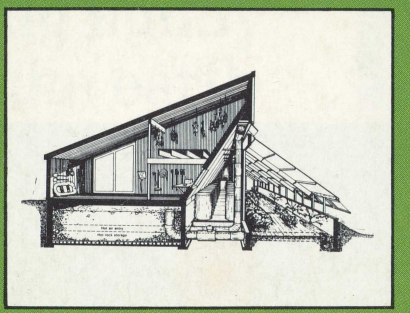
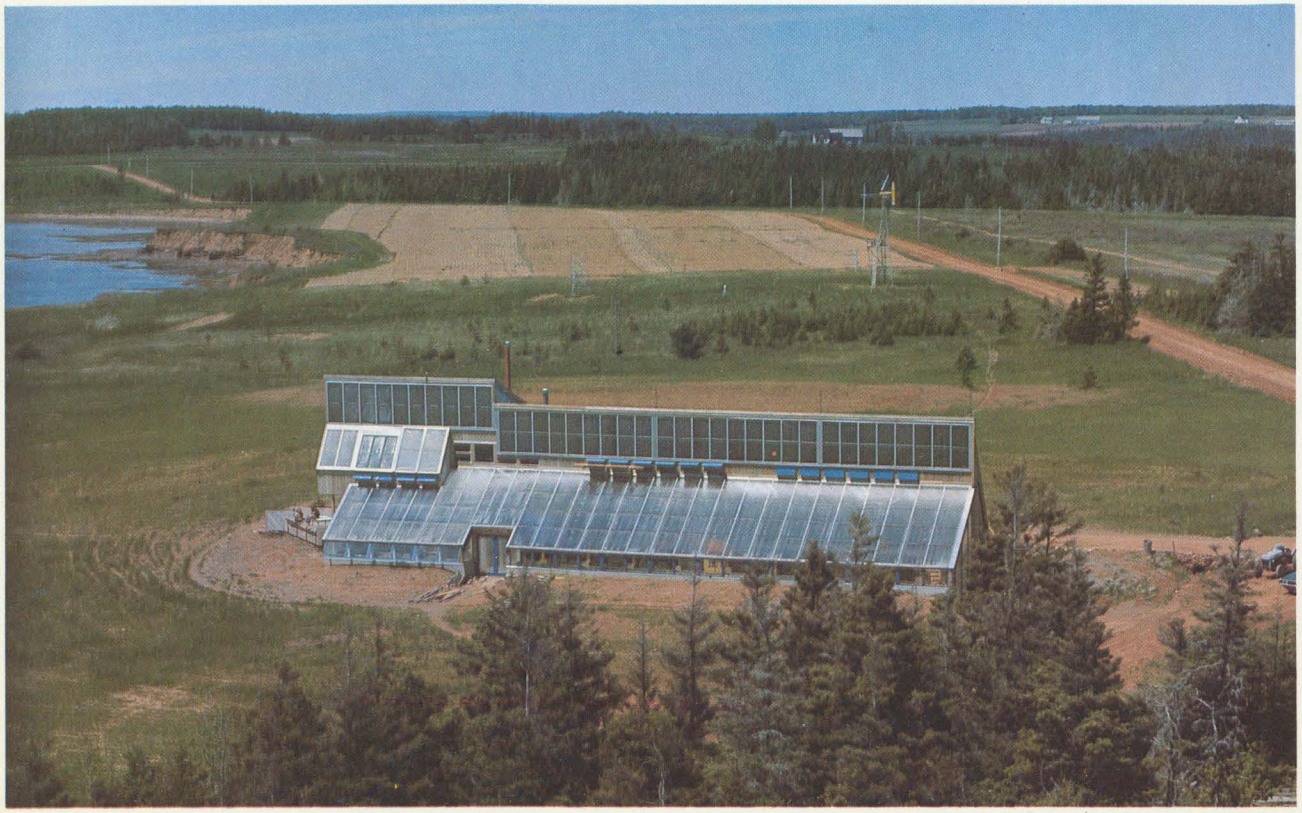
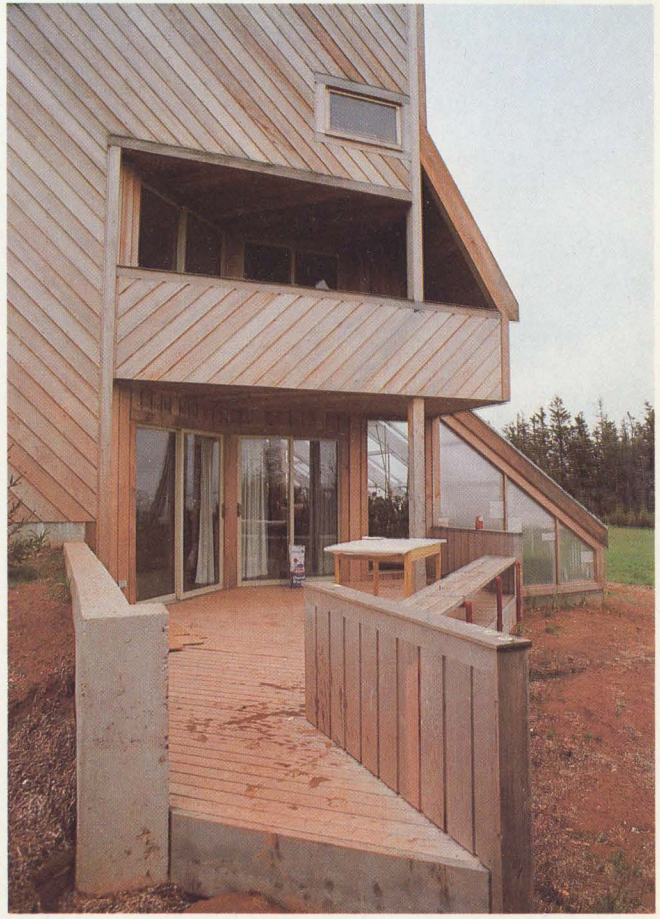
A Most Prudent Ark



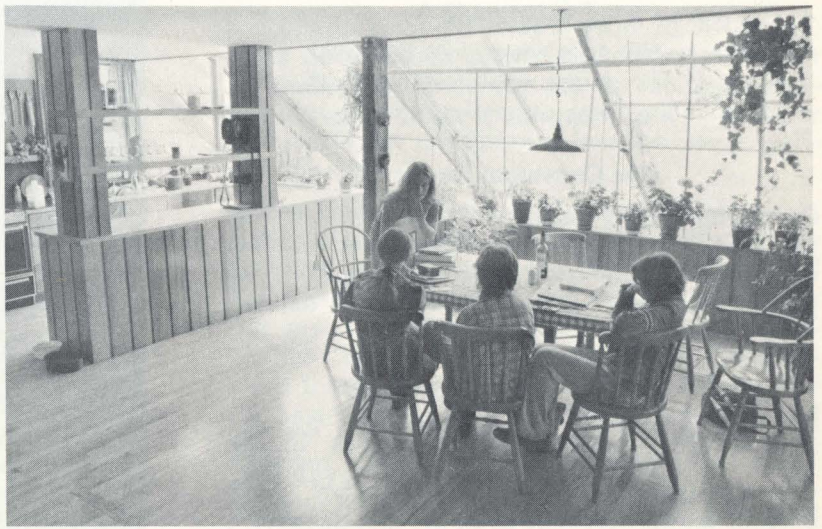
Fisheries and Environment Canada
Pêches et Environnement Canada

Catalogue no: EN21-21/1977
ISBN 0-662-01101-5





living lightly on the earth



Concept

Concept — an abstract idea generalized from particular instances

Ark — a structure that provides protection and safety, such as Noah's boat

The ARK at Spry Point, P.E.I. symbolizes a search for alternative ways of living on earth — a response to the threat of dwindling resources — a new morality based on prudence.

Our Consumer Society

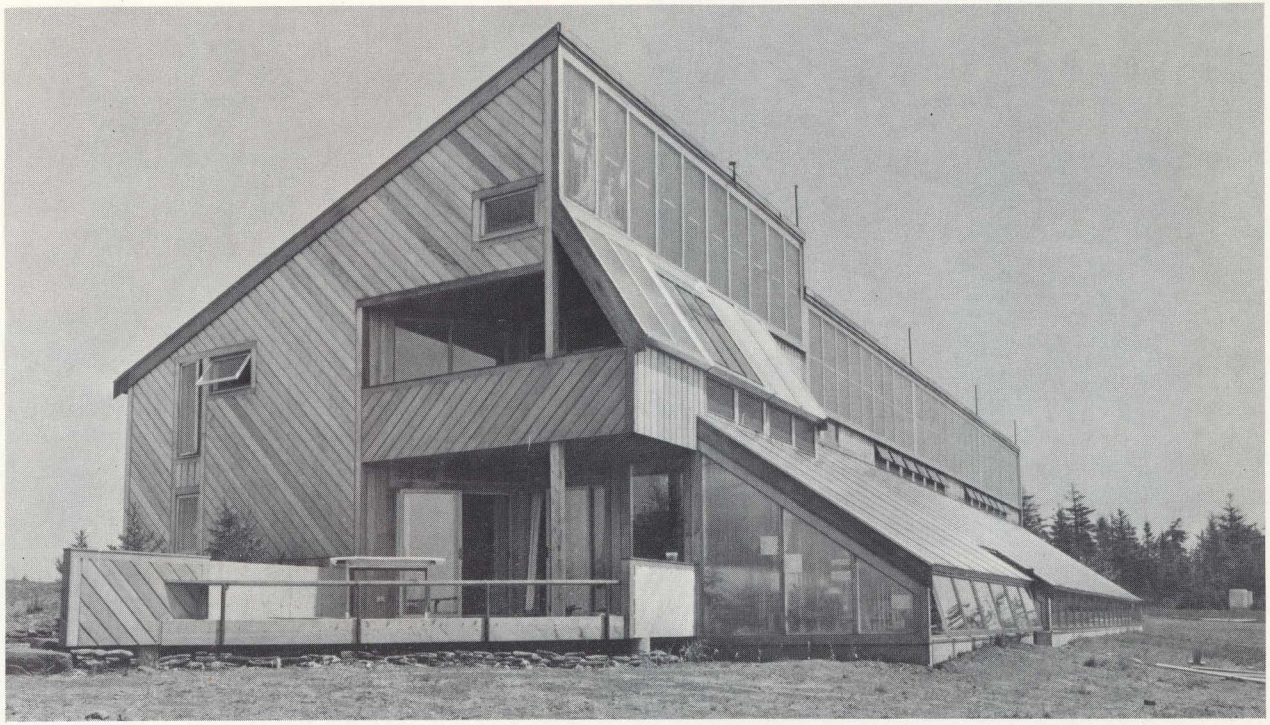
Industrial society has provided many amenities to living, but the cost is proving too great. Our material demands have exceeded our ability to provide without deleterious effects on our environment.

Many Warnings

Throughout history, thinkers have warned against excessive growth and high resource consumption. But there have probably never been as many warnings as in the last decade. In the 1960's Rachel Carson's *Silent Spring* shook western society by documenting the harmful effects of pesticides. Alvin Toffler's, *Future Shock* told of the social effects of the post-industrial society.

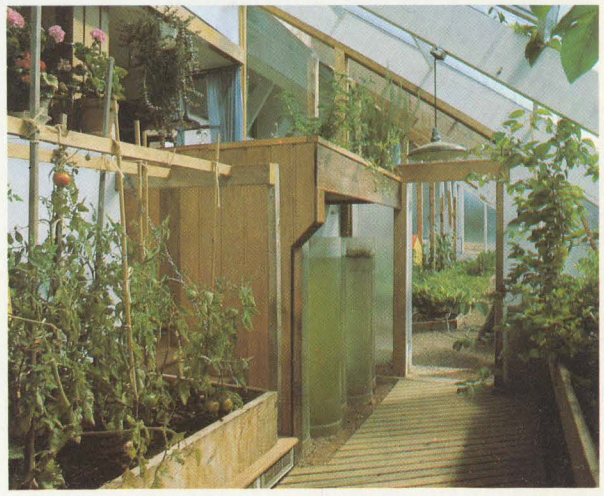
In the 1970's, the Club of Rome, informally organized by thinkers from many lands, brought together the best information available relating to the future of mankind. Analyzed with deep insight into modern world affairs, this information was summed up in two landmark publications *The Limits to Growth . . . Predicament of Mankind,* 1972, and *Mankind at the Turning Point,* 1974.

In essence, these and many other ongoing studies indicate that without immediate, profound, remedial change on a global scale, our present civilization is unsustainable and the future of mankind is bleak.



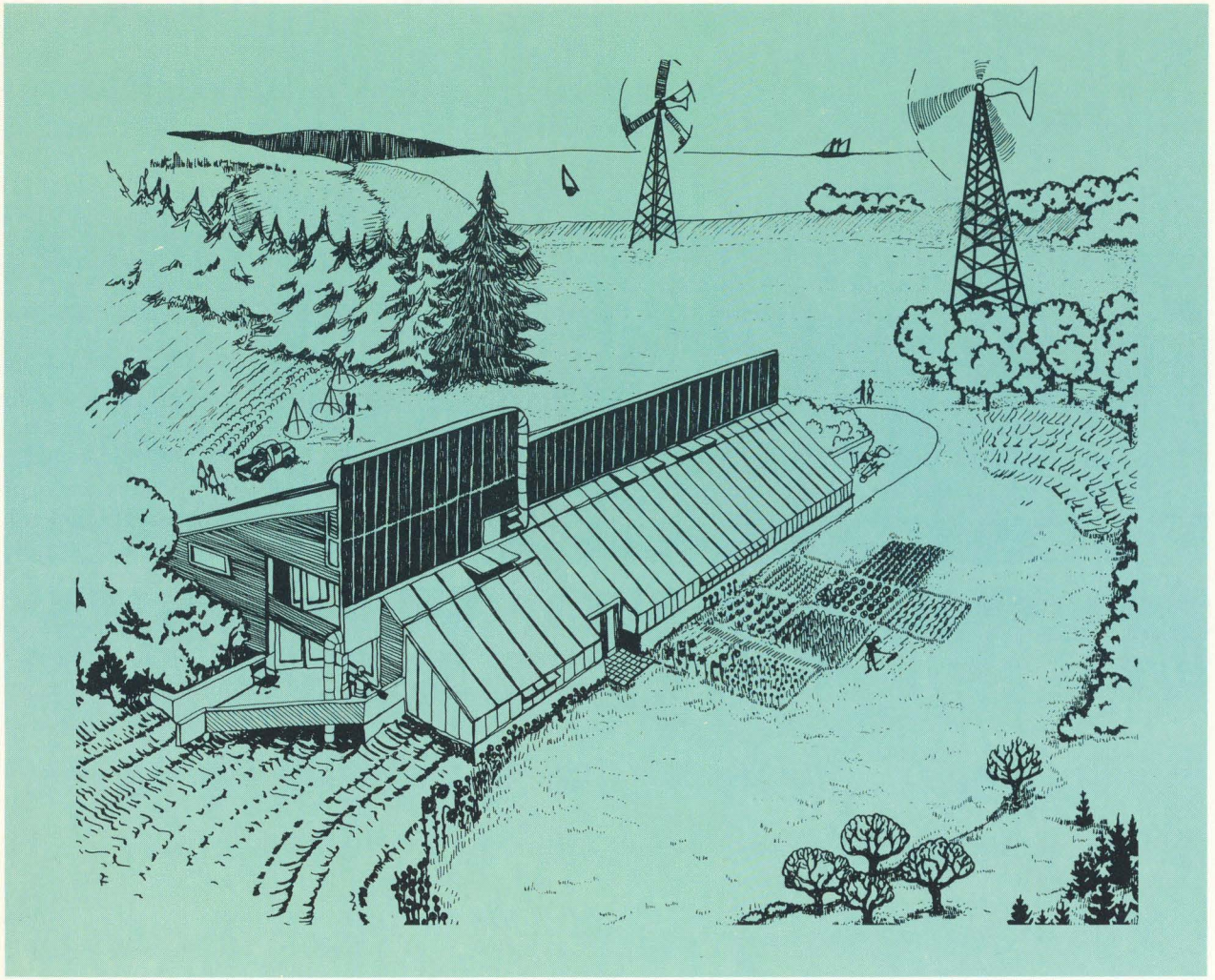
Looking for Ways

The New Alchemy Institute was established in 1969 to explore scientific strategies and provide a rational model for bringing about necessary changes within our society in an acceptable manner. A basic philosophy of the Institute is that, for present society to continue and improve, wasteful technologies must be replaced by efficient, low consumption technologies, powered by the renewable resources of sun, wind and biological systems. Success will depend on using methods which take advantage of natural forces and on assisting natural processes which already operate to our benefit.



Our Problem, Our Solution

In the cool-temperate climate where most Canadians live, much of the year is too cold for unprotected living and unaided food production. Our solution until now has been to use force and technology to shut out the elements; to import energy for comfort; and to rely in-



The southern facade of the ARK is dominated by solar panels; no windows face north. A glass wall divides the domestic and commercial greenhouses. The artist's sketch shows proposed and existing windmills, exterior landscaping with vegetable, fruit and flower areas.

creasingly on chemical pesticides and fertilizers and on other costly forms of energy for food production.

A Concept is Born

With dawning awareness that this cannot continue much longer, came realization that a self-sustaining society can be achieved only if social units or individuals become more self-sufficient.

Can a family or community meet their needs for shelter, warmth and food by applying our knowledge to harness the energy of natural systems without waste and harmful effects on our environment? The concept of a family "bio-shelter" was born: a self-contained, self-sufficient living environment, which could provide its basic energy and food requirements, and would not pollute or deplete non-renewable resources.

As the idea evolved, the similarity to a lifeboat or a self-sufficient refuge became clearer. It is therefore no coincidence that the New Alchemy Institute named their project "The ARK".

A New Kind of Society

Thus, the ARK leads away from present society, with its massive consumption and waste abandonment. The ARK points toward conservation and prudence, efficiency and recycling. Far from the traditional hermit-like view of frugality, a conserver society would be rich in both material and esthetic rewards. In a conserver society, people "live lightly on the earth", in unity with the natural world, developing individuality and competence, independence and self-worth.

A beginning

The Problems

The New Alchemy Institute is attempting to solve three foreseeable problems in our future: energy demand, food production and resource conservation. Success will only be attained by approaching more closely the way nature itself has been working all the while.

A Typical Canadian Problem

Prince Edward Island is typical of the mid-latitude region, about half-way between the equator and the North Pole, where much of the Canadian population lives. It is characterized by lack of mineral resources, but has unrealized potential in agriculture, aquaculture, and solar and wind energy. The experiment will search for ways to overcome problems of high resource consumption, a precarious economy, and a tendency for productive farmers to leave the land.

The Wind

The south-east coast of Prince Edward Island is a windy place, exposed to the vast energy of major weather systems. The ARK wind power installation pioneers a new type of windmill, a prototype which will provide information for further development of small scale windpower.

The Sun

Solar energy systems at the ARK are testing a technology originally designed for warmer countries. The Canadian setting with its characteristic colder, more northerly population centres is a challenge that the ARK seems to have already confronted successfully.

Food for Life

Aquaculture at the ARK pioneers indoor fish production by simulating the high productivity rates of tropical fish habitats. Fish protein, when combined with vegetable protein, supplies a nutritionally complete and balanced protein for an adequate human diet. In this way the ARK draws on the ancient knowledge of tropical countries where fish have been grown for food over many centuries.

The extensive greenhouse at the ARK tests new ways of producing indoor vegetable and fruit crops for a complete human diet. Native soils of P.E.I. are low in mineral and organic components and outdoor experiments will strive to improve the quality of the soil without resorting to artificial fertilizers.

The building and its systems

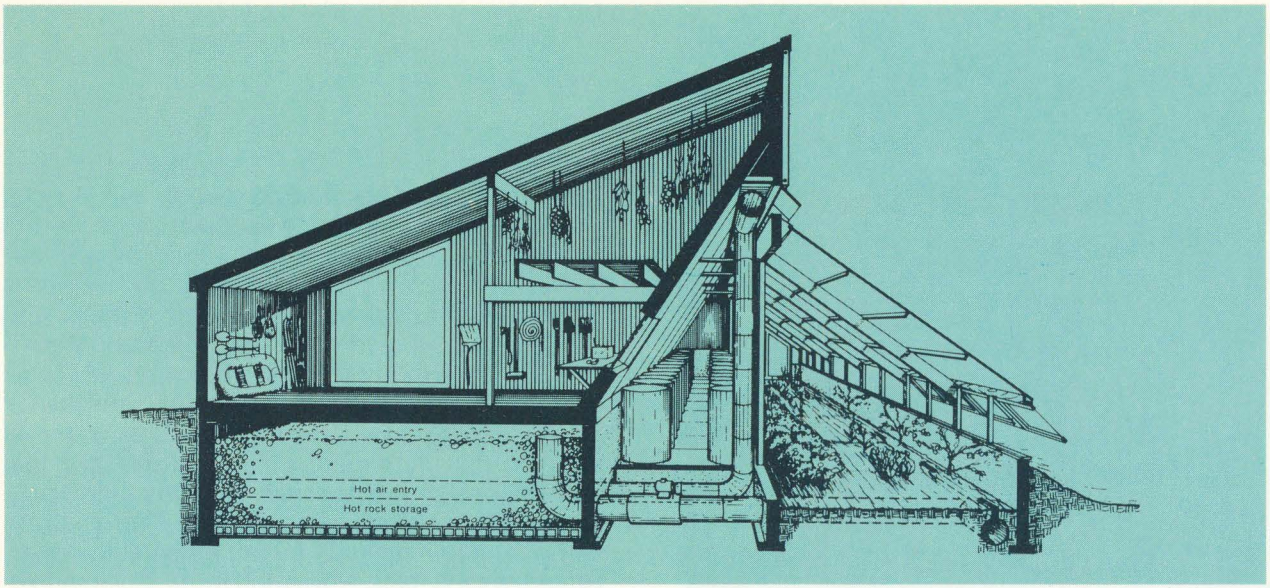
Familiar and Liveable

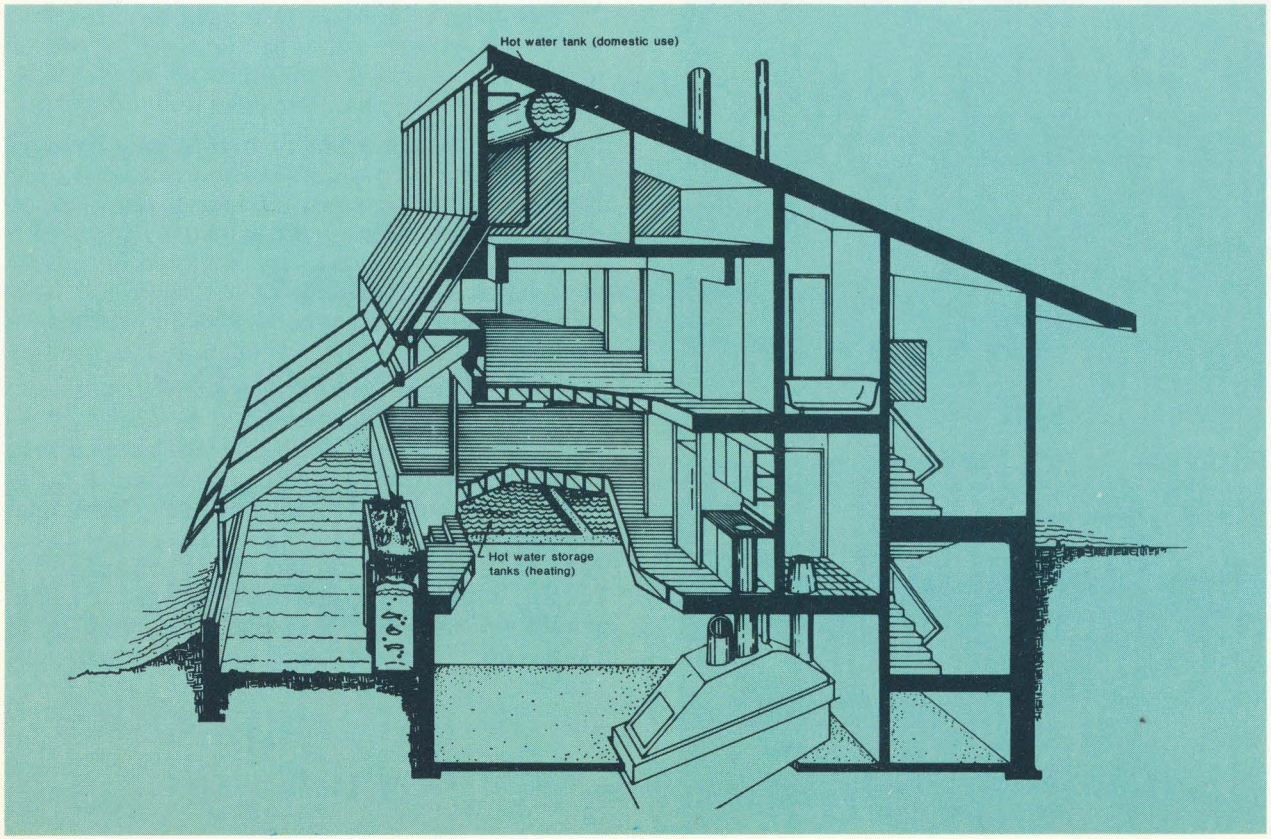
The most obvious sign that the ARK is a highly developed bioshelter is that the whole building and its operating systems face south, for best exposure to the sun. Solar energy is therefore the basis for the ARK's design. Each form of incoming energy, heat, light and wind, is collected, stored and used in appropriate ways for different purposes. Individual systems are designed to make best use of the special characteristics of each kind of energy.

The ARK building integrates solar heating design with traditional functions. A basic family dwelling is part of a larger greenhouse. Architecture is conservatively modern, highly functional and easily adapted to individual needs, tastes and lifestyles. Building materials are wood and concrete; construction methods are mostly conventional. Heat circulation is by ordinary forced air ducts. Cooling is accomplished passively by opening residential windows and doors and by a normal, greenhouse automatic system with ground level and roofline venting.

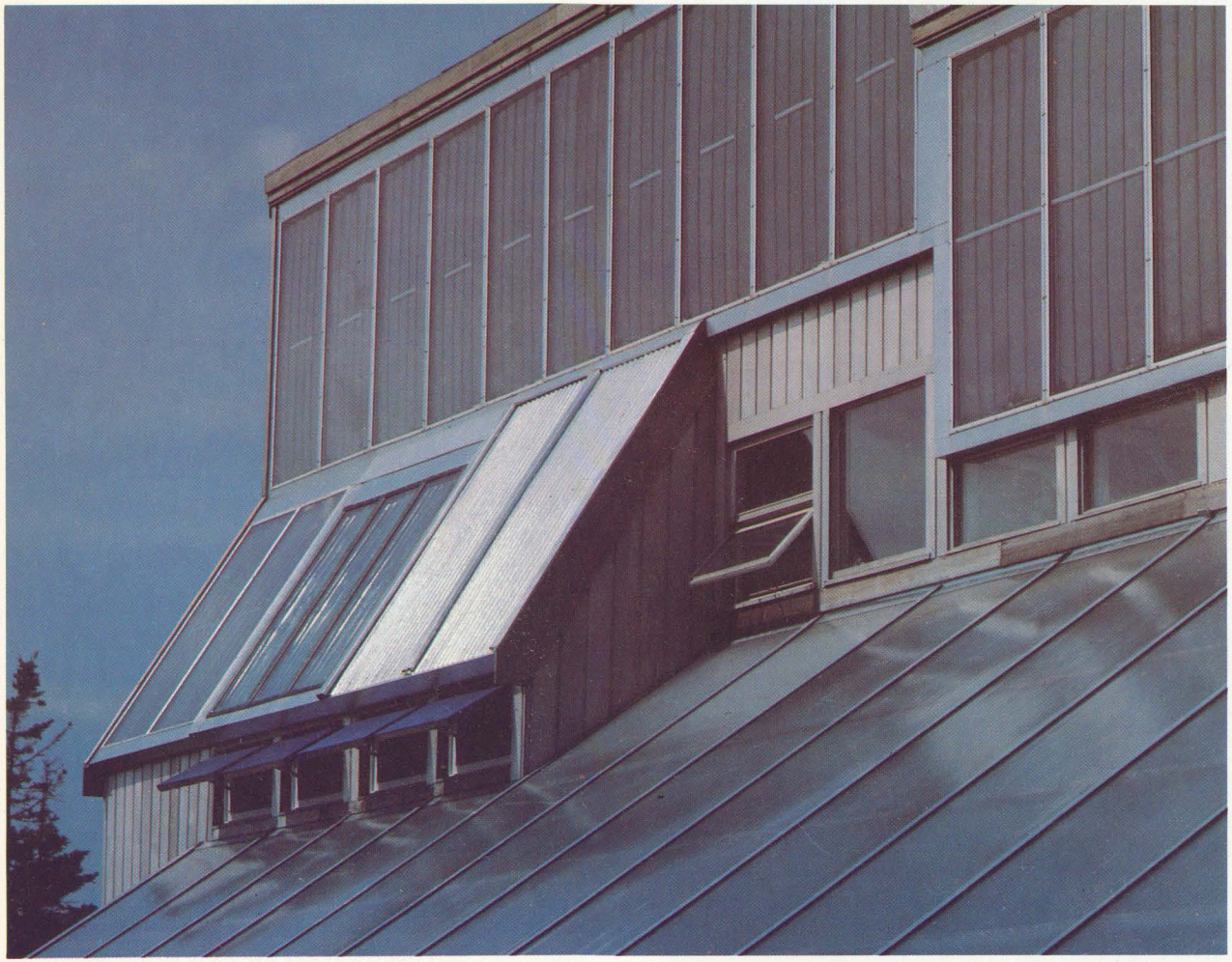
The ARK is a synthesis of what we already know. At the same time, it serves as a starting point. It is designed to develop new insights and methods.

The New Alchemy Institute is pioneering an integrated approach, bringing many technologies together for a common purpose. The ARK experiment is taking place in a resource-poor land where prudence and resource independence can be put to good use immediately.





Diagrams show the ventilation, composting, heating and heat storage systems incorporated with the living areas of the ARK. Photo illustrates aquaculture tanks and venting near the roof in the commercial greenhouse.



The black solar panels rear against the sky to collect energy from the sun. Three different types of panels are being tested. The windmill prototype is in a developmental stage, others will follow. The dark waters of the aquaculture tanks blend with the foliage of the vegetables grown in the commercial greenhouse.

The Physical Systems: Heating and Windpower

Harnessing the Sun

Thirty-six vertical solar collector panels run the length of the roofline, facing south. Water passing through pipes inside the panels absorbs heat which is piped into large, insulated basement storage tanks. When needed, hot water is pumped through coils in the air ducts and the warm air is blown through ordinary floor registers. The system is automatic, thermostatically controlled and indistinguishable from forced air systems which burn oil, gas, coal or wood.

Seven solar panels independently heat water and store it in a tank for domestic needs. Three types of panel are being tested.

Sunshine enters the greenhouse directly through the transparent roof and wall glazing, warming the interior. Excess hot air inside the peak of the sloped roofline is drawn down by a fan, through a duct and into an insulated basement rock chamber, forming a reservoir of heat which is released as needed. This hot rock storage serves only the greenhouse. It too is automatic and thermostatically controlled.

Additional daytime solar heat is absorbed in the greenhouse by the massive aquaculture tanks full of dark colored water and by the deep, dark colored soils of the greenhouse beds. At night and during cold weather these reservoirs of heat radiate their warmth and help to maintain greenhouse temperatures. The combined mass of water and soils is so large that enough heat is stored to last through several days of cold sunless weather.

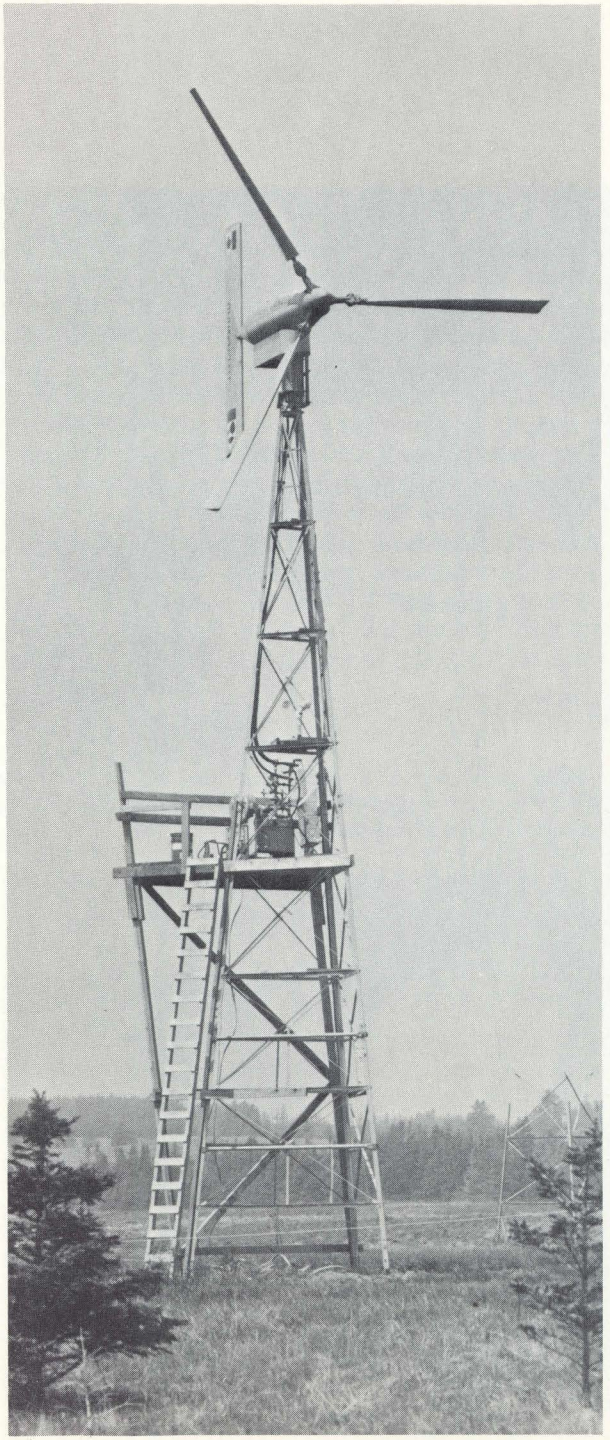
Alternative or supplementary heat can be obtained from an efficient wood burning stove in the family living room while an emergency furnace burns wood. The furnace, installed late in 1976, has not yet been needed and has been operated only for testing.

Harnessing the Wind

The ARK is designed to use wind-generated electricity to power normal household appliances as well as its own control systems.
A windmill has pitch-controlled blades. They operate a lightweight hydraulic pump which transmits energy through pipes to a hydraulically-driven generator at a lower level. Power is carried by underground wire to the ARK where direct current is converted to alternating current for domestic use.

Approximately 7.5 Kilowatts is available from the present experimental windmill. The technology of hydraulically transferred wind power is being developed so that heavy electrical generating equipment remains on the ground, while only the relatively light windmill and pump rest on top of the tower.

The ARK is connected to the local commercial power grid, but wind generated electricity will reduce this dependence and cost. Surplus power, resulting from high winds or unused generating capacity, can be fed back into the Island power grid.



Biological Systems: Food Production and Waste Disposal

Working with Nature

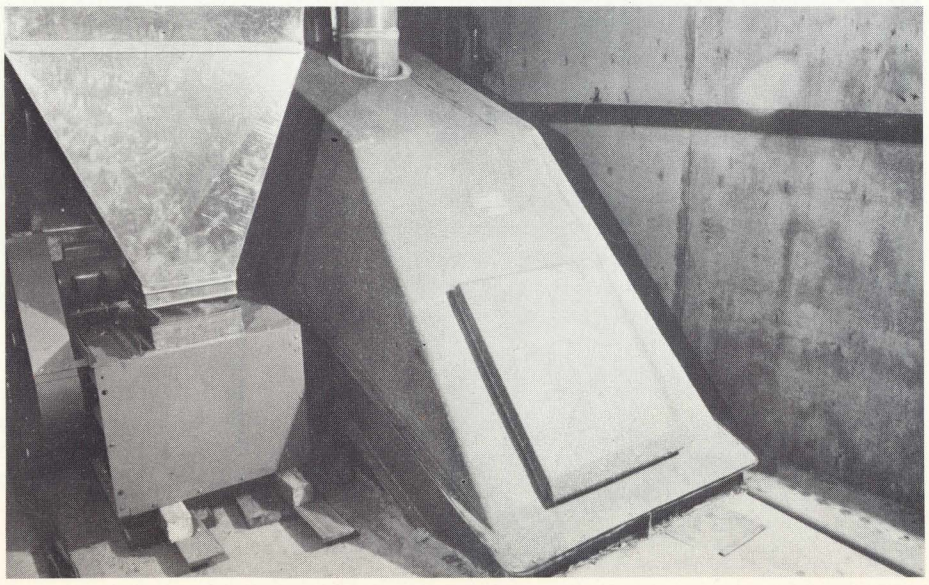
While conventional modern agriculture consumes energy and resources in the form of fertilizers and motive power, the ARK is designed as a low input, high productivity food producer based on principles governing natural ecosystems. Soil quality management is practiced in

the greenhouse beds through use of compost, local seaweed, nitrogen-rich wastewater from the fish culture tanks and organic fertilizer produced by the aerobic sewage treatment facility. Plants will be cultured without the use of chemical fertilizer or pesticides. (In fact, pesticides cannot be used because of their possible effects on fish.) Hence crops will be selected for their resistance to disease and pests while natural pest predators will be used — such as lizards and spiders. Cultural practises will thus be as close as possible to those of Mother Nature in an environment controlled by man's design and technology.

Important Protein

Western cultures have traditionally relied on cattle, sheep and hogs for the majority of their animal protein requirements. Properly cultured, fish potentially offer a cheaper and more efficient way of providing this dietary need. The fish culture experiments in the ARK will supplement the experience of the New Alchemy Institute in small scale fish culture techniques. Thirty cylindrical translucent aquaculture tanks line the back wall of the greenhouse in the Ark. The tank environment is balanced to provide optimum conditions for fish growth through the use of aquatic animal and plant species which will provide food for the fish and will purify the water.

All kitchen waste is dropped through the port on the kitchen counter-top to the fibreglass composting chamber in the basement.



Prudent Waste Handling

In present society sewage and garbage is expensively transported and treated, usually by anaerobic (airless) processes which, though fast, use large volumes of water and produce great quantities of incompletely decomposed, highly toxic sludge and liquids. These degrade terrestrial and aquatic environments and the resource materials are lost.

Waste disposal at the ARK follows the same principles as those found in nature. The system is based on aerobic microbiological reduction. Sewage and domestic garbage both fall directly into a fibreglass composting chamber in the basement. No water is added. Naturally occurring micro-organisms, in the presence of a good air supply, decompose the organic waste. Decomposition is slow, safe and complete. The decomposing chamber is vented beyond the roof and the system is odorless. The toilet requires no water tank and does not flush. Human and kitchen waste fall directly into the decomposition chamber. The system is virtually maintenance free and about once a year provides several hundred pounds of fine humus that is dry, safe, and an excellent natural plant fertilizer for the greenhouse.

Controls

Diversity of Systems and Controls

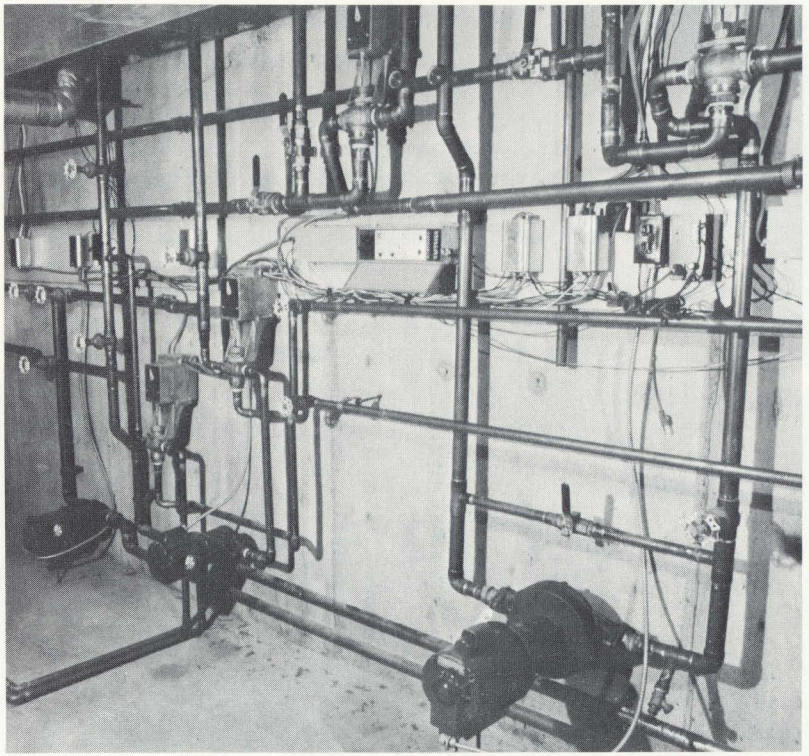
The stability of natural ecosystems is largely due to their diversity which permits options and alternatives in accommodating inclement environmental conditions.

In addition to the biological diversity being developed in the Ark, the design incorporates a technological diversity to insure against failure of one or more of the energy producing systems. Thus the ARK has six heating systems; hot water and warm rocks (active); aquaculture tanks, growing beds, and direct solar heating of living area (passive); livingroom wood stove (discretionary); and furnace (emergencies). There are two electrical supplies, commercial power and hydrowind.

The effectiveness of alternatives and backup systems was clearly demonstrated in November 1976 when an unusual, three-day storm and cold spell blacked out all electric power. Heat passively stored and released from the aquaculture tanks and greenhouse soil beds prevented the ARK from freezing up, when other systems were inoperative.

A Variety of Controls

Control systems in the ARK are conventional. Temperature is regulated through thermostats which control the heat processing systems. These systems can also be operated manually for experimental purposes or in emergencies. Some of the heating systems have the option of cross connections, so that heat from different sources can be stored and distributed in a variety of ways, as required. The diversity, which allowed passive heating during the storm and power blackout, also acts at all times to modify and partly control internal temperatures passively.



The windmill has internal electrical and hydraulic control and regulating devices.

One of the research aspects of the ARK is the monitoring of the many environmental control systems. A computer being installed will have the capacity to record and integrate information about the physical and biological systems. This will help to achieve the design objective of a fully-integrated bioshelter, both in its capacity for analysis and in its use for controlling various systems.

The complex arrangement of water pipes and electrical equipment are part of the programmed switching system to provide heat and hot water, illustrate the marriage between the traditional and modern methods to operate the ARK efficiently and prudently.

Inhabitants

Inhabitants as Part of the Ecosystem

As products of the Industrial Society, we have tended to live apart from, rather than as part of, nature. The New Alchemists strive to show ways and means for western man to live in closer harmony with nature. This is why the Ark design incorporated both living quarters and an experimental production unit under one roof. The Ark inhabitants — adults and children, scientists and laymen — are an integral part of the total physical and biological system. They find rewards and satisfaction in developing and running an efficient, productive bioshelter and in learning about the natural systems we rely upon for support. They contribute the manpower and the wastes which maintain the productivity of the Ark's systems and are benefactors of the products of those systems in a close symbiotic relationship.

The ARK is an early response to rapidly changing societal and environmental problems. It is a serious attempt to ensure that society evolves rather than declines or disappears.

Experiment

The ARK Experiment

The ARK is an experiment, testing concepts and technologies, exploring beyond present practices. Thus performance can only be forecast as estimates and probalities. Only operating experience can prove or disprove calculations and concepts.

In the short time since the ARK became operational, in the late fall of 1976, the many interrelated systems have performed surprisingly well, in some cases exceeding reasonable expectations. The ARK entered its first winter without a previous summer season to store heat. Nevertheless it maintained the expected temperatures throughout the winter and even survived a complete breakdown of all active systems caused by a storm and near-record low temperature in late November 1976.

The food production systems have been developing gradually. The 1976 winter crops demonstrated the feasibility of the system.

Biological reduction of household wastes has performed satisfactorily after minor initial problems. Regulation and control mechanisms have functioned well. The building structure has given no serious problems.

The wind power plant is still in its development stage.

Learning

The ARK is a beginning, a process, an experiment. Lessons from the ARK's performance will assist in planning improvements. They will also be incorporated in the design of more highly evolved bioshelters. Other concepts, meanwhile, are developed and tested elsewhere. All these experiments will provide us with a range of alternatives to our present consumption patterns and more appropriate means to support evolving lifestyles. Thus, the various research and demonstration projects throughout Canada and abroad bring us ever closer to the goal of an environmentally sustainable society.

Conserver ARK

Prudence — skill and good judgement in the use of resources

Prudence is the basis of a conserver society.

How the ARK does it

Prudence in the use of resources finds expression in every aspect of the ARK and its systems. Appropriate insulation makes the ARK several times as efficient at conserving heat as the average Canadian home. This one-time investment reduces heat loss without further expense during the lifetime of the building.

Windows allow the escape of heat, especially where there is no compensating heat gain from the sun. So the ARK has no north windows and elsewhere windows are double glazed. Greenhouse glazing uses a thick, transparent cellular acrylic plastic sheeting which allows solar energy into the Ark while preventing heat escape.

An earth mound a few yards upwind of the ARK deflects the prevailing winter wind up and over the building, reducing direct heat loss through windchill. It also prevents showdrifts from piling up around the building.

External disposal of materials is minimal at the ARK. Only so-called "grey water", the wash water used from kitchen, laundry and bathing, is discarded in a conventional covered sump pit.

History of the Project

1969 The New Alchemy Institute formed at Woods Hole, Mass., by Dr. John Todd, a Canadian biologist.

1974 The New Alchemy Institute (P.E.I.) was established and submitted a proposal for "An ARK for P.E.I." to the federal and provincial governments and searched for a location on Prince Edward Island. Design of The ARK began.

1975 Design of the physical and biological systems under way. Contract between the Federal Government and The New Alchemy Institute to build The ARK signed on September 17. Broke ground on October 16 on land provided and prepared by the Province of Prince Edward Island.

1976 Main construction and installation of physical and biological systems carried out. Testing of all systems began.
The ARK was dedicated on September 21, by Prime Minister Trudeau for Canada and Premier Campbell for Prince Edward Island.

1977 Project completion report accepted February 15. The ARK began its first operational year. The windmill undergoing testing and modifications. Development and testing of biological systems proceeding. Ongoing funding for The ARK arranged. Planning for computerized control of ARK systems underway.

The New Alchemists

To Restore the Lands, Protect the Seas, And Inform the Earth's Stewards

The New Alchemy Institute is an international, non-profit organization supported by private contributions and research grants with centres in, or planned in several countries with a variety of climates.

It seeks to research and educate on behalf of man and planet Earth, believing ecological and social transformations should take place at the lowest functional levels of society. It considers as a major task the creation of ecologically derived forms of energy, agriculture, aquaculture, housing and landscapes, that will permit a revitalization and repopulation of the countryside... to create a greener, kinder world.

Credits

Contractor and principal investigator
John Todd, PhD
President
Nancy Willis, Ark Project Director
New Alchemy Institute (P.E.I.) Inc.
RR 4, Souris, P.E.I.

ARK Design
New Alchemy Institute
RR 4, Souris, P.E.I.

Architecture & Construction Management
David Bergmark
Ole Hammarlund
Solsearch Architects, Little Pond, P.E.I.

Hydrowind Project
Joseph Seale, Project Manager
New Alchemy Institute
RR 4, Souris, P.E.I.

Materials

Solar Collectors
Hoflar, Surrey, B.C.
Solatherm, Weston, Ont.
Sunworks, Guilford, Connecticut

Solar Aquaculture Tanks
Earl Davison, Kensington, P.E.I.

Waste Disposal
Clivus Multrum USA Inc.
manufactured in Sweden and available in Canada and U.S.A. from Amy Rockefeller, 14A Elliot St. Cambridge, Mass. 02138

Electrical Equipment, Inverter
Gemini PCV-1, Windworks Inc.
Thiensville, Wisc.

Greenhouse Glazing
Rohaglas SDP 16 - Chemacryl Plastics Ltd.

Donations

De Luxe Equipment Inc.
JØTUL Fireplace,
Conserver Society Products Co-op Inc.
Hunter River, P.E.I.

Tarm of Denmark Wood Burning H.S. Boiler
Emporium Ltd.
Box 88, Church Pt., N.S.

Johns-Manville Corp.
Insulation

A. O. Smith Corp.
Water Heater

Garden Way Manufacturing Corp.
Troy, New York
Troy-built Rototiller

Enterprise Stove Foundry
Sackville, N.B.
Electric stove

Specifications

Dimensions

overall, outside 48′ x 110′ (14.6 m x 33.6 m)	5280 sq ft (490 m^2)
family living area (total)	1403 sq ft (131 m^2)
commercial greenhouse	1910 sq ft (178 m^2)
family greenhouse	234 sq ft (21.7 m^2)

Structural Materials

foundation & water tanks — concrete
superstructure — wood
glazing — greenhouse, 2,500 sq ft, (233 m^2) acrylic plastic
— residential, sealed twinglass units
residential floors — hardwood
residential walls — drywall

Insulation

foundation — 2″ (5 cm) polystyrene foam on outside
exterior walls — 4″ (10 cm) fibreglass & 1″ (2.5 cm) styrene bead board
hot water tanks — 4″ (10 cm) urethane foam

Solar Collectors

for interior space heating	700 sq ft (65 m^2)
for domestic hot water	125 sq ft (11.6 m^2)

Hot Water Storage

tank A 1,633 imp. gals. (7,430 l)
tank B 4,148 imp. gals. (18,880 l)
tank C 7,730 imp. gals. (35,170 l)

Rock Storage

112 cubic yards (85.7 m^3) of 3″ — 5″ (7.5 — 12.5 cm) stones

Waste Disposal

Clivus Multrum unit,

Hot Water Boiler

200,000 BTU (50,400 kcal)

Electrical Supply

commercial service: 200 A
hydrowind: prototype 7.5 kW
final development 25.0 kW

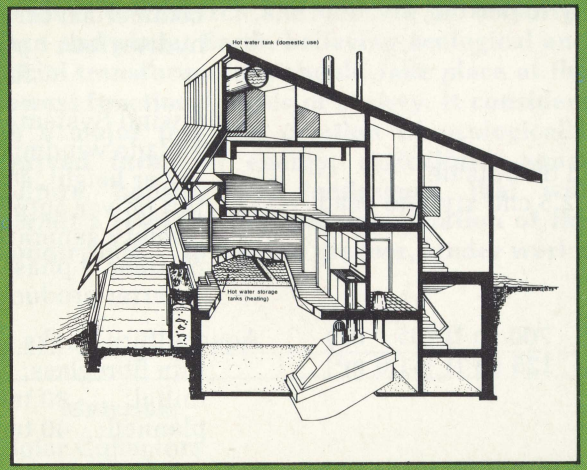
Hydrowind Systems

3 blade windmill, 20 ft (6.1 m) diameter
tower height, 40 ft (12.2 m)
full power output in wind 25 MPH (40 km/h)
primary generation 7.5 kVA, 400 Hz at 1714 R.P.M.
rectifier, 3 phase 1/2 wave bridge
inverter produces 120-240 VAC 60 Hz 3 phase 8 kW

Aquaculture Tanks

thin fibreglass: 5′ (1.53 m) high, 4′ (1.22 m) diameter
initial: 30 tanks, combined cap. 11,700 gal. (53,200 l)
planned: 40 tanks, combined cap. 16,300 gal. (74,200 l)

Text: R. Dalton Muir
Design: Eiko Emori
Photos: Kevin McVeigh
R. Dalton Muir
Typesetting: Typographic Service Ltd., Montreal



Spry Point, Prince Edward Island, Canada

Fisheries and Environment Canada
Pêches et Environnement Canada