EXECUTIVE SUMMARY of BEST ELECTRIC MACHINE:

- Electric motors consume at least 45% of the entire global supply of electricity with a compounded annual growth of 4%, electric generators produce virtually all of the entire global supply of electricity, which includes electricity generated from renewable energy, and electric motors and generators for propulsion will consume the entire 70% of additional growth in the global supply of electricity to accommodate propulsion for Electric Vehicles (EV) as the expected primary means of transportation by circa 2035:
  - As the backbone of the electricity infrastructure, more efficient electric motors and generators (i.e., electric machines) would save considerable amounts of electricity, associated cost, and resulting environmental emissions, such as CO2. For instance, a reasonable 2% incremental improvement in electric motor system efficiency (e.g., 90% efficiency to 92%) could save nearly 1% (e.g., Δ2% x 45%) of today’s entire global supply of electricity; or by arbitrarily assuming 45% of all EV loss is associated with the propulsion electric machine system, the 2% incremental improvement could increase the range of a fully regenerative electric vehicle (EV) another 9% (e.g., Δ2% x 45% or extend range from 300 miles to nearly 327 miles).
  - By including renewable energy (e.g., wind, hydro, tidal, hydrogen, etc.), electric transportation (e.g., ships, EV, electric airplanes), and industrial applications, the very competitive electric machine system market (including electronic control) is well over $300B, all of which use the same century old electric machine system architecture that comprises a passive rotor assembly of slip-induction dependent windings, permanent magnets (PM), reluctance saliencies, or DC field windings.
  - In response, professional articles are being published almost daily that effectively focus on improving the efficiency, cost, and size of the century old electric machine system with readily available but better electromagnetically performing materials, winding, thermal, packaging, and control techniques.

- All electric machine systems operate with the combination of two orthogonal vector components, magnetizing current (or permanent magnet coercivity) for air-gap flux density and torque current to satisfy Lorentz Law for moving force or rotating torque production:
  - The DC magnetizing current component of electrical loss can be eliminated by replacing the magnetizing current carrying magneto-motive-force (MMF) with the coercivity of PMs but only with the competitive high BH energy product and practical persistent magnetizing life of neodymium-dysprosium rare-earth PMs (RE-PMs).
  - Virtually all of today’s high-performance electric machines are electronically controlled (i.e., electric machine systems) for practical operation, such as for a functional PM or reluctance electric machine system, for optimum application, such as adjusting the frequency of excitation for variable speed, for higher speed and electronic reliability, such as adjusting magnetizing MMF (i.e., field weakening), and for torque control, such as adjusting torque current.

- The RE-PM was originally discovered (circa 1980) by USA subsidized or funded research and development (R+D) but now with controlling ownership over the abundance of RE minable resources and without environmental restrictions, the global affiliates and shell companies of the Communist Chinese Party (CCP) are the de facto manufacturer and supplier of virtually all RE-PM electric machine systems, components, and materials with huge geopolitical consequences:
  - Because of anecdotal superior performance attribute of no magnetizing MMF provisioning and the prodigious amounts of inherited USA taxpayer funded or subsidized R+D, CCP RE-PM electric machine systems are becoming universal for at least electric vehicles and large wind
turbines, which again allows the CCP to easily hijack other original pioneering work and investment by the USA (or others), such as the prodigious amount of taxpayer subsidized R+D, manufacture, and installation investments in RE-PM electric machine systems for offshore wind and electric transportation.

- Without addressing the self-defeating consequences of consistently offshoring taxpayer funded R+D and manufacture, USA is now funding research into electric machine systems that decouples the CCP RE-PM influence: 1) by using proportionally less RE-PM material with smaller, higher speed electric machine systems provisioned with the additional compounding cost, size, loss, complexity, and reliability of a speed reduction gearbox and sophisticated high frequency electronic control, 2) by using RE-PM material more efficiently with the application of higher performing electromagnetic material, winding, packaging, manufacturing, thermal, and high speed control techniques, and 4) by eliminating the coercivity of RE-PM materials, altogether, with optimized magnetizing MMF electric machine systems, such as slip-induction dependent, DC field wound, reluctance, or futuristic superconducting electric machine systems:
  - A dominant proportion of any electric machine system research always reverts back to RE-PM electric machine systems by the huge inherited R+D investment momentum in RE-PM electric machine systems with blind disregard to the CCP geopolitical consequences and limited operating life expectancy of RE-PMs.
  - The consistent offshoring of USA taxpayer funded research and manufacture is self-defeating, particularly with CCP as the likely final recipient because of its stealthy penetration and influence into every aspect of the electric machine system industry and academic research, including superconductor electric machine systems, as a result of controlling RE-PM electric machine systems.
  - Equally affected by the CCP RE-PM debacle, at least Japan has taken a more proactive and protective approach with the purchase of Metglas, which was the inventor of amorphous metal ribbon, to continue Japanese empirical research in a practical, cost effective electric machine manufacturing method and nanocrystalline derivatives, such as Nanomet and Finomet, that reduce RE-PM material in electric machines by increasing core permeability; but unlike the USA, Japan forbids offshore manufacture of taxpayer funded research results.

- The superior performance fixation on RE-PM electric machine systems is more anecdotal:
  - An “optimally” designed “slip-induction dependent” electric machine may show up to 9% (e.g., 0.09) more electrical loss (and size) than an “optimally” designed RE-PM electric machine because of the orthogonal vector of magnetizing MMF. For instance, if a RE-PM electric machine shows 10 watts of electrical loss (e.g., 90% efficiency for a 100watt rated motor), a magnetizing MMF electric machine, such as a slip-induction electric machine, would show a tolerable 10.9 watts of loss (e.g., 89.1% efficiency) with similar optimization but without the expense and geopolitical consequences of RE-PMs or without considering the compounded loss, cost, and size of the necessary system gearbox and high speed electronic controller.
  - The relatively recent spawning of a RE-PM recycling industry obviously shows the finite operating life expectancy of RE-PMs but more importantly, shows the lack of enough global mineable RE-PM material to support the expected future growth in RE-PM electric machine systems.
  - Although the original reason for migrating to RE-PM electric machine systems was the elimination of magnetizing MMF electrical loss, cost, and size associated with slip-induction, DC Field wound, or reluctance electric machine systems, RE-PM electric machine systems are
ironically re-introducing magnetizing MMF (with similar associated electrical loss, cost, and size) into their circuit and control architecture to regain magnetizing current’s coveted benefit of field weakening.

- Exemplifying the blind fixation on the notion that PM persistent magnetism provides superior performance, recent research is ironically trying to eliminate expensive RE-PMs by substituting inexpensive Ferrite PMs with short persistent magnetizing life and very low BH product, which are not performance competitive with similarly optimized magnetizing MMF electric machine systems.

- For comparison purposes, Best Electric Machine (BEM) classifies all electric machine systems into two categories: 1) the century old, me-too, asymmetric electric machine system comprising a “passive rotor assembly” of slip-induction dependent windings, RE-PMs, reluctance saliencies, or DC field windings with distinguishing performance improvement or so-called invention between manufacturers solely dependent on the strategic application of available me-too material, winding, thermal, packaging, and control techniques, or 2) the patented and only symmetric electric machine system, called SYNCHRO-SYM, with active multiphase winding sets on the rotor and stator, respectively, which effectively eliminates the entire “passive rotor assembly” of the century old me-too asymmetric electric machine system where reasonably half of the electric machine cost, size, and loss occurs, by providing a continuously stable “active rotor assembly” that does not rely on slip-induction, as only possible with an automatic, instantaneous, and sensor-less control process, called brushless real time control or BRTEC, as electric machine experts have hypothesized since at least the 1960s.

- With the anecdotal mindset that RE-PM electric machine systems have superior performance, Original Equipment Manufacturers (OEMs) of EVs are acquiescing to the CCP geopolitical consequences by effectively branding the same optimized asymmetric CCP RE-PM electric machine system with little discernable performance difference but with marketing suggesting differently.

- In retrospect, all OEMs would be better served by at least providing the “economy of scale” from the highest volume of manufacture with an industry generic asymmetric electric machine system without the nuances of branding, such as from a universal OEM component supplier.

- With the only honest solution to the CCP RE-PM debacle, Best Electric Machine (BEM) has leveraged the patented brushless, symmetric doubly-fed synchronous electric machine system circuit and control architecture, called SYNCHRO-SYM, and also, BEM has leveraged a patented high speed, programmable method of 3D Printing axial-flux electric machines with high electromagnetic performance amorphous or nanocrystalline metal ribbon, called MOTORPRINTER. Together, BEM, SYNCHRO-SYM and MOTORPRINTER provide the following:

  - R+D by the tried and true old fashion way with private sweat equity and investment in innovative free enterprising solutions that did not acquiesce to government funding that continues to direct R+D and manufacturing towards me-too RE-PM electric machine systems with careless disregard to the geopolitical consequences of CCP control.

  - Innovation that brings the very “best” electric machine system technology and manufacturing to the free enterprise market instead of the cartel control of the CCP without competitive choice.

  - Simple direct selectable speed, torque magnitude, and leading, lagging, or unity phase process control but with stochastic perturbations, such as kinetic energy, excitation frequency, or excitation phase perturbations, automatically and instantaneously addressed, as only possible
with BRTEC of a symmetric electric machine system, instead of addressed with the detrimental reaction delay and imprecision of offline measurement, estimation, compensation calculation, and excitation synthesis processing as always provided by state-of-art controllers of the century old me-too asymmetric electric machine systems, such as Field Oriented Control (FOC).

- Simple qualitative observation easily shows the century old me-too asymmetric electric machine system performance is at least twice magnified while cost and loss are halved by effectively eliminating the entire “passive” rotor assembly that comprises slip-induction windings, DC field windings, reluctance saliencies, or RE-PMs where reasonably half of the cost, size, and loss occurs.

- Likewise, twice magnifies the performance improvement expected from the strategic application of advanced material, winding, packaging, and control techniques that all century old, me-too asymmetric circuit and control architectures are required to use for their performance improvement or so-called invention.

- Provides at least octuple the peak torque of the century old, me-too asymmetric electric machine system nominal frame size by uniquely holding airgap flux density and port voltage constant with increasing torque current, which for instance, is essential for eliminating the compounding size, loss, cost, maintenance, and reliability of an electric vehicle gearbox.

- Saves precious CCP RE-PM materials for more strategic applications by eliminating RE-PM material from its major consumer, RE-PM electric machine systems, while simultaneously improving the electric machine system performance, cost, and reliability.

- Democratize the manufacture of high performance amorphous or nanocrystalline axial-flux electric machines with portable, high-speed, universally programmable, additive manufacturing (i.e., 3D Printer) to at least provide distributed manufacturing with similar “economy of scale” as the high-volume manufacture of a generic me-too product.

- Brings superconductor electric machine systems of today closer to practical reality; but when AC superconductors become available, the fully electromagnetic SYNCHRO-SYM will be the electric machine system of choice.