langson Helical Screw Energy Converter, by Dr. Ron DiPippo, Renewable Energy Consultant 2012
- <sup>5</sup> <http://www.epa.gov/cleanenergy/energy-and-you/affect/natural-gas.html>
- <sup>6</sup> <http://www.eia.gov/electricity/data.cfm#gencapacity>
- <sup>7</sup> Report 01 - Analysis – Air Cooled Condensers by Dr. Ron DiPippo, Renewable Energy Consultant 2010
- <sup>8</sup> US Department Of Energy - Steam Tip Sheet #10 - Recover Heat from Boiler Blowdown
- <sup>9</sup> Report 32 - LEI Steam Machine Combined with Gas Turbnes by Dr. Ron DiPippo, Renewable Energy Consultant 2013
- <sup>10</sup> Report 12 - Applications for the Langson TRG by Dr. Ron DiPippo, Renewable Energy Consultant 2010
- <sup>11</sup> EPA Federal Register / Vol. 78, No. 21 / Thursday, January 31, 2013 / Rules and Regulations
- <sup>12</sup> [http://en.wikipedia.org/wiki/Superheated\\_steam#Saturated\\_steam](http://en.wikipedia.org/wiki/Superheated_steam#Saturated_steam)