

The Vortex Engine: Energy from Nature

Proponent: Don Cooper

Business Plan

Project purpose

Using the principle of an atmospheric vortex engine, to develop and market the technology for:

- sustainable generation of electrical power for the Grid or local usage
- transmission of waste heat from Earth's surface to the top of the troposphere
- enhancement of precipitation in the system's locality
- scrubbing pollutants from the Atmosphere

The Problems

1. Renewable energy is critical to our environmental, economic, and National security. Demand for renewable energy is rapidly on the rise, both as electrical power and also conversion to carbon-free fuels such as ammonia and hydrogen.
2. The development of sustainable energy systems is mandatory in order to reduce and eventually reverse global climate change
3. Particulate discharge from fossil fuel combustion and burning of rainforests is responsible for the unprecedented and unsustainable 'Asian Brown Cloud' over much of India, southeast Asia and China. Apart from causing severe health problems, the pollution inhibits atmospheric convection and hence the efficiency of radiation of heat from the atmosphere to Space

4. Flaring and venting waste is estimated at 8% of global natural gas production annually <https://www.pnas.org/content/117/23/12503>

This equates to 300 billion m³/annum, worth around \$60 billion.

5. This also contribute 6% of global greenhouse gas emissions, and disperses a range of pollutants that harm human health and local environments. <https://www.pnas.org/content/117/23/12503>
6. Atmospheric pollutants from gas flaring include CO₂, CO, CH₄, NO_x, N₂O, H₂S, hydrocarbons, Particulate matter (PM), etc. Of the emitted gaseous species, CH₄ and N₂O are both greenhouse gases with much higher global warming potential than CO₂. In addition, the associated gas containing H₂S (sour gas) can be very toxic. Dispersal at high altitude would effectively eliminate the hazard.

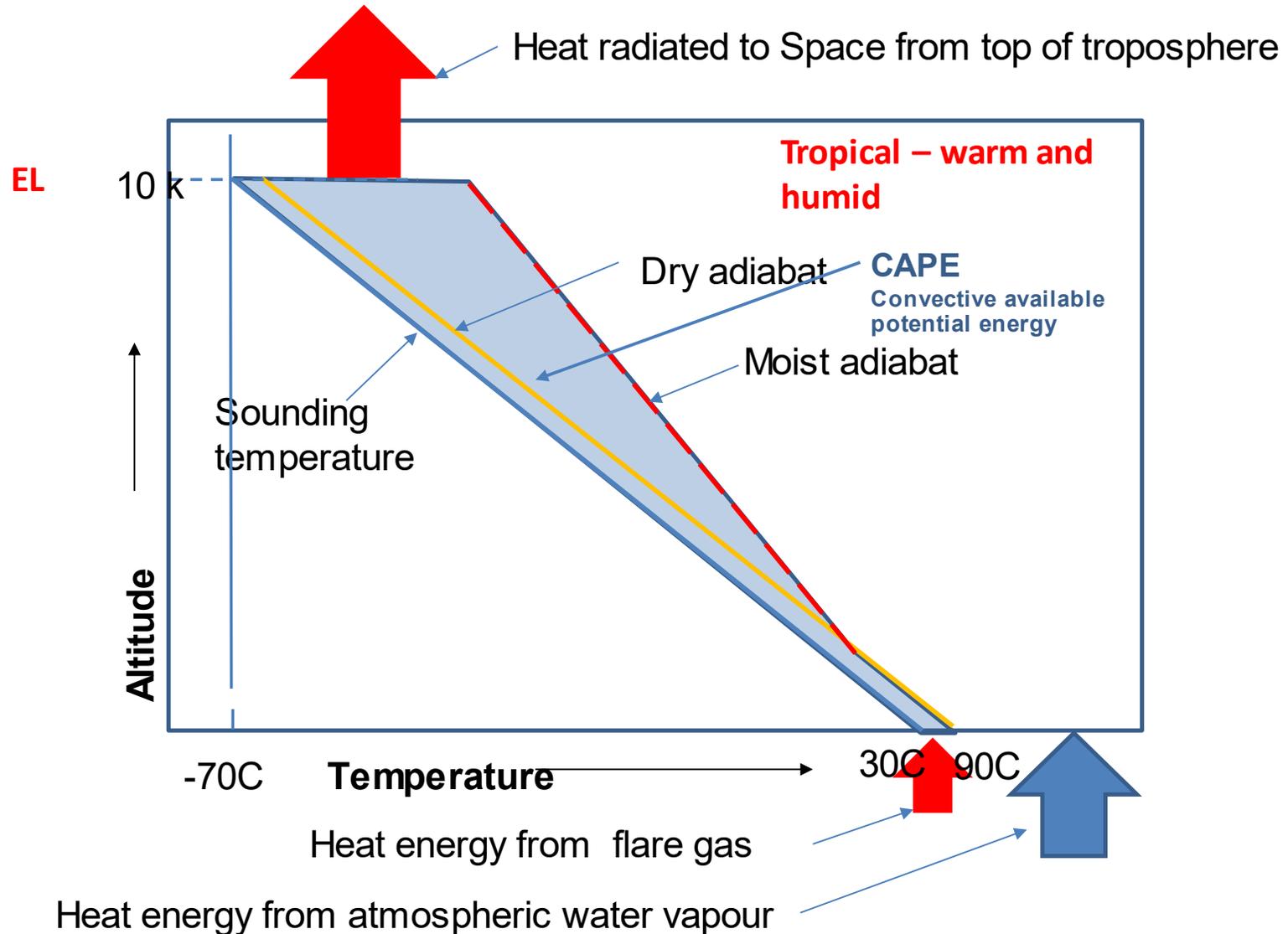
7. Particulate matter from gas flaring mainly takes the form of soot or black carbon. Black carbon (BC) is thought to be second [only] to carbon dioxide in terms of global warming. It directly warms the atmosphere by absorbing sunlight and also indirectly, reducing surface albedo via deposition on ice and snow covers. In contrast to greenhouse gases with long lifetimes, BC usually stays in the atmosphere [only] for days to weeks, and thus is considered to be a short-lived climate forcer (SLCF). In this light, control of black carbon particles by emission reduction measures would have *immediate* benefits for air quality and global warming..."

<https://www.nature.com/articles/sdata2016104>

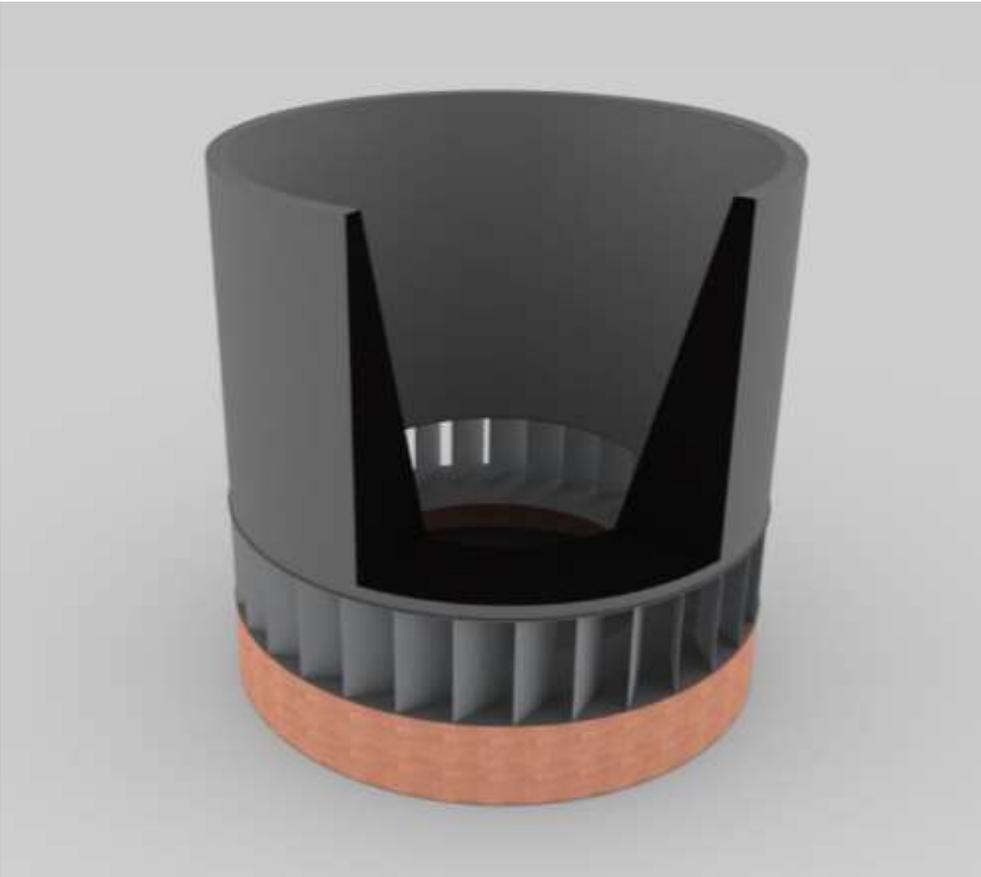
The Solution

- The vortex engine can generate power by using relatively 'low grade' heat, through tapping into the temperature differential between the top and bottom of the troposphere (~100C). Examples of this otherwise waste heat would be low grade geothermal (50 – 90°C), thermal power station flue gas and condenser cooling systems, and in this case, waste flare gas from petroleum and natural gas production
- Smog can be reduced and eventually eliminated by using a system such as the vortex engine which:
 - Has very low particulate emissions
 - Can act to effectively 'scrub' the atmosphere through enhanced local precipitation
- The vortex engine will make it financially attractive for Third World nations in tropical regions to **retain** rainforests and utilise their natural resources in synergistic partnership for power generation

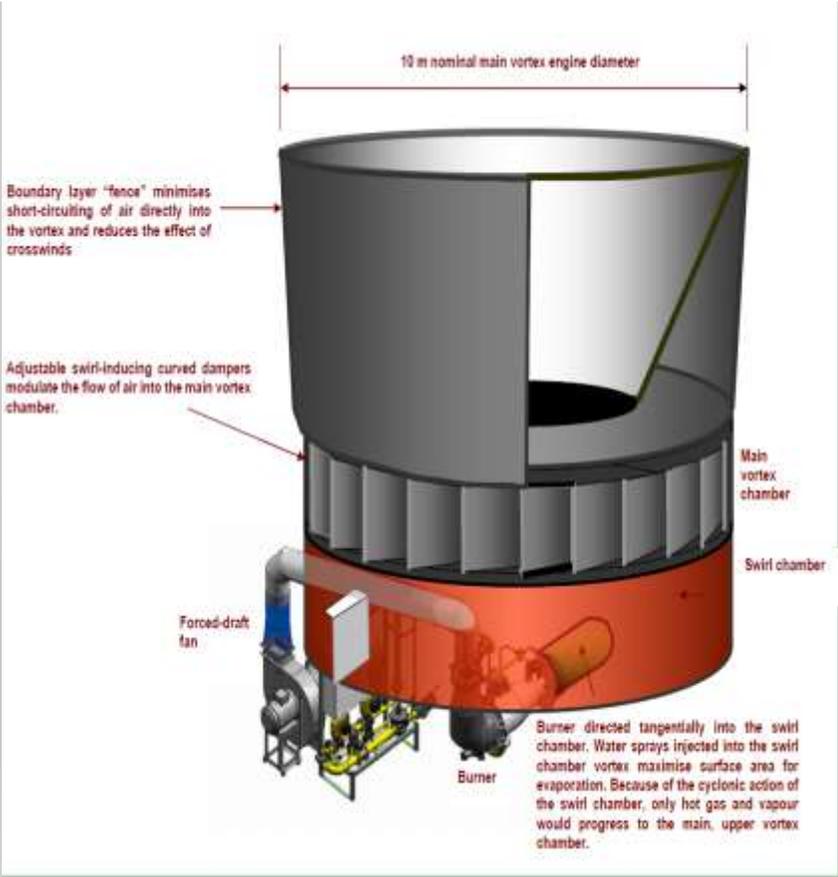
The Vortex Engine can leverage heat transfer by use of the energy of atmospheric water vapour



The Vortex Engine (Gas Flaring)

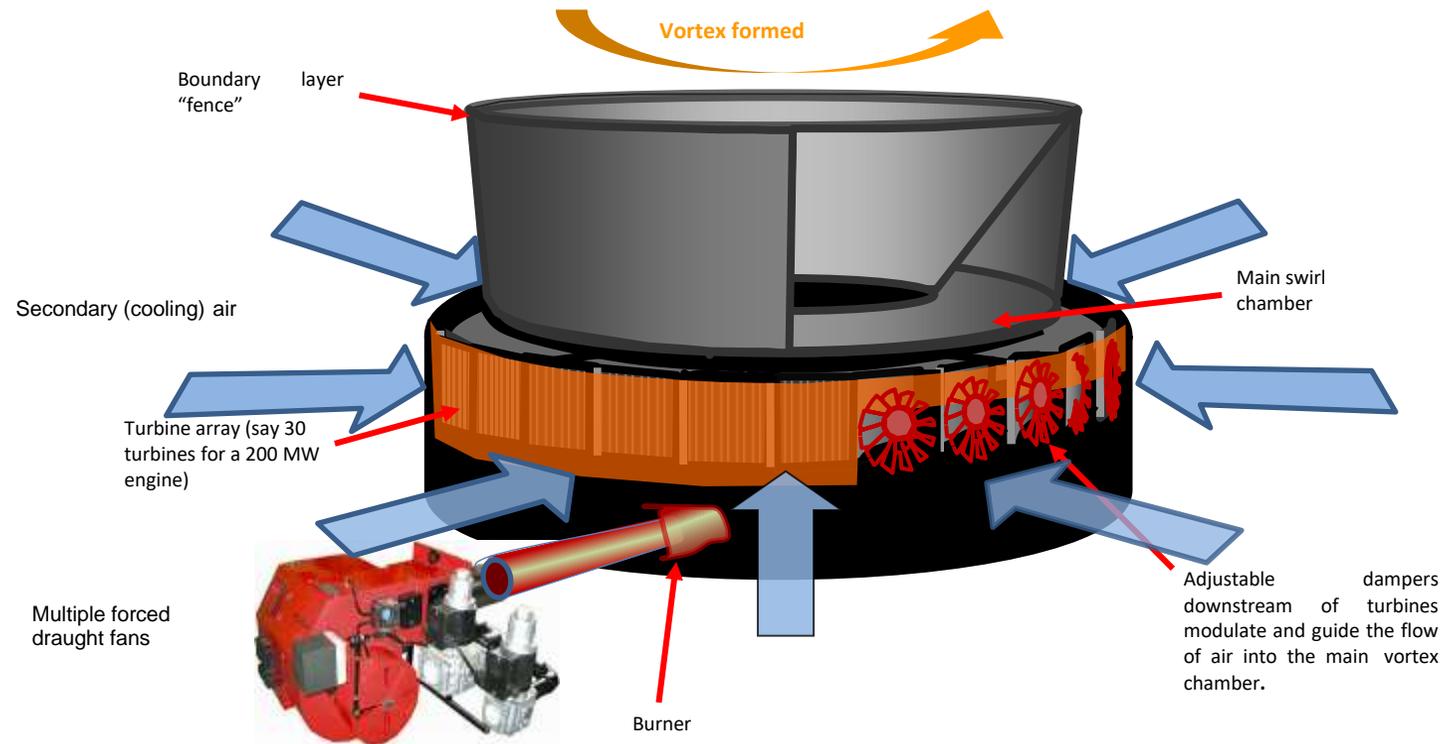


Engine core



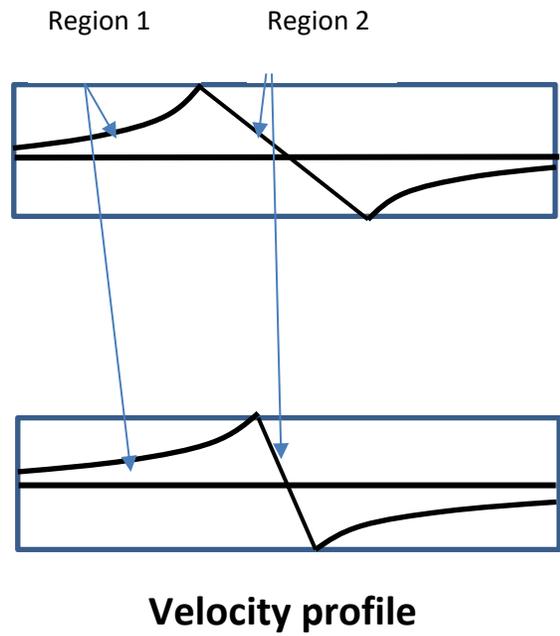
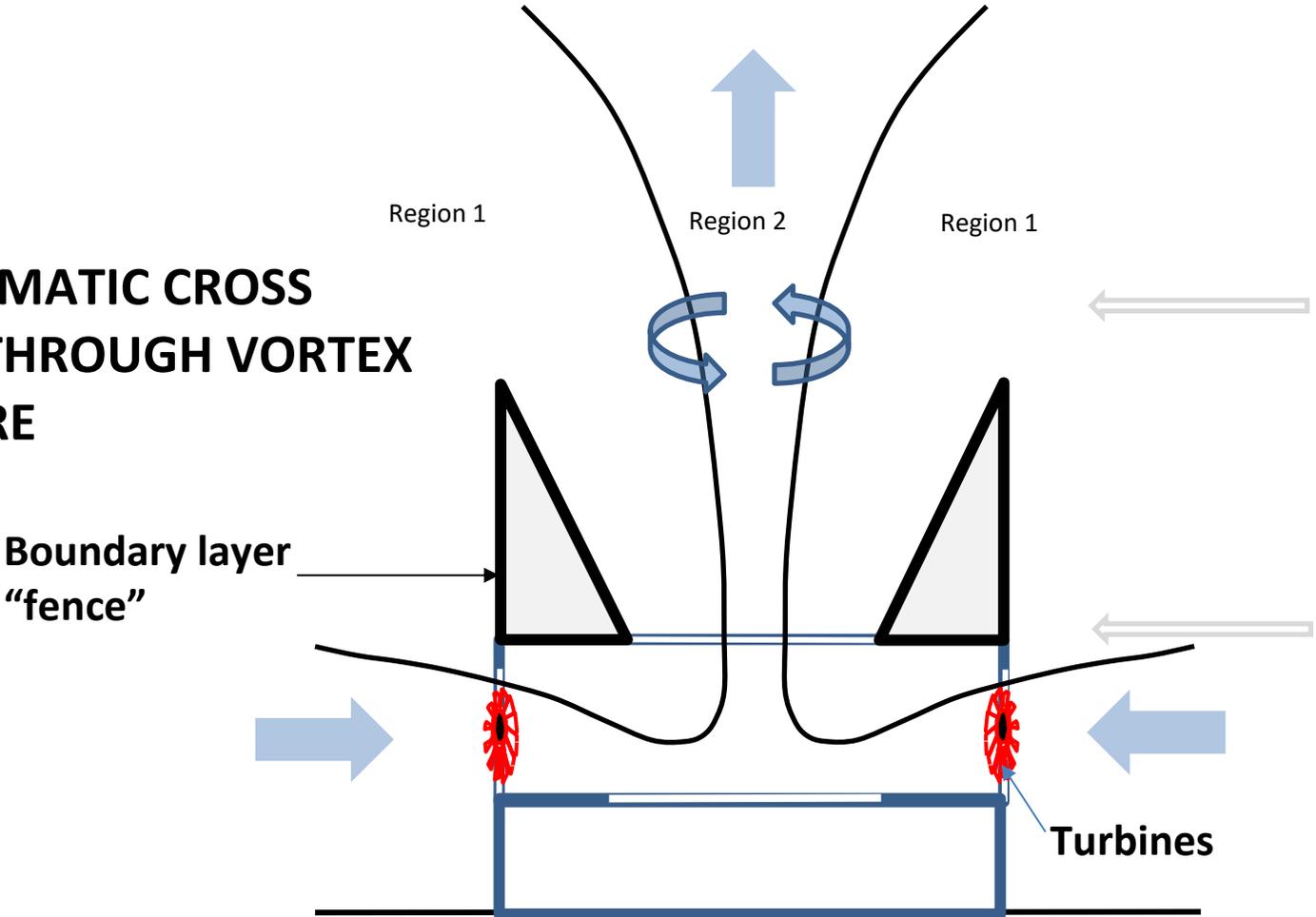
Arrangement

Small scale prototype



Full scale system

DIAGRAMMATIC CROSS SECTION THROUGH VORTEX STRUCTURE



Why now?

- We are in a race against time to prevent irreversible damage to our global environment
- We have competitors:

Including:

- Canada
 - AVETec
- The US
 - GATECH consortium
- New Zealand
 - University of Auckland

Arguably, none of the above is currently past the relatively small-scale research rig stage.

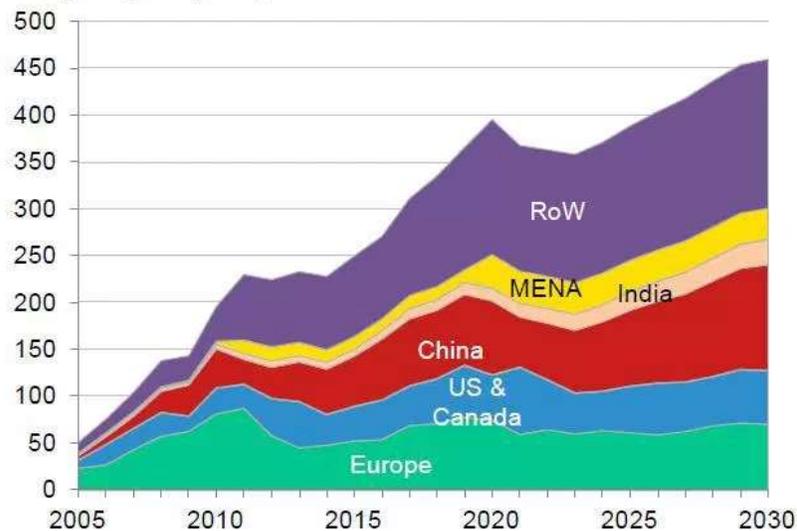
- **The use of waste energy from gas flaring will allow fast-tracking of a proposed research and development program**

Market size

- Meeting new renewable energy growth:** The market for renewable energy construction in 2015 was on the order of USD\$250 billion. It is currently growing at a rate of 12% per annum. On this basis, the renewable energy construction market in 2030 is projected to be USD\$450B. Based on an achievable 20% share of this for the Vortex Engine, the potential market would be US\$90 billion.

However, these expenditures are nowhere near enough to mitigate global warming to the extent required to meet the objectives of the United Nations Paris Climate Conference. The Vortex Engine technology is therefore in an excellent position to attract investment away from conventional thermal power plant construction, which could easily double the available market.

Annual value of renewable energy capacity installed, 2005-30 by region (\$bn)



MENA = Middle East North Africa

RoW = Rest of World

Source: Bloomberg New Energy Finance

Comparison of advantages of Wind, Solar and Vortex Engine based on 500 MW plant capacity:

	Wind	Solar	Vortex Engine
Estimated site size	7000 hectares	3500 hectares	400 hectares
Installed cost for 500 MW in China	\$750 million *	\$400 million *	~ \$500 million +
Useful life (yrs)	20	25	50
Generates power 24/7	No	No	Yes
Predictable output	No	No	Yes

*based on figures from <https://w3.windfair.net/wind-energy/news/18208-product-of-the-week-wow-what-power-the-solar-wind-energy-tower>

+based on personal estimate.

Replacement of existing power generation technology: *Since 2000, the world has doubled its coal-fired power capacity to around 2,000 gigawatts (GW) after explosive growth in China and India. A further 236GW is being built and 336GW is planned.* <https://www.carbonbrief.org/mapped-worlds-coal-power-plants>

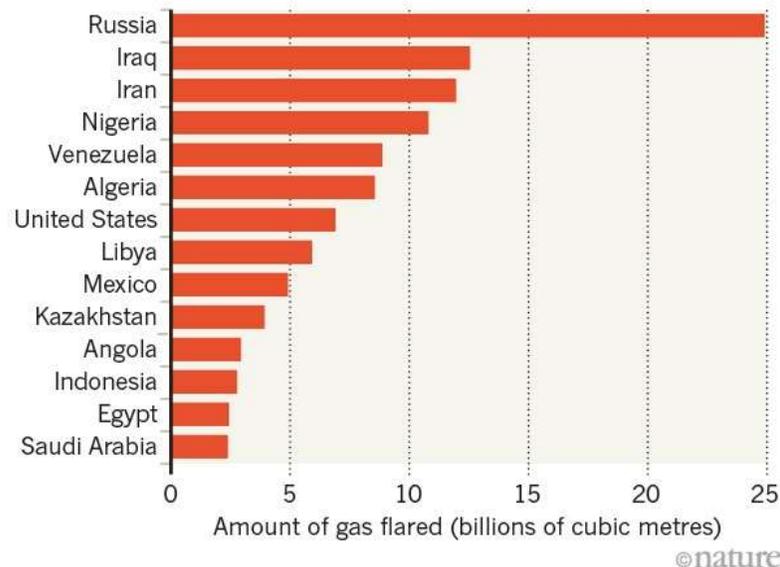
China possesses 1000 GW of coal plant. If the indicative capital cost of 1GW of generating capacity in China is USD\$750M (a reasonable figure), there is more than \$750B of Chinese power station to be replaced with one or more non-coal technologies. The Vortex Engine would be an excellent fit; based again on capturing a conservative 20% of that gap, there is another \$150B market in China alone.

- 8. Use for power production by flaring of surplus natural gas:** Currently around 8% of world natural gas production is wasted: 3.5% flared and a similar amount vented. See Nature news: <https://www.nature.com/news/flaring-wastes-3-5-of-world-s-natural-gas-1.19141> and <https://www.pnas.org/content/117/23/12503>

When considering the negative effect in terms of climate change, the cost would be far higher. “...*The World Bank aims to end routine gas flaring at oil production sites around the world by 2030, in an [initiative](#) launched last year. Some 45 governments, organizations and oil companies had signed up to the plan by the end of the international climate negotiations in Paris...*”

TOP NATURAL-GAS-FLARING NATIONS

More than 143 billion cubic metres of natural gas was wastefully burned in 2012, around 3.5% of the world's supply.



Product

- 1. Phase 1:** initially a research rig of around 10 metres diameter using waste natural gas for proof of concept. A desktop theoretical design assessment and computer modelling of the rig would be required before building began
- 2. Phase 2:** doubling the geometric scale to 20 metres diameter, in order to generate usable power output (although still not maximum industrial scale).

This 20m rig could also be redesigned to function as a retrofit for existing process plant, with the primary objective of high altitude dispersal of waste gases.

- 3. Phase 3:** a fully “industrial power” scale prototype.

Business model

1. Design of phase 1 research rig AUD\$100K
Funded one third each from venture capital, government and university “in kind”
Note that this is the only item covered by this business plan.

2. Build and test phase 1 rig AUD\$10M
Funded one third each from venture capital, government and university “in kind”

The later stage costings are necessarily less meaningful due to the novelty of the technology:

3. Design phase 2 rig AUD\$2M
4. Build and test phase 2 system AUD\$50M
5. Design build and test phase 3 industrial 200MWe rig AUD\$500M

Research and development program

The plan offered here is for a phased, accelerated, research and development program designed to produce a commercial-scale power generating Vortex Engine in approximately 10 years. The reason for an accelerated program, in addition to the great need for this technology, is the lack of IP protection – the basic physics and engineering have been in the public domain for decades. Therefore a first-to-market position, and a commanding lead in development, are best obtained by an accelerated program. Opportunities will certainly arise to patent or otherwise protect improvements and ancillary inventions during the program.

Phase 1 of four years duration would develop and test a generic technology demonstrator, fully instrumented. This would be a small Vortex Engine to use as a test bed and proof of concept. For an example, see above under Scale. Phase 1 would begin with a discovery and due diligence process, plus detailed budgeting.

Preliminary budgeting for Phase 1 suggests a total cost of USD\$10M. Completion of Phase 1 would allow detailed cost modelling for Phases 2 and 3.

Phase 2 of three years would develop a waste gas Vortex Engine which would carry industrial waste gases toward the altitude of the tropopause. This would contribute to overcoming Asia's smog problem, and would generate a return on the R&D investment.

Phase 3 of six years duration in *parallel with phase 2* would be to develop a larger scale Vortex Engine for power generation. This more expensive undertaking would be partly funded from the commercialisation of Phase 2.

It is not yet possible to meaningfully cost Phases 2 and 3, particularly given the commercialisation opportunities that can be expected once Phase 2 is demonstrated.

From there, as noted above, it should be possible to deliver 200MWe Vortex Engine power stations for around USD\$500M in the USA, or \$175M in China.

Proponent



Donald Cooper is a mechanical engineer and inventor strongly interested in alternative energy and the implications of climate change.

See LinkedIn profile at: <https://au.linkedin.com/pub/donald-cooper/17/7ab/638>