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High-torque low-speed test stand for current energy converter generator testing

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INTRODUCTION

As current energy converter (CEC) generators mature, emulating real world conditions is necessary to determine the response behaviour. Generators connected directly to turbines will turn at unusual speeds and torques not normally encountered with traditional electric generation. Using a 75hp induction motor and 30:1 gearbox, the system will be designed to provide rotary output up to 10,000 N-m at a wide range of speeds to simulate different current velocity, turbine diameter, and power rating combinations.

AIM

The aim of this project is to design a generator test stand that is able to emulate a direct drive turbine in a current flow. Given several limitations such as prime mover speed and transducer maximum torque, an additional goal is to determine the operating envelope of the system. Finally, using the operating envelope, simulation parameters such current speed and power rating can be defined.

METHODS

In order to estimate turbine diameter, RPM, and torque needed by the generator, some assumptions must be made. The efficiency of the turbine blades is assumed to be 45% and density of water is 1000 kg/m3. The tip speed ratio is also assumed to be 5.5. Using these assumptions, all the necessary parameters can be calculated. See results section for full progression of equations.

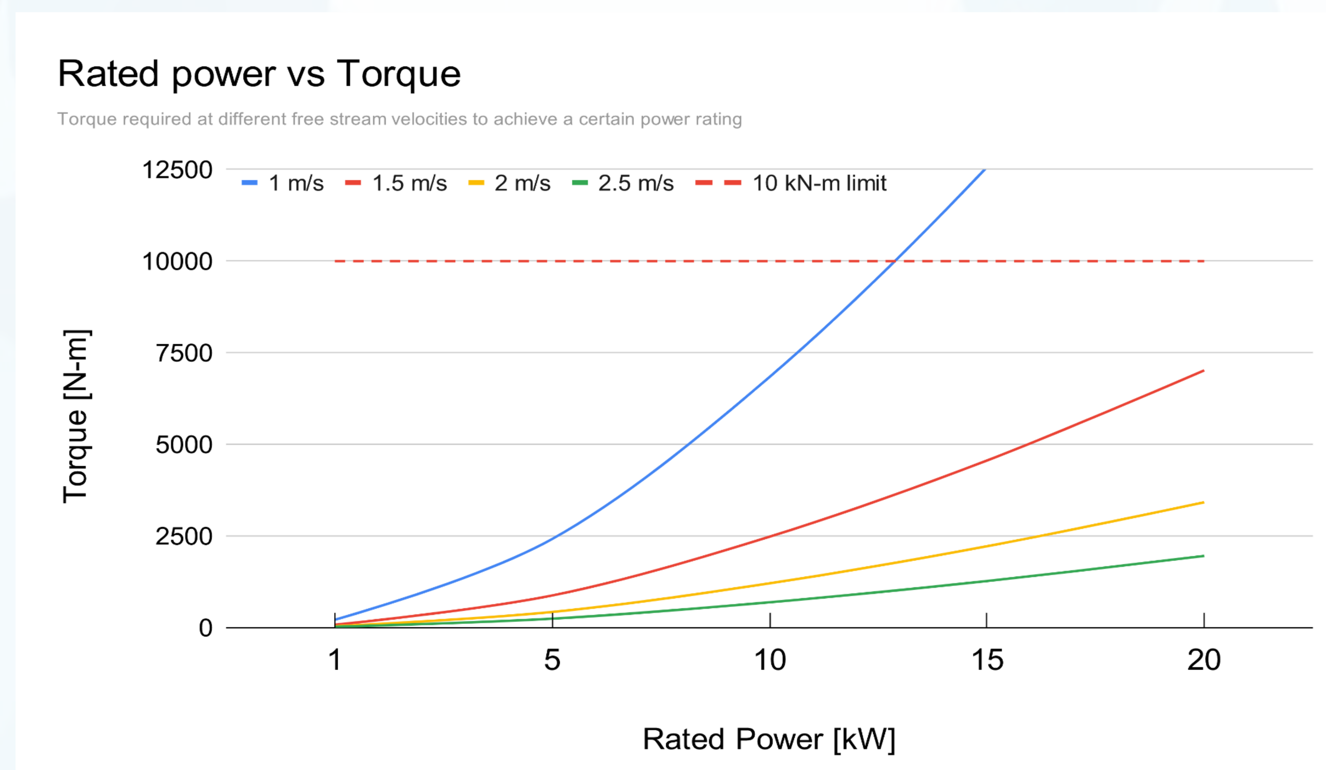
CONCLUSIONS

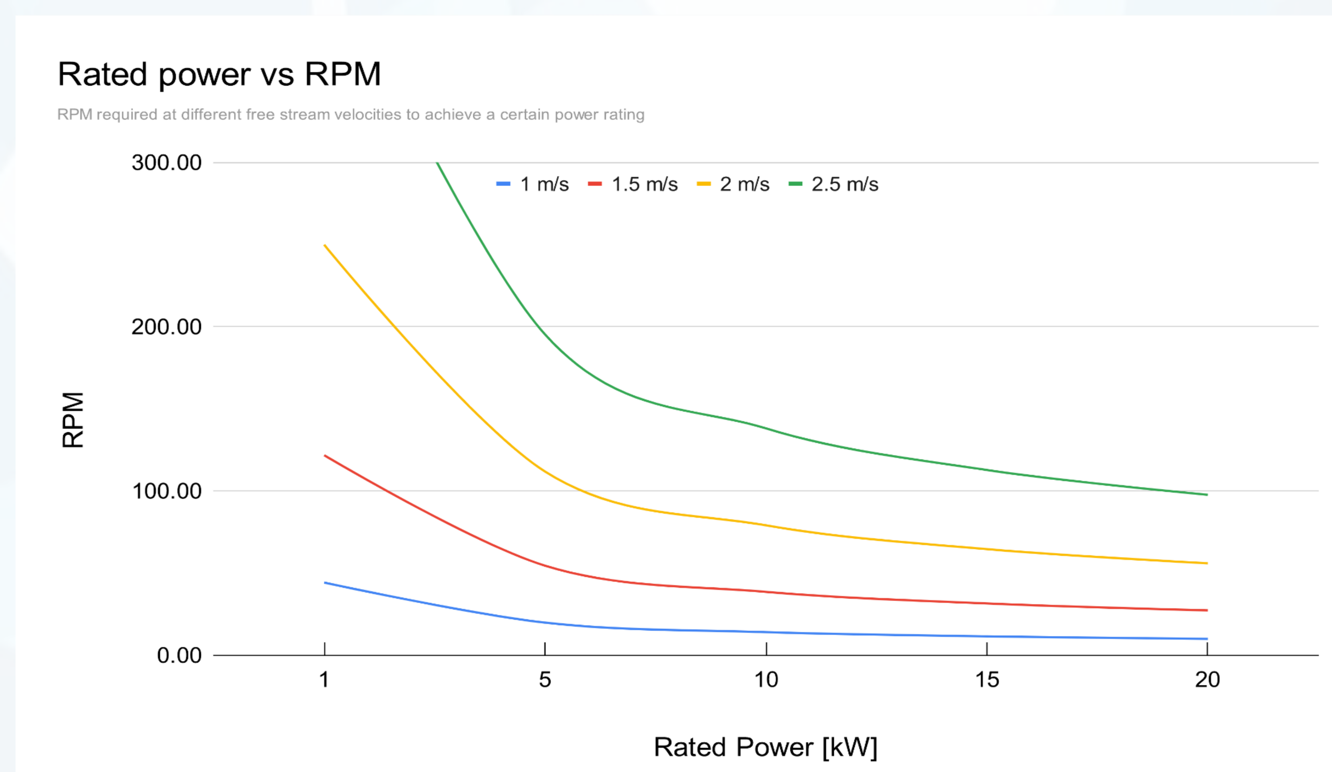
A 75HP induction motor paired with a 30:1 gearbox is capable of emulating the mechanical output of CEC rotors at a range from 7.5 m diameter rotor producing 10kW at 14 rpm to 5m rotor producing 35kW at 43 rpm. However, an auxiliary belt drive on a second output shaft will be needed in order to emulate smaller diameter CEC rotors turning at higher speeds. A combination of a gearbox and a belt drive covers the necessary simulation area determined to be relevant.

RESULTS

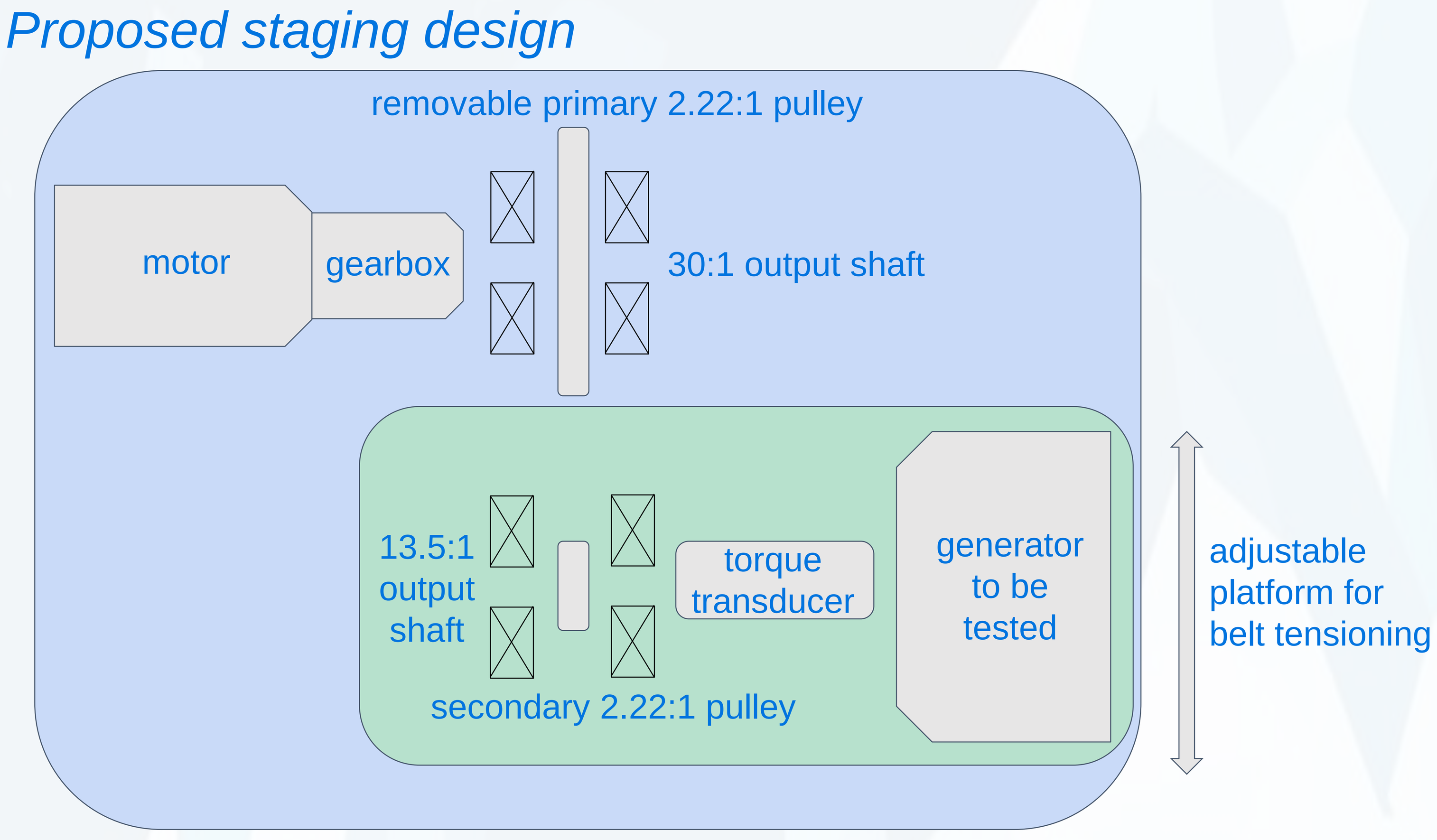
Equation progression given ρ (density), η (efficiency), and λ (tip speed ratio)

Turbine power	Combine & solve for r	Tip speed ratio to find RPM	RPM to find torque
$P = \frac{1}{2}\rho A \eta V^3$	$r = \sqrt{\frac{2P}{\rho \pi \eta V^3}}$	$\frac{\lambda v}{9.55 r} = RPM$	$\tau = \frac{9.55P}{RPM}$
Area of a circle $A = \pi r^2$			



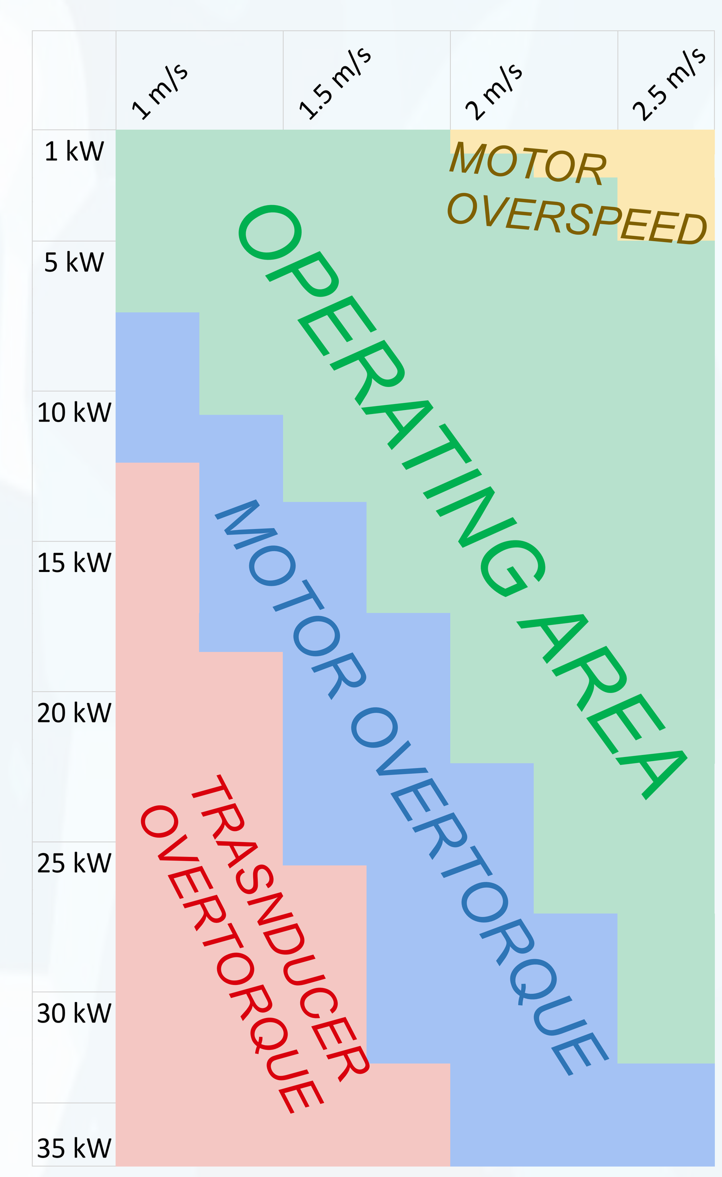


Proposed staging design



75 HP + 30:1 gearbox

75 HP + 30:1 gearbox + 1:2.22 belt drive



FUTURE WORK

The gearbox, motor, couplings, and transducer are to be assembled and tested before use. Once finished, this new capability at the Alaska Center for Energy and Power at UAF will include a full vector-control VFD and suite of mechanical, thermal, and electrical instrumentation to test novel generator technology.

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