Unitary Electrification of the Americas and Antarctica

A Macro-Imagineering 21st Century Powerline Scenario

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Abstract: The development of a proposed means to physically connect the electricity grids of North and South America requires the linkage of two intercontinental macro-projects. In order to conform such an electrifying linkage requires two major international implementations: (1) a submarine cable spanning the stormy Drake Passage which should integrate a coast-sited encircling linear Antarctica wind-power collecting installation, the Bolonkin-Cathcart proposed Fabric Aerial Dam and Wind Turbine Stations, plus (2) at least one insulated cable-transmitted HVDC electricity passing safely and efficiently around the Darien Gap. Because the latter environment is a still significantly pristine 100-120 km-wide Tropic Zone landscape, it is critical to protect it by mostly preventing further intrusive schemed or unplanned real-estate development of the extant remaining, but vulnerable, inhabited rainforest therein. Critical to this macro-imagineering project is the requirement for a massive and reliable power source. We suggest the possibility of a basic North American single-source for electric energy generation at Yellowstone National Park's huge caldera that was produced by an ancient super-volcano eruption. Such an amalgamation macro-imagines a 21st Century Americas and Antarctica electrical power generation and distribution system, a demi-globality planning scenario, that results in one completed infrastructure totality.

Key words: Drake Passage, submarine power cables, Darien Gap, the Americas, HVDC grid links, Brazil, California, Yellowstone volcano caldera, Alexander A. Bolonkin (1933-2020), Antarctica.

Resumo: O desenvolvimento de uma proposta para unir fisicamente as redes eléctricas da América do Norte e do Sul requer a ligação de dois macroprojetos intercontinentais. Para configurar tal ligação, são necessárias duas grandes implementações internacionais: (1) um cabo submarino que atravessa a tempestuosa Passagem de Drake, o qual deve integrar uma instalação de coleta de energia eólica linear na Antártica, localizada na costa, a *Fabric Aerial Dam* proposta por Bolonkin-Cathcart e estações de turbinas eólicas, e (2) pelo menos uma transmissão elétrica HVDC, passando de forma segura e eficiente em torno do Darien Gap. Dado que este último ambiente é uma paisagem ainda significativamente intocada e vulnerável da Zona Tropical, com 100-120 km, é fundamental protegê-la, evitando principalmente o desenvolvimento imobiliário intrusivo, planejado ou não. Fundamental para este projeto de macro-*imagineering* é o requisito de uma fonte de energia massiva e confiável. Sugerimos a possibilidade de uma fonte única básica na América do Norte para geração de energia elétrica na enorme caldeira do Parque Nacional de Yellowstone, originada pela erupção de um supervulcão. Tal amálgama "macro-imagina" um sistema de geração e distribuição de energia elétrica para as Américas e a Antártida do século XXI, um cenário planejado que congrega infraestruturas completas.

Palavras-chave: Passagem de Drake, cabos de energia submarinos, Darien Gap, Américas, ligações de rede HVDC, Brasil, Califórnia, caldeira do vulcão Yellowstone, Alexander A. Bolonkin (1933-2020), Antártida.

1. Introduction

Because rural, suburban, and urban people in Central and South America have little or zero access to low-cost electricity, millions of these inhabitants are essentially disempowered citizens. It is an indisputable fact that from a global perspective and not only from the geographic regions of the Americas, the availability of electricity pervasively affects people's health and wealth [1]. For those who are served by electricity service, the occurrence of blackouts (to prolonged total loss of power) emphasizes that urbanists are physically dependent on many kinds of electrical equipment and functioning machines that include, for example, life-support devices [2]. How to generate and configure the electrical infrastructure for the Americas is perhaps the principal long-term Macro-imagineering challenge facing modern civilization in the 21st Century. Developmental scenarios are central to technology that connects geophysical and social research that includes projected effects (adverse impacts) as well as underpinning discussions of adaptation and mitigation. Sometimes considerations of intentionally extreme scenarios, such as exploratory syntheses and public policy-relevant verbal projections, are required to digest remedial possibilities that can be realistically applied to potential outcomes. In brief, this cursory synthesis focuses on the concept of "omission reduction," according to a recent request by prominent editors at the international journal Nature: "Engineering and science are like two ships that have set sail close together, but in many ways have gradually drifted apart. We can't let that continue. Having engineers back in Nature's pages is long overdue, not least for the health of our planet and the well-being of all people" [3]. Extrapolation of this plea introduces the exposition of a macro-engineering idea that focuses on the potential for seamless, high-voltage, direct-current power transmission line connections joining every country in the Americas? Already, grand proposals have been made to implement an electric grid for nearly all the states of Africa south of the Sahara [4] to ensure empowerment by linkage of generation locations with places of consumption [5].

2. Looking North from the South Pole

Antarctica is defined, both etymologically and by common geographical imagination, in opposition to the Arctic [6-7]. The potential development of a trans-polar shipping route, one that transits the North Pole region, will allow the commercial cargo and passenger movement industry to circumvent legally demarcated central Arctic nation-state delimited territorial waters and their mandated Exclusive Economic Zones as well. Currently, Antarctica exhibits ~29 airports, uncounted Southern Ocean-facing ice-ports for various mobile and immobile watercraft types, and a 1,600 km-long seasonally-compacted snow road (the so-called "South Pole Traverse" or "McMurdo-South Pole Highway" marked by pole-flags) used to deliver supplies to South Pole outposts during the Southern Hemisphere's summer. Remarkably, only ~0.35% of Antarctica is ever ice-free! The lowest air-temperature at the Earth-surface (an incredibly cold minus 89.20 C), was recorded on 21 July 1983 at the 1,300-km inland Vostok Station at an elevation of 3,488 m. By way of stark contrast, Antarctica's highest surface air-temperature (17.50 C) ever recorded occurred on 24 March 2015 at the Argentine Research Base Esperanza which is situated opposite the tip of South America close to the northernmost point of the Antarctic Peninsula. However, despite its status as a continent where the autonomy of Homo sapiens requires virtually a total disengagement of the living human body from the environment's below ice-cold physiological insults, predicted global atmospheric warming as well as inevitable technological impacts, especially Antarctic energy production facilities operated during the 21st Century, can modify that tenuous current continental status rather quickly [8-9]. In other words, accurate descriptions of humanity's essential deliberate technical survival requires alterations of regional climatic regimes and water-based topography. Beneficially imagined and common applications of material-moving drone equipment is nowadays increasingly hastening the tempo of reshaping, construction, and erasure of transformable

landscapes almost everywhere. Perhaps comprehensible "Global Climate Change" policies might be usefully redefined as any Earth-bioshell event-process that overwhelms humanity's already in-place, being assembled, or planned infrastructure by sharply decreased asset value? That is, it seems advantageous for macro-imagineers to demand from infrastructure developers some exact non-arbitrary statistical limitation concerning what actualized amount of natural damage (to completed and forecast infrastructure) can be tolerated by megaproject owners.

3. Exportable Commercial Wind Turbine-Generated Electricity, Coastal Antarctica

Established in AD 2002, the government-owned utility State Grid of China, is building the world's first 1.1-million-volt HVDC transmission cable (an estimated 3,200 kilometers-long) that will connect Xinjian Region located in China's northwest to Anhui in the east. Coordinated electricity generation stations, sited within the interior of that vast ecosystem-nation, will soon be connected to densely populated coastal cities [6]. Because State Grid of China is currently Brazil's biggest electric-power distributor, it seems that there is organizational capability for optimization of investment costs for imaginative long-term interregional electrical power integration. That is, South America's incompletely-networked national electrical power systems have potential to be linked with Antarctica. This engineering feat could potentially utilize multiple long HVDC mass-impregnated or extruded bipolar cables with double-layer armoring to withstand tensional forces during laying across the intervening ~1,000 km-wide Drake Passage [10-11] (Figure 1, below). This proposal seems possible because the cost-effect limit for electricity transmission is often assumed to be ~1,200 km. Widespread builder experience with laying submarine cables on the deep-sea bottom is historical, adapted from the technology of tele-communication undersea cables (telephone, Internet fiber-optics). China, for example, has a demonstrated technical interest in emplacing a reliable fiber-optic cable onto the Arctic Ocean's seafloor for direct communication with Europe. This proposal becomes especially attractive if prolonged (and recurrent) El Niño climate regime effects cause persistent future droughts that permanently reduces the Panama Canal's major role in world shipping routes [12].

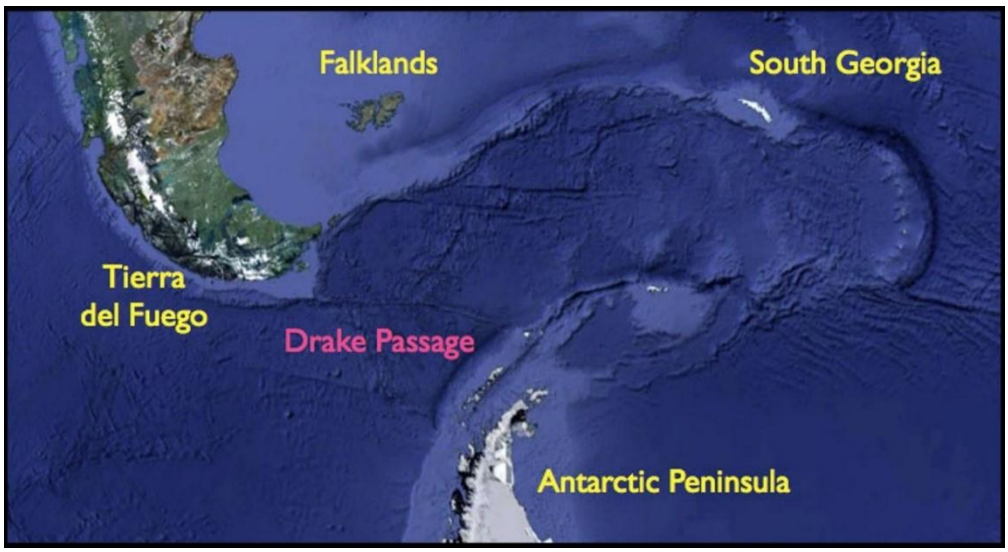

Figure 1. Situated between Antarctica and Argentina-Chile, the Drake Passage is a formidably deep shipping waterway. (Google image.)

Macro-imagineering scenario amazements have resulted from comparison of the anticipatory foresight of an 20th Century article [13] with a 21st Century article [14]. In particular, the design of ice-phobic material surfaces for powerlines and windmills has advanced markedly. With an average wind speed of ~22 meters/second, the most sustained katabatic wind regime anywhere in the Earth-bioshell close to sea-level occurs at Cape Denison (670 S. latitude by 142.70 E. longitude) and was discovered almost a century ago by courageous explorers; since then, >100 differently located Antarctic automatic weather stations operate today to help define Antarctica's surface wind-flow.

Coastal weather stations, located near the base of an ice-cap fully exposed to katabatic wind flow oceanward, indicate that the periphery of Antarctica is suitable for an operationally unified linear wind-farm. This integrated facility would be of enormous geographical extent, possibly of ~18,000 km unified length, since the persistent katabatic winds blow all year and supply the boundary-layer with unsaturated air which causes significant low-level sublimation of snowfall. Wind turbines at remote sites under extreme climatic circumstances (e.g., very low temperatures and high winds) must be manufactured to tolerances that accommodate the severity of environmental conditions that generally reduces the stiffness and toughness of fabricated materials. Basically, successful harnessing at commercial scales, our postulated Earth-bioshell's wind-power resource becomes an air-movement technology-attunement action by energy-needful humans. By means of numerous networked Alexander A. Bolonkin-Cathcart Fabric Aerial Dam and Wind Turbine Stations [15], it may become possible soon to generate at least ~6 TW of exploitable and exportable HVDC electricity transmittable to southernmost South America and thence, by hard-wired interconnection, to the entire Americas! Non-commercial scientific research infrastructures at the South Pole are also potential customers [16]. Exported power to South America (Figure 2) simply adds to the pre-existing capacity, which is enormous and increasing. For instance, the Itapúa Binational Hydroelectric Dam straddles the Parana River border of Brazil and Paraguay and could generate >0.014 TW [17].

4. HVDC and other appurtenances, Darien Gap, Central America

The Hitchhiker's Guide to the Galaxy, a 1979 AD-published novel by Douglas Noel Adams (1952-2001), purported the whole Earth's environmental demolishment by uncaring Aliens for the installation of their "hyperspace bypass". (Note: the word "hitchhiker" is a circa 1920 AD tautological compound with both elements meaning the same, as in "pathway".) If placed entirely underground, a horizontally bored electric-cable carrying tunnel cannot be responsible for the despoliation of the tropical rainforest landscape in the Darien Gap that is rudimentarily controlled by Panama and Columbia. English and Spanish languages differ in the meaning of "gap": anglophones prefer "gap" whilst hispanophones prefer "tapon" ("stopper"). In any case, the Darien Gap is a preserved zonal landscape because it is an intentional biogeographical barrier against disease-carrying insects [18]. Many spin-offs and unrelated macroproject organizations, which are proliferating globally, all originate from just a few European, American, and Chinese innovational catalyst groups that are devising new tunneling machines.

Contrary to Figure 2, here, we propose using the offshore bypassing rights-of-way principle to legally facilitate the transmission of cabled HVDC power underwater across substantial distances, yet less than that of the Drake Passage. This proposal would constitute for Panama and Columbia a significant means of transmission and routing that differs from other previous Central American macroprojects that are comparable in scope. For example, including Panama's early-days Camino Real route [19] and the region's first interoceanic canal (built in Columbia by Antonio Cerezo) during approximately the same era of recorded human history [20]. Although the Darien Gap is not a wind-gap or a water-gap, it remains an infrastructural blank-slate (the controversial so-called "gap") due to the absence of an international highway [21] and

electrical grid connections between Columbia and Panama. Unfortunately, post-2020 AD unmanaged migration has somewhat despoiled sections of the Darien Gap's landscape.

Figure 2. The cooperatively managed electricity grid of South and Central America as it might appear by mid-21st Century. (Google image.)

This CALIBRE report is meant as a provocative minimalist Macro-imagineering scenario or "White Paper." That is, this brief and transitory documentation is presented as a hybrid of organizational expertise, journalistic-styled published article communication, and institutional advocacy; in other words, a potential news-media focus and, subsequently, a dialogue high-lighting the convergence of all 21st Century electrical infrastructure R&D with modern-day Macro-Imagineering/Macro-Engineering promulgation. Obviously, one of our goals, in part, is to "re-brandscape" both Panama and Columbia as ecosystem-countries with unique infrastructural and geopolitical co-ordination possibilities (blending? melding? sharing?) that are inevitably impending. (Neither the positivist terms "brandscape" or "re-brandscaping" were exposed by philologist David L. Gold in his otherwise thorough examination of then-known English-language words terminating in the productive suffix "-scape" [22].) For sure, indifference to the practical societal costs related to the proposed twin Central America submarine HVDC cablings as well as, perhaps, the additional enclosed vital

associated appurtenances are intolerable. If imprecise oversight is present in our CALIBRE "White Paper", it might unfortunately invite future-projection scenarios and realizations that cannot be seriously enjoyed by those in electrical power management who require a sound basis for promulgation of public policy.

Both Panama and Columbia were once considered obvious worksites for a new transisthmian sea-level canal that could be excavated with multiple nuclear explosive row-charges that would create an inter-ocean shipping route serving ever-more gigantic oceanic ships as well as naval vessels. In most instances, even using supposedly "clean nuclear explosive excavation" [23] entails the implication of "cratering" by fracturing and ejecting huge volumes of rock and soil almost in an instant. Implementation of this proposal would have been an unmatchable ecological fiasco! Science and technologically skeptical social movements backed by wise legislators foreclosed the proposed effort to dig a sea-level canal in Central America. More recently as of 2024 AD, there are many national leaders that are incapable of visualizing non-classical outcomes (e.g., Macro-Imagineering projects) and who exhibit an apparently natural tendency to relate other person-proposed future real-world infrastructural outcomes to previous experience [24]. The fact that so-called potentially clean nuclear blasting explosives may be technically feasible, sadly serves to maintain, and perhaps even reinforce, some time-worn opinions of influential radical public opinion-leaders. However, so far, no publicized postulation to promote regional infrastructural development in Central America outdoes the Chilean engineer Jorge Cortines Delfino's macroproject concept of a tunneled 50 km-long transisthmian ship canal that, unrealistically, neglected to project the increasing enormity of ship volumes because today's containerized ships were just beginning to be developed at that time [25]!

The bizarre science-fiction movie Battle Beneath the Earth (1967), available for payment-free viewing on YouTube, featured a stereotypical Chinese NGO madman boring an enormous system of secret transpacific tunnels below the continental USA's ground surface. The concomitant planting of thermo-nuclear bombs below strategic locations was intended to blackmail one of the world's several supposed Superpowers. In contradistinction to the madman plan just outlined. the voices and normal everyday activities of the native population living on both sides of the Darien Gap rainforest landscape will be supplemented by an unavoidably amplified and slightly industrialized soundscape at both ends of the submarine electricity transmission cables where they come ashore and are connected to industrial infrastructures. For the Darien rainforest landscape, the ideal conserved natural tropical ecosystem features maintenance of the pre-exploitation vegetation and associated dependent biota as well as the "primordial" aerial and geological background. Preservation activities by the power cable-protective HVDC builders would ideally prolong the existence of such a high-quality mostly still "natural" region. The power transmission cables must be immune to seismically-induced severe seabed sediment liquefaction damage owing to local earthquakes. Of course, there is social risk of disruptive post-installation behavior by influential state actors in Panama and/or Columbia. These risks might focus on legal, economic, and geopolitical outlooks because each ecosystem-nation could adopt a diplomatic posture of intransigence focused on throughput rent, once the marine macroproject circumventing the Darien Gap (Isthmus of Panama) is completed. In other words, there is a remote possibility of a financial battle for supremacy of immediately offshore oceanic crust by two countries necessarily trapped in a trust situation where both must take a national risk to learn how trustworthy the other is. Certainly, resolute geopolitical certainty might ruin bilateral progress since a time could come where the governments of both states realize that they have spent tax and loan monies to install submarine infrastructure could become obsolete (by, say, post-3 March 2023 space-based broadcast solar power) [26]. Such is the always the risk of opting on any technology because with progress, essentially all technology becomes socially ephemeral.

5. North America Geothermal Power-Plant Unifies the Antarctica-Americas Grid

South America's first geothermal powerhouse, Chile's 48 MW Cerro Pabelion Project constructed by 2017 AD, proves that the Americas are rich in geothermal potential. Magma, molten rock material that moves within the Earth and onto its surface as lava, is the purest form (highest grade) of geothermal "ore." The world's first magma-enhanced geothermal system was created in Iceland by drill penetration during 2009 AD [27]. In effect, artificial lava eruptions have occurred and, consequently, Anthropic Rocks derived from deep volcanic sources are nowadays present in some places [28]. Therefore, volcanic eruptions that are technically unmanageable have potential to damage or destroy infrastructures that are vital to modern civilization, That is, the potential exists for disruption of engineering structures wherever they are located, within or atop the planet's fractured and many types of fluid-lubricated rocky crust segments [29-30]. This critical realization has prompted, as well as initiated, academic formulations of new ethical exploitational paradigms [31] as well as an explosive "Method for Dispersing or Arresting Lava Flow" (US Patent 4,451,178 awarded on 29 May 1984) and heated pipes to regulate "Magma Evacuation Systems for the Prevention of Explosions from Supervolcanoes" (US Patent 7,284,932 B2 awarded 23 October 2007).

Some researchers who anticipate dangerous global climate change are currently seeking to concentrate all the officially-designated "excess" aerial carbon dioxide gas by using geothermal energy [32]. By way of a poignant example, Portugal has examined in-situ mineral carbonization in a partially buried offshore composite volcano. Although evidently dormant, these Late Cretaceous volcanic basalts near the West Iberian coast, are viewed for permanent storage of self-determined and documented air-mined national aerial carbon dioxide gas emissions because, once the mined gas is mineralized, it is presumed geologically emplaced permanently [33]. The permanency of this emplacement is, however, suspect because relatively nearby lies the epicenter of the famously devastating 1755 AD earthquake tsunamigenic site. Nevertheless, during 2022 AD, CGG Services SAS, in its 13 October 2022 application for a patent (WO2022214867-Geothermal Plant for Extracting Energy from a Geothermal Reservoir Located Below the Ocean Bottom), sought future control of a technology that can allow access and harvesting of magma heat upwelling at, for example, the mid-Atlantic Ocean Rift Zone which terminates on land in Iceland! Some researchers hope that geothermal energy under the seafloor, a capacious high-temperature resource that has never been accessed to generate electricity, might provide enough baseload energy to stabilize atmospheric carbon dioxide gas buildup attributable to fossil fuel combustion.

The Yellowstone National Park "super-volcano" caldera (in Wyoming, USA) is unpredictable like other continuously monitored active volcanoes. Yellowstone's most recent "catastrophic" eruption occurred about 640,000 years ago but magma has been noted burring about below the surface preceding the last Ice Age about 10,000 years ago [34]. It is commonly thought that, by using a modern-day geothermal energy extraction system, perimeter wells of this super-volcano could cheaply generate at least 3.46 GW of electrical power. More ambitiously, two expert researchers have strongly suggested that "…given the (potential) interconnected nature of the American continent's power grid, excess power could be supplied to Canada and possibly Mexico and Central and South America as well" [35]. Additionally, as an aside, Iceland could export geothermally generated electrical power to Europe and Hawaii could become self-sufficient using the same technology. The proposed gargantuan Yellowstone machine could conceivably deliver twice the 0,6 TW amount expected to be required by the USA's 2050 AD population, or ~1.255 TW! So, approximately 0.6+ TW can be fed into the macro-imagineered intra-America Electricity Grid.

6. Conclusions

This macro-imagineering proposal features an hypothetical postulation that is based on developing geothermal electrical power generation. Heat sources for power generation occur in the geographic vicinity of the Yellowstone hotspot where molten rock (magma) from the mantle rises toward the ground surface. With an unlimited heat source in the northwest corner of Wyoming (USA), it is proposed to physically connect the electricity grids of North and South America, forming an integrated Americas bicontinental connection, and eventually with a linkage to Antarctica. This potential tricontinental linkage of electricity grids includes an environmental safety valve in the Darian Gap (Panama) and a subsea connection from the southernmost tip of South America to Antarctica via the Drake Passage. This narrowest stretch of water in the Southern Ocean extends between the southern tip of South America and the northern tip of the West Antarctic Peninsula. In addition to the geothermal power-plant unification of the Antarctica-Americas Grid, this macro-imagineered project receives an additional potential benefit of sequestering officially-designated "excess" atmospheric carbon dioxide gas by underground injection for in-situ mineral carbonization in volcanic deposits. Modern-day geothermal energy extraction systems using perimeter wells of the Yellowstone hotspot could conceivably generate at least 3.46 GW of inexpensive electrical power, which would be a boon to industrial, commercial, and domestic users. The interconnection of national power grids, such as proposed for the Americas and Antarctica, stir the imagination for the development of macro-imagineering projects. For advanced societies that depend on reliable electrical power generation at economical costs, this proposal seems to be a prudent consideration.

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