U.S. DEPARTMENT OF ENERGY

CHP Technical Assistance Partnerships

NORTHWEST

CHP Case Studies in the Pacific Northwest

525 kW Wind/Diesel Hybrid CHP System

TDX Power Wind Turbine Integrated with Diesel CHP on St. Paul Island in Alaska (Courtesy of Northern Power Systems)

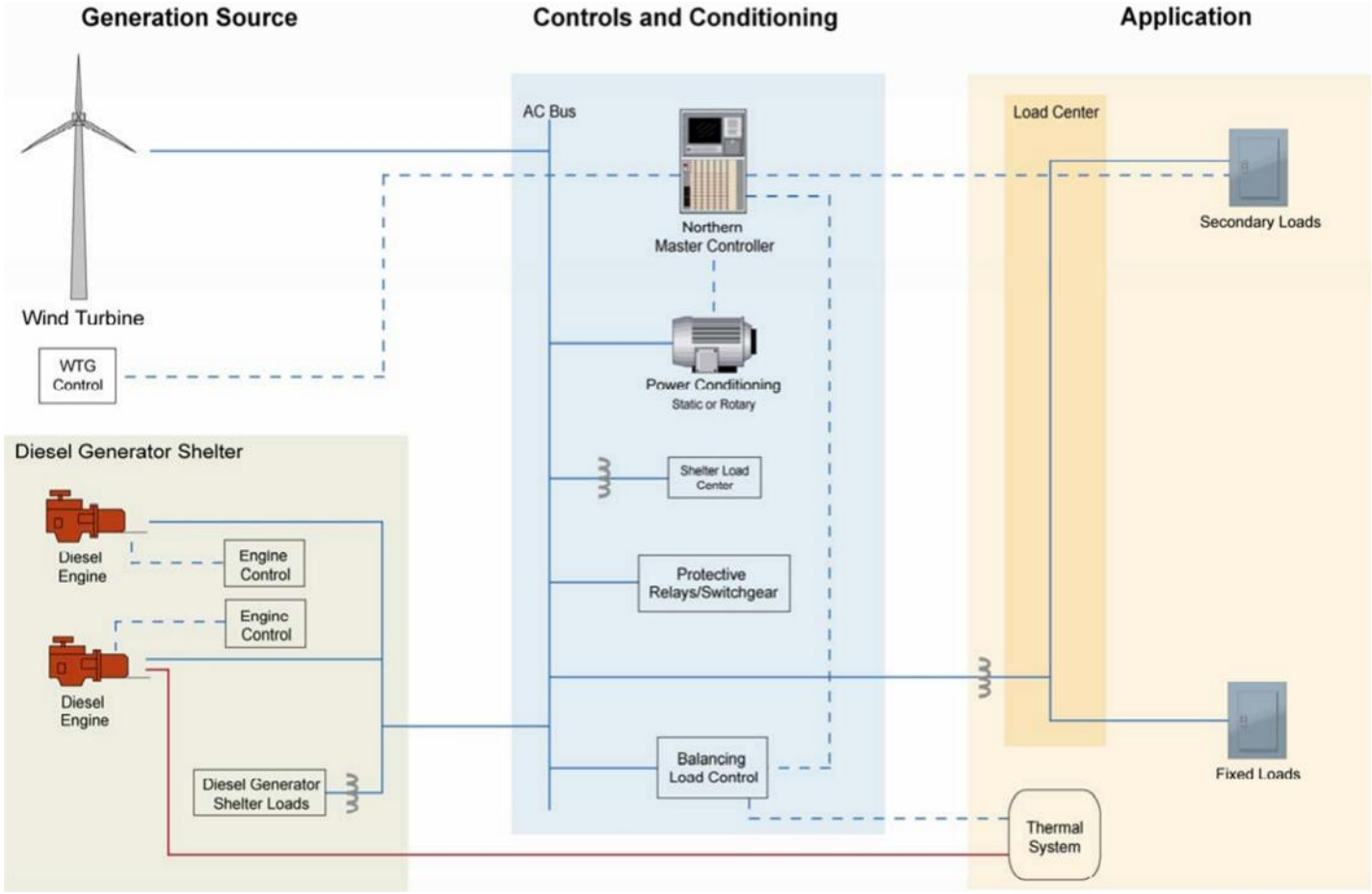
Site Description

Tanadgusix Corporation (TDX), an Alaskan, native corporation, owns and operates several facilities on the island of St. Paul, part of the Pribilof Islands in the Bering Sea. In remote areas such as this one, electric power comes from diesel engine generators serving individual facilities or small community microgrids. With electricity costs around 29¢ a kWh and diesel costs exceeding $1.30 a gallon, TDX looked for a way to utilize wind energy effectively in their power system. TDX also wanted to reduce their diesel fuel consumption for environmental reasons.

TDX selected POSS Camp, an 80,000 sq. ft. industrial facility and the Island's airport under their ownership for a stand-alone hybrid wind/diesel system. POSS Camp has an average load of 60 to 125 kW and almost year-round space heating requirements.

The system, designed and installed by Northern Power Systems, is comprised of a 225-kW wind turbine and two 150-kW diesel gen-sets. The system supplies electricity and space heat to an airport and industrial complex with airline offices, equipment repair, and storage facilities.

Two primary considerations drove the power system design process: reducing overall energy costs for the POSS Camp electrical and heating loads, and maintaining reliable, utility-grade service. Northern Power Systems met these design goals with a high penetration/no storage wind-diesel configuration. *High penetration* is defined as a high percentage of wind power capacity versus peak load. This system architecture maximizes the energy contribution of the wind. When the wind



Courtesy of Northern Power Systems

turbine exceeds facility load requirements, the diesel engines shut off. Limiting diesel run time in this manner increases long term energy cost savings. Often, high penetration systems include enough wind capacity to allow engines to shut down for significant periods, hence high penetration systems can improve the efficiency of the diesel generator by reducing the amount of time that the generators are run at low engine loads. A high penetration system however requires significant modifications of the diesel controls, and entails new diesel control panels. In addition, a secondary load must be integrated into the system and this in turn requires sophisticated supervisory control systems.

Plant Configuration

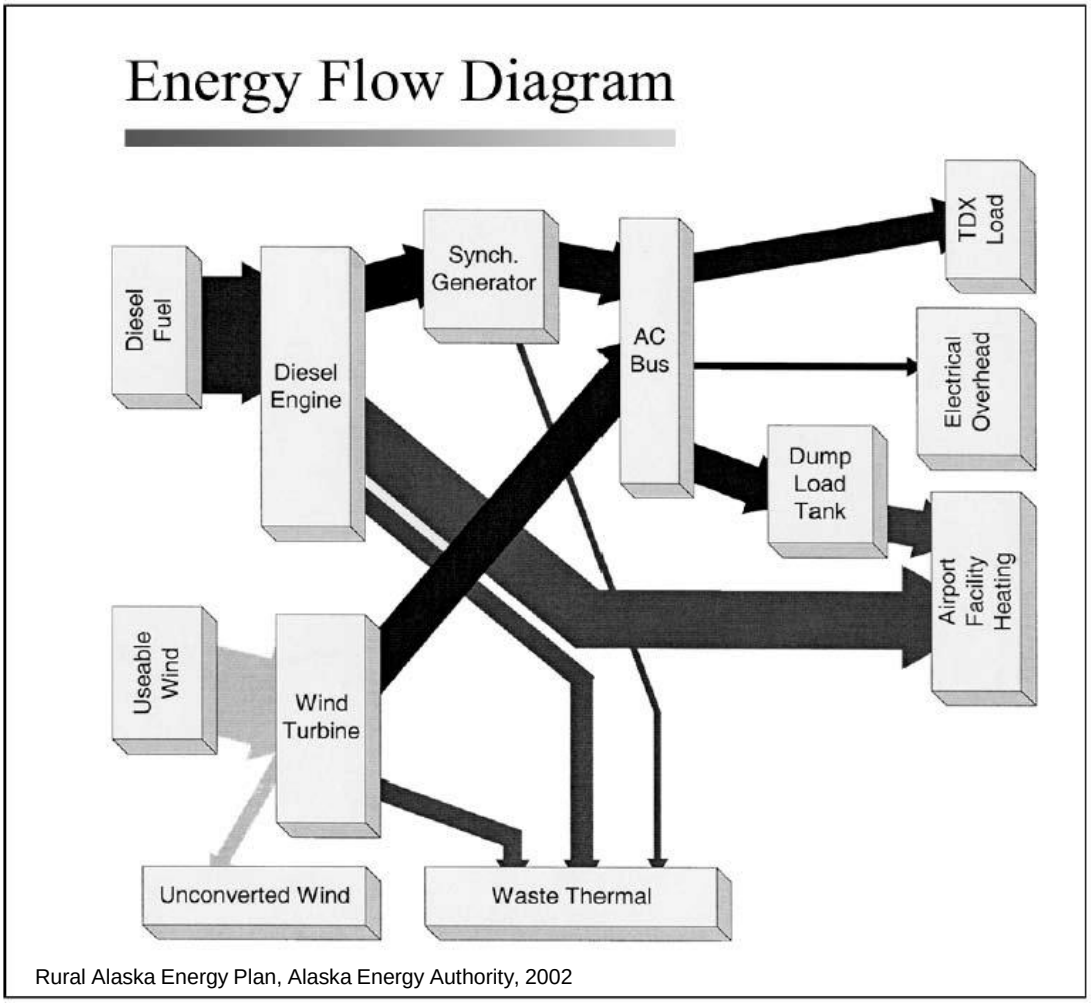
The major generation for the hybrid system is provided by a 225 kW Vestas V27 wind turbine. A 300 kVA synchronous condenser allows the turbine to provide smooth power to the facility. Twin 150 kW Volvo diesel generators feed power into the facility AC bus and can work independently or together with the wind turbine. Heat recovery from the diesel generators is used to provide space heat. A unique aspect of the system is that resistive loads are used to maintain load on the wind turbine while, at the same time, providing hot water for heating the facility.

Power quality must be maintained during normal fluctuations in wind energy output.

Small stand-alone power systems typically use batteries to buffer variations in wind and facility loads, as well as to provide energy storage. Northern provided continuous power supply and electrical stability in the TDX system by diverting excess wind energy to a secondary load and by installing a 300 kVA synchronous condenser.

This secondary load consists of multiple three-phase resistive heaters switched in binary sequence. The resistive heaters are mounted in a 6,000 gallon insulated water tank from which a 165° F. hydronic loop heats the offices and shop spaces of the TDX facility. The secondary load controller (SLC) switches elements of the binary load on or off to match the total electrical load demand to the power being generated. The SLC acts as the prime bus frequency control during operation at high levels of wind power penetration. This subsystem enhances overall system economics by significantly reducing heating fuel requirements.-

Utility-sized wind turbines generally employ three phase induction generators, which must be connected to a stable voltage source for excitation and reactive power support. Normally, this source is the utility grid. In the TDX power system, a proprietary Northern synchronous condenser package, complete with autostart controls and a 3- phase AC-synchronous alternator coupled with an AC pony motor, provides the required reactive power and load synchronization. Integration of state-of-the-art control technology with traditional, rugged, rotating equipment delivers clean, uninterrupted three-phase AC output.



Rural Alaska Energy Plan, Alaska Energy Authority, 2002

Northern's master controller monitors and manages the operation of all the power system components. As required by conditions, the controller will stop/start the diesel gensets and/or wind turbine, maintain the shelter environment and respond to all alarm functions. Northern's RemoteView™ software allows the system to be monitored and controlled from off-site locations via telecommunications links. All controls and switch-gear are utility-grade and built to National Electric Code specifications to ensure system protection and personnel safety.

The installation of the hybrid system was completed on March 31, 1999 and was formally commissioned on June 12, 1999.

Energy/Financial Analysis

The total 525 KW wind/diesel CHP system cost approximately $1 million including in-kind support from TDX Corporation. The project was installed on a commercial basis; no grants were used to fund it.

The system has eliminated $200,000 per year in utility electric charges at the current diesel grid cost of $.34/kWh. The facility has also significantly reduced the annual 30,000 gallon $50,000 purchase of diesel heating fuel.

Operating and maintenance costs are $60,000 per year covering a site operator, fuel, maintenance, trips, and repairs.

Operating Experience and Results

The plant has been operating for five years with excellent availability. During the first 2 years of operation, system availability averaged 99.9% equivalent to less than 8 hours/per year of downtime. During this period the wind turbine met 54% of the total electric and thermal energy used by the camp. During some months, the wind share exceeded 70%. St. Paul's abundant wind resource ensures significant periods of "wind only" power production.

During the first year, the wind turbine gearbox failed resulting in down-time for the wind turbine of about a month and a half. During that time the facility electric and thermal needs were met by the diesel generators. Other minor problems during the first two years limited with wind turbine availability to 70-80%. After this initial shake-down period, the wind turbine has achieved availabilities of about 97%. Based on the wind turbine rating of 225 kW, the current average capacity factor is about 35%.

Environmental Profile

The use of wind energy reduces the emissions associated with diesel power generation, oil furnaces, and boilers.

Lessons Learned

TDX encountered and fixed various technical problems with the system. The redundancy designed into the system with the two diesel gen-sets, each capable of assuming the entire load, provided for excellent overall availability.

There were issues and adjustments in dealing with education and training of local operators. As a remote native corporation, TDX, had to train all of its on-site operators, all of whom were completely unfamiliar with this type of equipment. TDX believes that training on a project such as this one needs to begin as soon as construction begins. In addition, an extended period of technical support is needed while local operators gain familiarity with the equipment.

Native corporations, like all communities, have competing needs for funds. There are issues of community acceptance and support for investment in advanced energy

technologies in the face of other pressing social and economic needs.

IDX has built the first Native-owned and -operated hybrid wind-diesel power plant in Alaska using only private financing. Ihe Department of Energy and the National Renewable Energy Laboratory (NREL) have recognized this achievement and are working closely with IDX to expand on this success. NREL has held numerous workshops and conferences to promote wind power in Alaska and has invited IDX to many of these meetings to showcase this success story with hybrid wind-diesel power.

Future Plans

IDX Power plans to expand the power plant on St. Paul to help meet the growing demand for affordable heat and electricity. IDX is developing a cold storage/fish processing facility, and affordable power will be a requirement. Although the exact specifications of the plant are yet to be finalized, IDX will invest $1.3 million in 5-600 kW of wind power capacity and additional heating infrastructure.

IDX Power is in the process of commencing feasibility studies for wind power at its electric utility in Sand Point. Like St. Paul, this Aleutian community has tremendous wind power potential, and development is likely. IDX Power has also been asked by the Alaska Energy Authority to assist with design engineering for a wind-diesel facility in Nikolski, a small community on the far west end of the Aleutian chain often described as the oldest continually inhabited community in the world.

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Organizational Profile

Power Plant Design and Equipment:
Northern Power Systems
Local Electric Utility: IDX Power, Inc.