BENEFICIAL USES OF THERMAL DISCHARGE[1]

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The attendees gathered at the Atmospheric Sciences Research Center (ASRC) Whiteface Mountain Field Station on the evening of October 14, 1969. After dinner, Dr. Vincent Schaefer welcomed the attendees and presented the concept of the origin of the Adirondack-type conference (Schaefer 1957) and the results of past conferences (Vonnegut 1969). Mr. Raymond Falconer then provided a briefing on the weather for the next three days and a slide show on the development of the Whiteface Mountain Facility.

On the morning of the 15th Mr. Sveinbjorn Bjornsson of the National Energy Authority, Iceland, led off the conference with a description of the present and future uses of geothermal discharges in Iceland. For 25 years water has been transported to 16km to Reykjavik with a drop in temperature of 3°C from the original 87°C. This flow is augmented from wells in the city (population 80,000) and distributed for space heating, processing, industry, swimming pools and other sporting facilities. During the space heating cycle the temperature of the water drops from 90°C to 40°C. (The 90°C temperature being obtained by mixing the incoming 87°C water with the discharge from the city wells.) Normally 2KW per inhabitant or 23.2 watts per m^3 of house is considered as the maximum load factor. Total costs are approximately $\$1.02/10^6$ Btu (compared to U. S. costs $\$1.45/10^6$ Btu). Projected plans include a 30km, 16" diameter pipe which will transport 180°C water under pressure. The temperature drop will be 5°C. One half of the volume (at 130°C) will be used by industry at $\$0.50/10^6$ Btu. The other half will be used by the domestic market (at 90°C) at $\$1.00/10^6$ Btu.

Besides lower heating costs the service replaces oil or gas burners which cause air pollution, saves installation cost and space in houses and reduces danger of fire in the city. Of the 30 acres in greenhouses which are heated by the geothermal discharge (air temperature 20°-30°C), one-third is used for flowers and two-thirds for tomatoes and cucumbers. Year-round growth is restricted by available radiation. However, a recent U. S. Patent (No. 3.352.058) described a method for converting incoming radiation into the spectral range plants can absorb, thus increasing the percentage of radiation absorbed. The costs of the construction of greenhouses is approximately $\$15/m^2$ for timber frame and $\$20/m^2$ for aluminum frame. Heat consumption is 1200 Btu per m^2 per hour. The value of the products from the 30 acres is $800,000 per year.

Although no data is available to us at this time, another experiment is being carried out at Oregon State University. Dr. Larry Boersma, Department of Soil Science, is heating agricultural grounds using the discharge of a power plant. This program is supported by Pacific Power and Light.

The Icelandic fish culture, designed to raise salmonoids to release-size in eight months instead of the normal growth period of two years, uses the geothermal discharge to maintain the proper temperature range. The best temperature range for the growth of Atlantic salmon is 10-12°C. A similar system in the research stage at the Hunterston nuclear plant in Scotland raises the Dover sole to market size in two years instead of four. Again the thermal discharge is used to maintain the proper temperature range. The plaice grown under a similar system produce 2,000 tons per year per km^2. Feeding is a serious problem as each ton of fish produced needs 12-15 tons of food per year. One method which will help in solving this problem will be mentioned later.

Of greater economic significance is the use of the steam for freeze-drying. A freeze-dried product weighs about 10-30% of its original weight and may be stored for several years. This decrease in weight is due to the distillation of water from the product and as such, provides a source of distilled water for home and industrial uses. For instance, to freeze 1kg/fish take 10.5 Kwh (36,000 Btu). In Germany and

Great Britain approximately 45% of the cost of processing is energy costs. The discharge from a 1,000 MW plant contains sufficient heat to freeze-dry 200 tons of fish per hour. Meat and fish are approximately 80% water. Thus 100 tons of meat and/or fish passing through the freeze-dried process would release a maximum of 80 tons (2×10^4 gal.) of water. However, freeze-drying requires steam at 140°C which must be taken directly from the turbine, not from the discharge. This will affect the overall efficiency of the reactor but aids the economy of a complex system which includes reduction of thermal pollution as a final goal.

Next, the discussion went into the agro-industrial complex (1000 MW) which might involve 200,000 acres of farmland at one time. Desalting could produce 3×10^8 gal. per day with nitrogen, ammonia and phosphorus also being produced. Other processes in the complex would depend upon raw materials available or mining the sea. The initial investment would be $2 billion and could support 3 million people at minimum standards.

The U. S. energy requirements for generation of electricity will approach 10^{16} Btu/yr by 1980. Approximately two-thirds of this amount will be released as waste. Greenhouses, which are effectively horizontal cooling towers, appear to be the best means for cooling the discharge and providing a basis for economic support within the complex. By using exhaust fans the residual heat is eventually discharged to the atmosphere after usage. For instance, a 1000 MW reactor could heat a 500 acre greenhouse farm producing $12 million/year in crops (wholesale). Using the newer type greenhouses (such as fiberglass or the Goodyear plastic houses used at Sonora, Mexico and Wooster, Ohio) initial investment decreases significantly. The greenhouse structure is approximately 70% of the initial investment, with fans, roads, pumping, etc. making up the final 30%. Besides growing vegetables or flowers in greenhouses, it also seems economically reasonable and desirable to heat chicken houses in the complex. The U. S. market for chicken is of the order of $2 billion per year. The discharge from a 1000 MW plant could also be used to irrigate 200,000 acres if designed to do so. This could also keep 15 km of river ice-free on the St. Lawrence, or support 2×10^6 pounds of shell fish, or 9.5×10^6 pounds of fish or 30×10^6 pounds of algae.

The discussion shifted to cooling towers and their various environmental problems. The cost of cooling towers, ponds, etc. is often cited as reasons for not using these methods. With 1% evaporation from a tower a (1000 MW nuclear power plant uses approximately 10^6 gal. min^{-1} of cooling water) 10^4 gal. min^{-1} evaporates. This is sufficient to create clouds, fog, and icing under appropriate conditions. By the year 2000 it is expected that we will need ten times the power requirements of today and will release 7-10 times as much heat. Possible means of useful weather modification were discussed including the dissipation of fog and ice at airports by dry closed circuit cooling systems or dissipation of the heat by induced atmospheric vortices. Thermal plumes were compared to smoke plumes considering rise vs. downwind distance. The smoke plumes release from 10^4 watts m^{-2} to 10^6 watts m^{-2}. (Solar radiation provides 200-400 watts m^{-2}.) A comparison was also noted in relation to the Icelandic volcano, Surtsey, in that the power output of proposed nuclear power stations is one order of magnitude less.

The possibility of mixing or stratifying the discharge in a body of water offered the opportunity to display modelling vs. actual experience. Although the total amount of heat released remains the same the option of controlling the rate of heat discharge and thus temperature in the receiving waters becomes a reality. The overall control is still limited, however, by the volume of flow available in the receiving waters. Flow visualization was presented on several slides explaining the modelling procedure.

During the final session an attempt was made to summarize the discussions. The result is best shown by Figures 1 and 2. Figure 1 summarizes the possible uses of hot water and low grade steam, indicating the temperature range for heat needed in each operation. Space heating, swimming pools and greenhouses are already in operation in Iceland, fish culture is in the experimental stage, D_2O production and production of sea chemicals from thermal brine have been projected.

Figure 2 shows schematically how an agricultural and aquacultural complex could use the thermal discharge from a nuclear plant and thus prevent thermal pollution due to the release of heat into rivers or through cooling towers into the atmosphere. The cooling water from the turbine condenser goes in a loop consisting of greenhouses, fish ponds, irrigated farmland and water storage. (This loop could also include the chicken houses mentioned previously.) Evaporative losses are compensated by water taken from a river. A freeze-drying plant using steam extracted from the turbine would greatly increase the value and storing life of the products from the complex, and decrease storage and transporting costs. The freeze-dried products could be used for balancing out variations in production and market demands. Additional factors could be waste water treatment, adding water to the cooling system and food to the fish ponds, space heating of a nearby city during winter and central space cooling and air conditioning during summer using the same distribution system in the city and the central cooling facilities in the complex.

This complex is designed to provide a step-down method of using the available energy as it passes from high-grade readily available energy to low-grade partially unavailable energy. The result is an economically feasible complex which reduces thermal pollution after making maximum use of the available energy. It may be used in most climates by choosing those options which are suitable for the area.

The Adirondack-type conference holds sessions in the morning and evening with the afternoons off for other activities. This year the attendees visited the summit of Whiteface Mountain (including a 15 minute climb for those who didn't take the elevator) where the new ASRC mountain-top station is under construction. From the top of the mountain we then traveled to a nearby abandoned Atlas missile site and descended to view the cosmic ray laboratory under the direction of the State University College, Plattsburgh, New York. The laboratory is designed to locate areas of cosmic ray emission and the experimentation is being carried out by Dr. Donald Ryan.

The following day Mr. Sam Wiggans (one of the attendees) provided a tour at the University of Vermont, Burlington, Vt. which included several of the new buildings (zoology, botany, soil science, library, bookstore). The final tour on the way from Whiteface Mountain to Albany, New York included the new Institute for History, Art and Science at Lake George, New York where the ASRC and the Department of Atmospheric Science, SUNYA are developing a research center for air-water interface and ecological studies.

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