A Human Power Conversion System based on Children's Play

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ET/Renewable Energy – A new frontier for R&D

- Depletion/Unreliability of non-renewable energy sources, e.g., oil
- Environmental pollution, e.g., coal use
- Needs of increasing population, e.g., in developing countries
- Global Warming/Climate changes
- Applications in modern, high-tech settings – e.g., wearable computing, portable electronics

The High Cost of Energy

- Though developed countries have access to cheap and abundant energy, an estimated 40% of the world's population – or 2.5 billion people, mainly in less developed countries (LDCs) – do not even have regular access to electricity ☹
- Moreover, their number is expected to double by the year 2050 ☹

Why?!

- Lack of existing energy sources and infrastructure
- Lack of capital to explore/exploit new energy sources
- Even renewable energy is very expensive for the LDCs, 50% of world's population have incomes of just $2 a day ☹

Challenge

Problem: Low-cost, low-resource means of energy conversion?

Solution: Conversion of collective human power into electricity for basic needs such as lighting, communication, and so on.

History of Human Power Conversion (HPC)

- Human muscle power was perhaps the first source of energy for work !
- Earliest uses: tool-making, plowing, rowing boat, etc
- Mechanized uses:

  - Hand cranking – Romans

  - Pedaling – 19th century (bicycle)

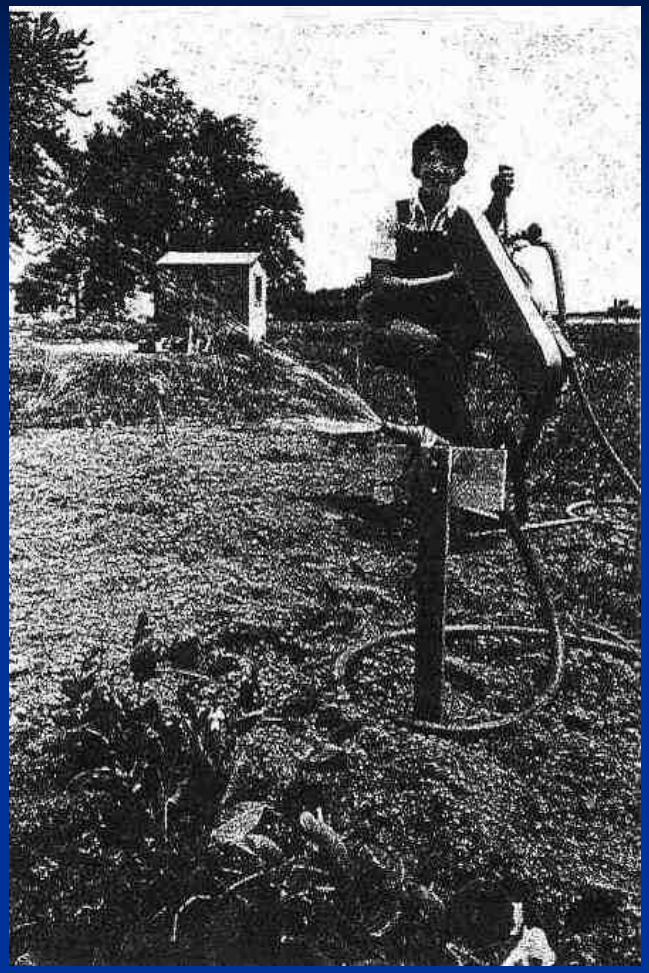
Decline of Human Power Use

- Human power was widely used in the 19th and early 20th centuries.
- However, interest in human power conversion declined with the availability of

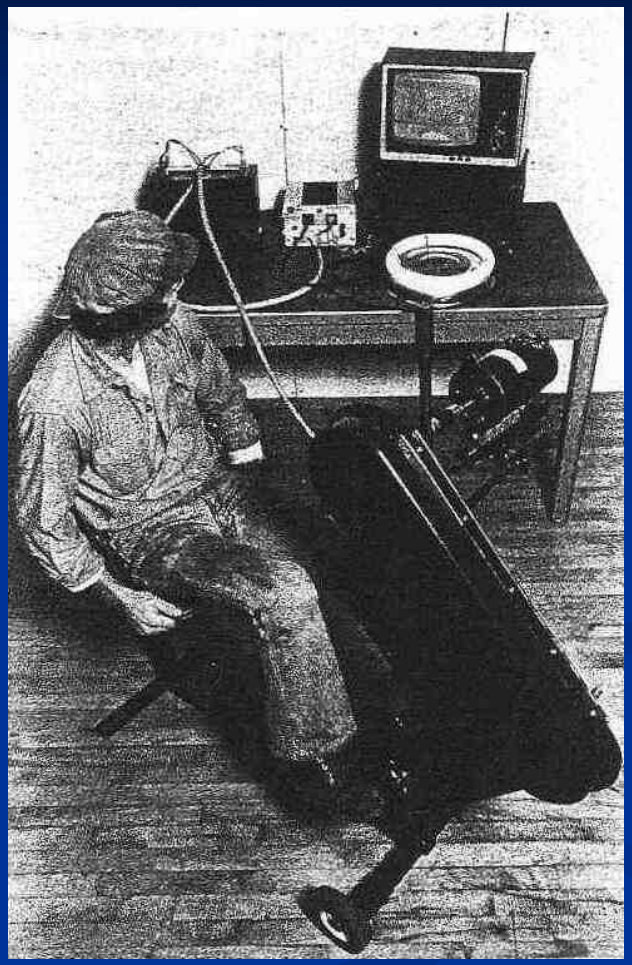
  - cheap, abundant electrical energy

  - use of compact, powerful, and versatile electric motors and lights

  - cheap, disposable batteries for portable use



Pumping water



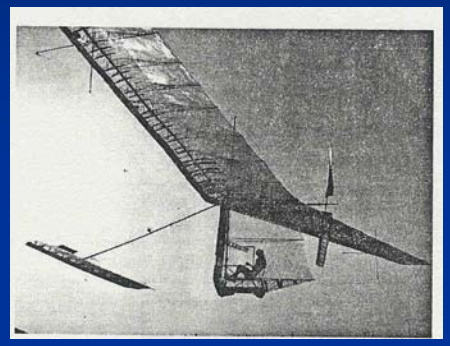
Generating electricity

Resurgence of Human Power

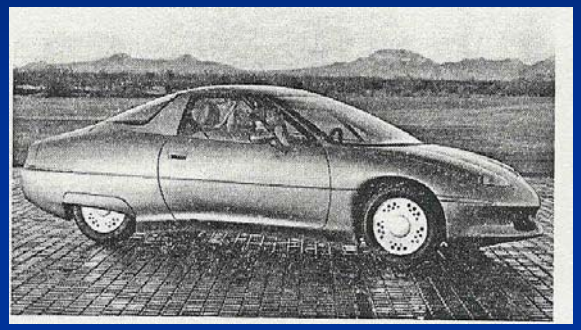
- Applications in developing countries and remote locations
- Portable/Wearable computing – absence or lack of batteries
- Energy shortage and limits to solar/wind power
- Use in emergency situations – e.g., hurricanes and earthquakes
- Energy conservation – e.g., power assist for elderly and disabled
- Environment friendly – batteries are energy-intensive and non-biodegradable
- Advances in actuators, materials, and storage techniques
- Technological challenges – e.g., human-powered flight

Human Powered Flight

(by Paul Macready –
ASME Engineer of the Century)

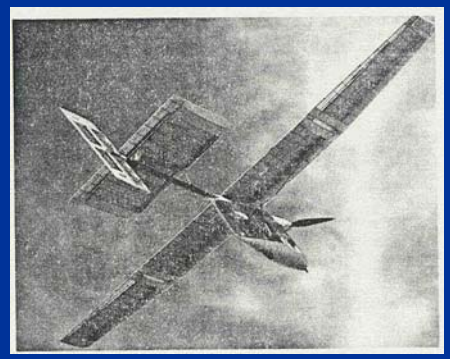


Gossamer Condor



Impact EV

Dragon Eye



Solar Challenger

Wasp MAV

Charger bicycle

HPC-based Products

Clockwork Radio

Shakelight

Typing powered PC (Compaq)

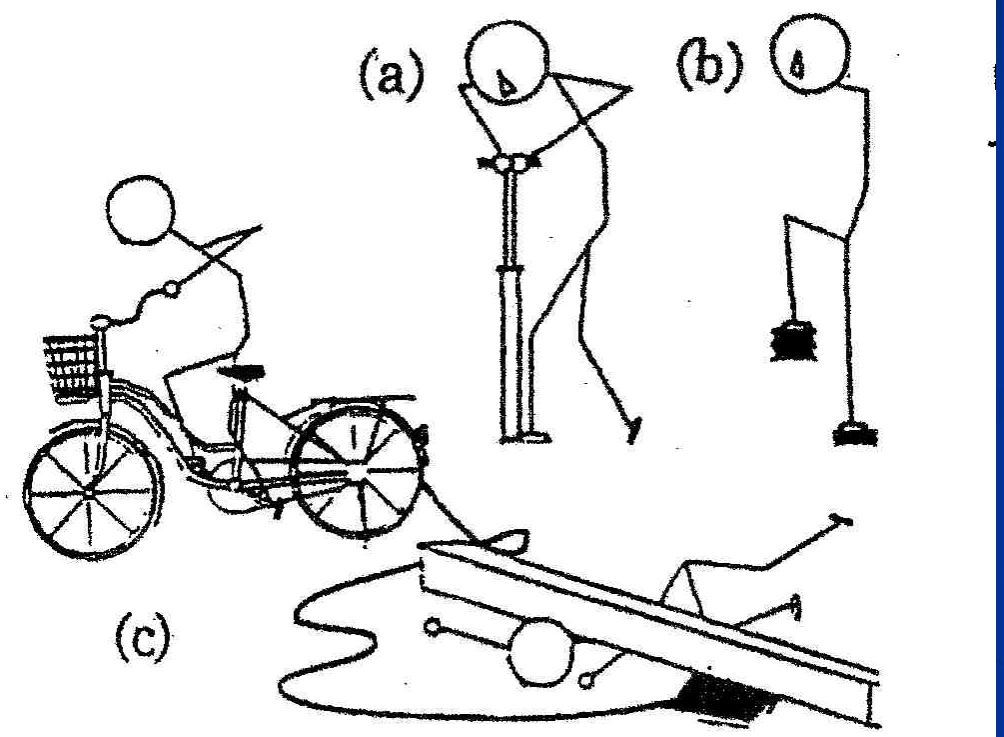
Seiko Kinetic Watch

HPC for Wearable Computing

Power harvesting boots
(SRI Intl.)

Energy scavenging shoes
(MIT Media Lab)

HPC for Earthquake Rescue

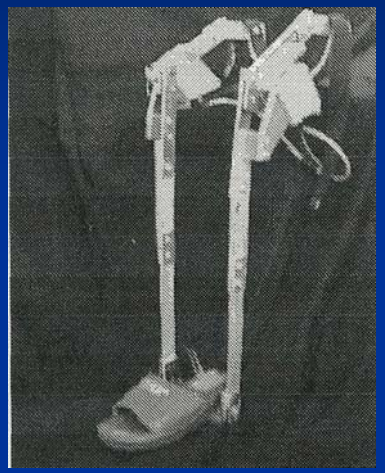


Three kinds of pump by human power for rescue.

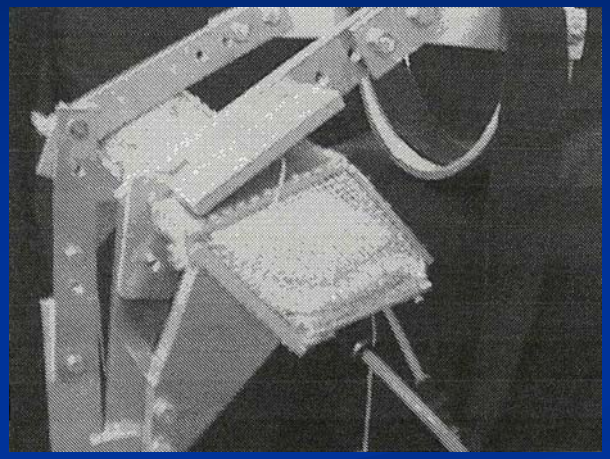
Tokyo Institute of Technology, Japan

Human power assist for robotic orthosis

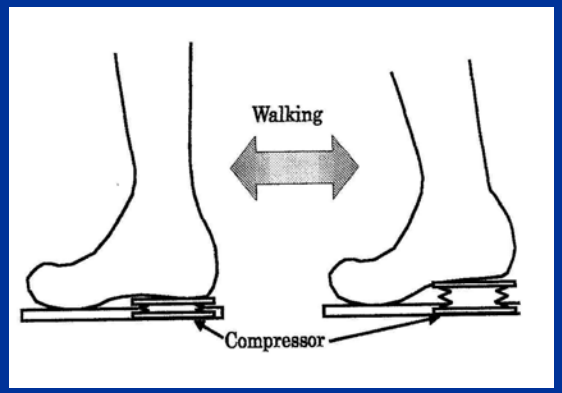
(Ritsumeikan University, Japan)



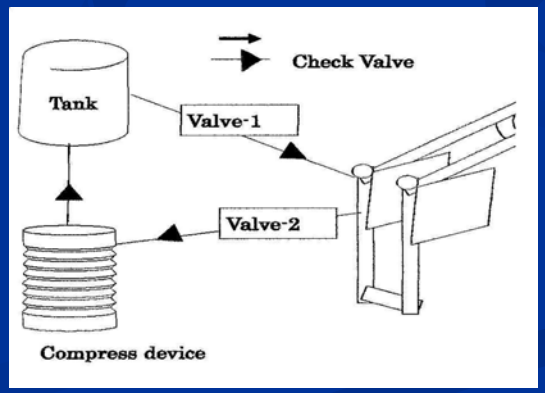
Active orthosis



Hexahedron rubber actuator



Footwear compressor



Compressed air system

The HPC Problem

- ***Potential***:

  - Average human calorific consumption:

  2500 kcal/day

  - 1 cal = 4.184 J

  => 2500 kcal = 10.5 MJ ~ 3kWhr

  Equivalent to 1050 AA alkaline batteries!

  Eating a hamburger gives us the energy of >100 AA batteries

- ***Limitation*** **:**

  Human activities also consume large amounts of energy, so the ***net*** energy available for conversion is limited in practice.

- ***Problem Definition*** **:**

  To harness human muscle power for basic needs, e.g., electricity or mechanical work.

- ***Constraints*** **:**

  Minimize cost, reduce complexity, minimize discomfort to humans, and ensure safety.

Estimates of Maximum Power

Movement	*Maximum human power*
Push (16 N x 40 mm)	0.64 watt
Squeeze (400 N x 30 mm)	12 watts
Rotate crank or handle (30 N x 100 mm radius x 1.5 x 2 pi)	28 watts
Ride bike (at 25 km/h)	>100 watts

Power Consumption of Appliances

Product	*Power consumption*
Portable FM radio	30 mW
Walkman (play mode)	60 mW
Cell phone (talk mode)	2 W
Flashlight	4 W
Laptop PC	10 W
Fluorescent light	10-30 W
Desk fan	25-50 W
TV (20 in)	50 W
Water pump	100 W
Microwave	1000W

A New Approach to HPC

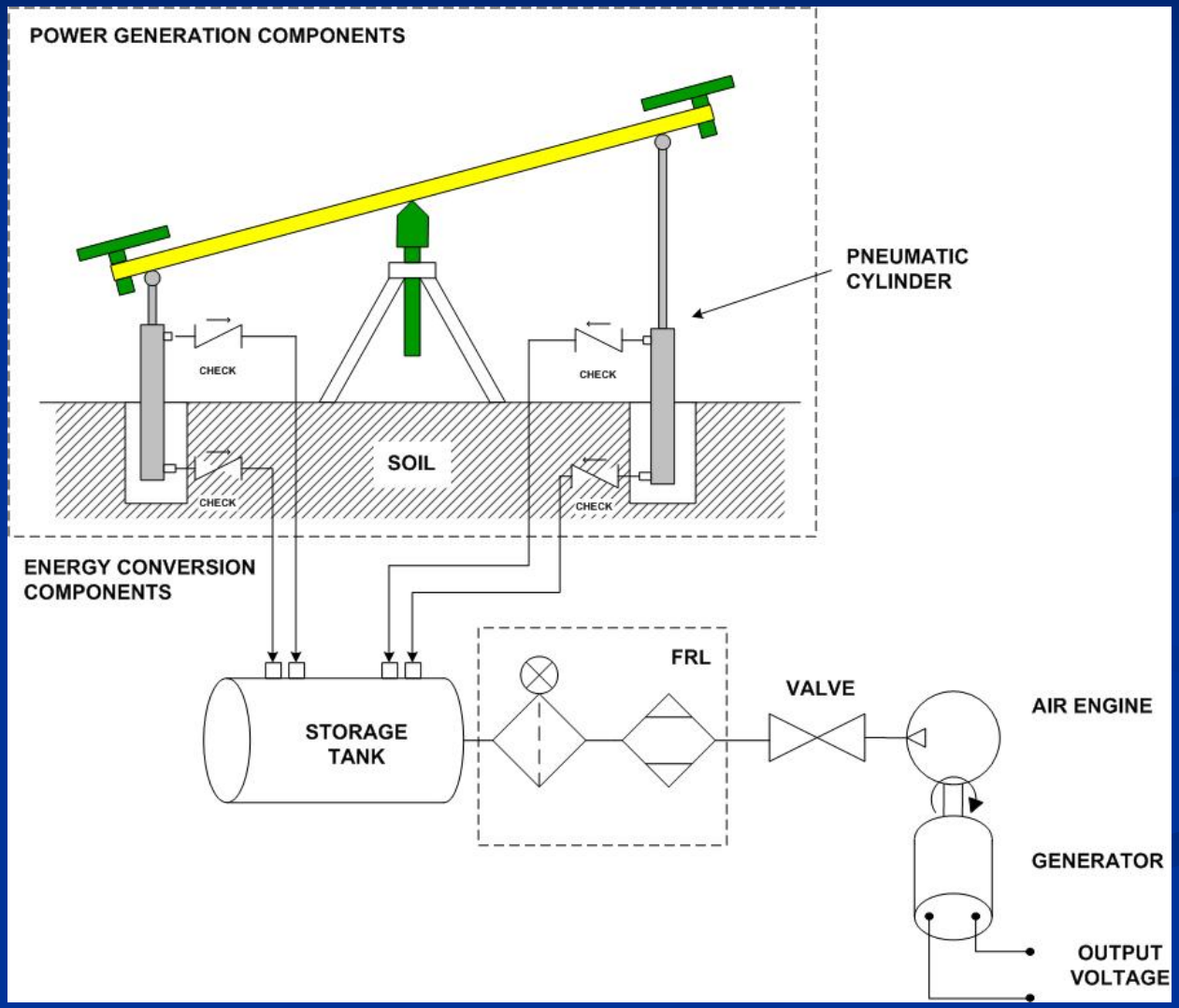
- **Existing methods**:

  Based on deliberate effort by individuals, output small power (~1 watt), sufficient to operate consumer electronics appliances
- **Proposed method**:

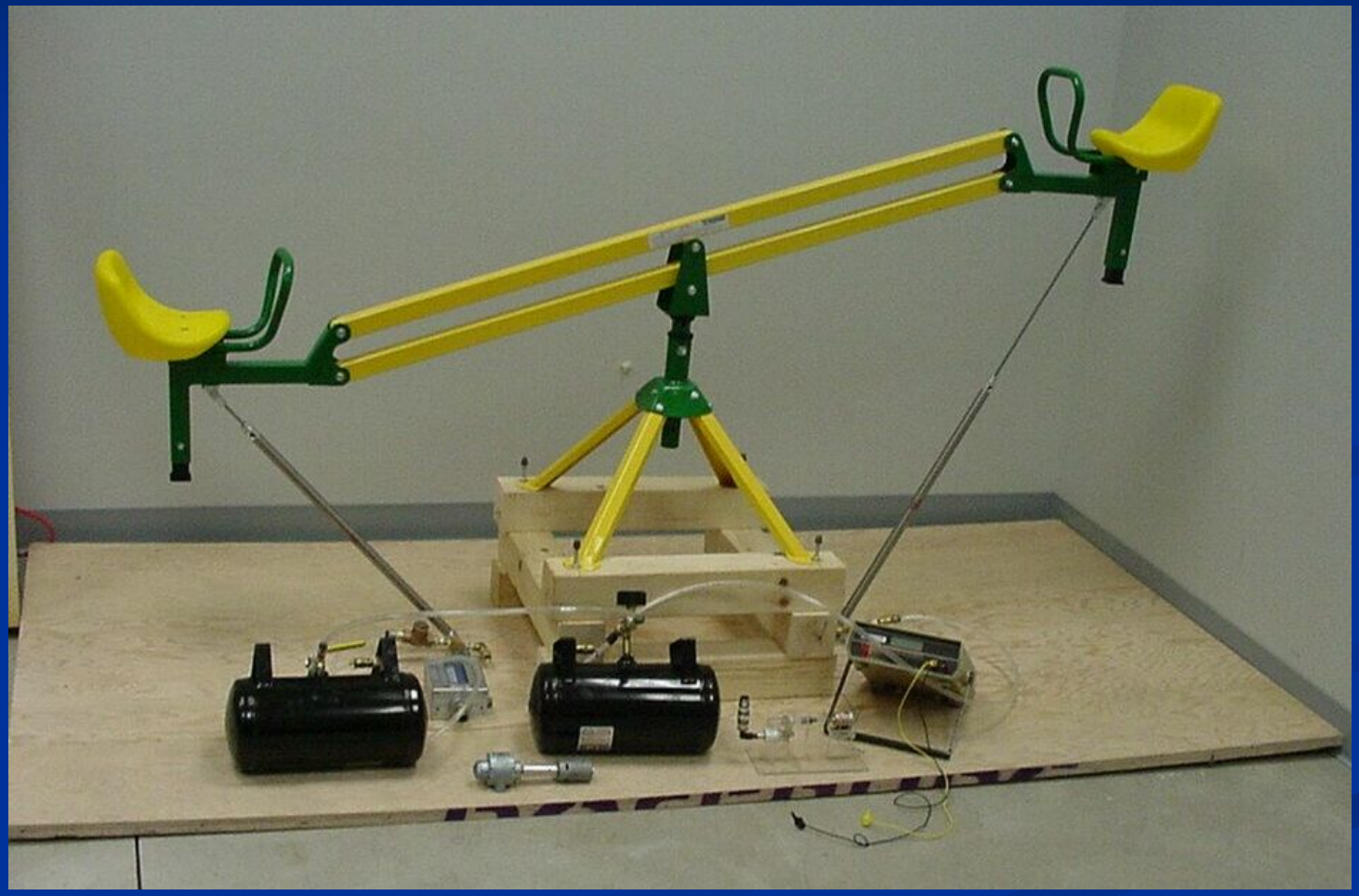
  Based on playful effort by children, outputs more power (5~10 watts), sufficient to operate basic appliances
- **Potential uses**:
  - In schools in LDCs, as an ***auxiliary*** power source
  - In schools and museums, as an educational tool

Playful Energy Conversion

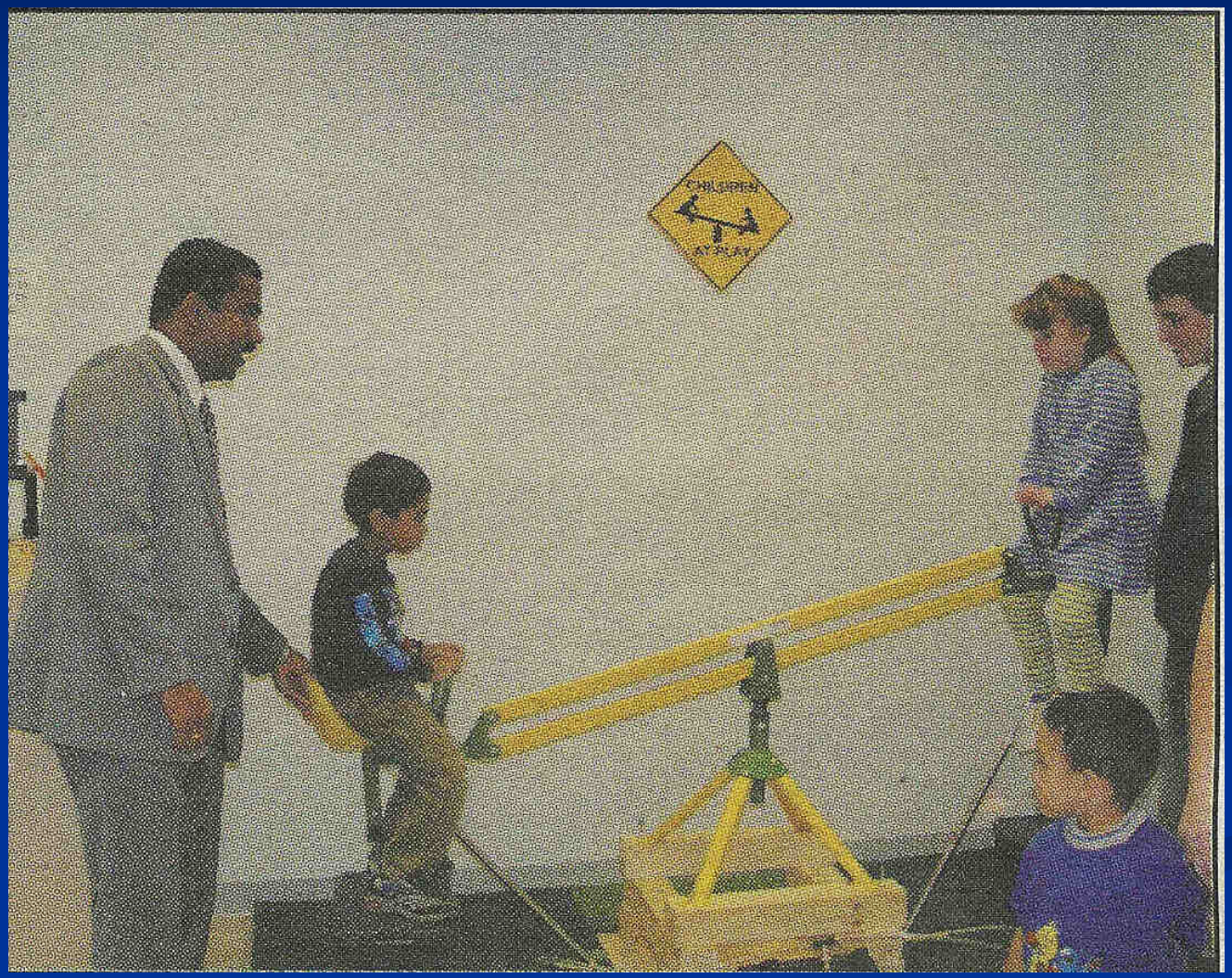
A Teeter-Totter Human Power Converter



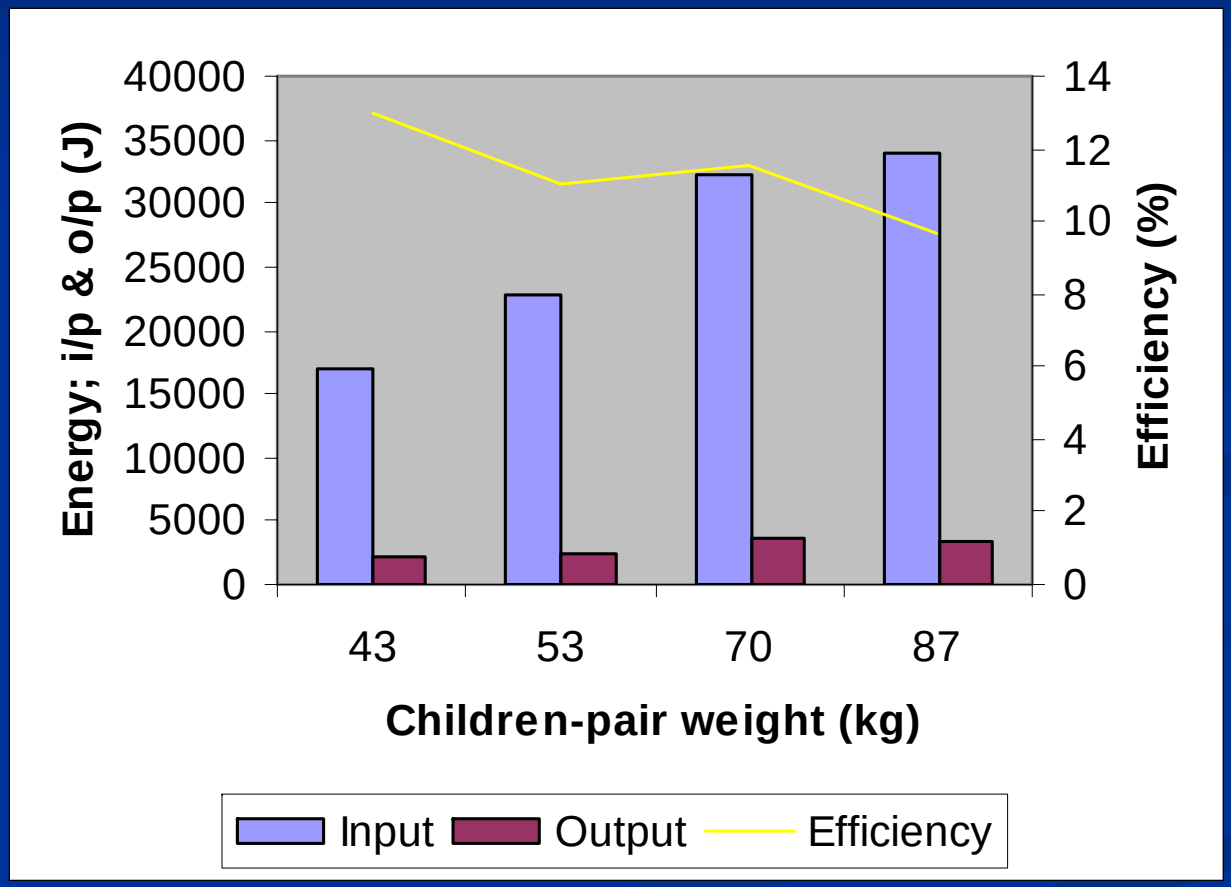
Laboratory Prototype



Kid Power in Action!

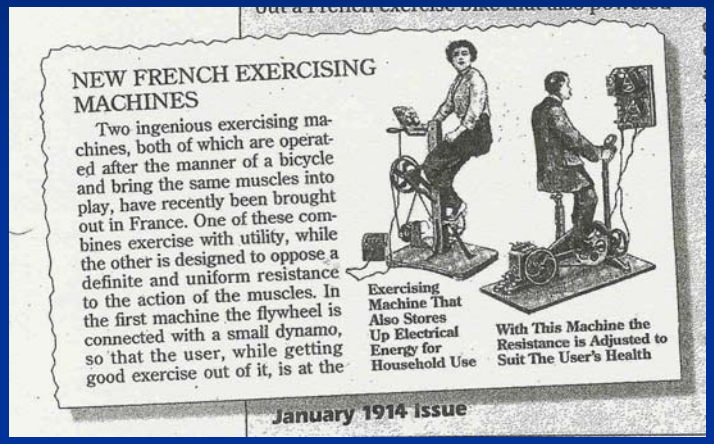


Result of Seesaw Prototype



Practical Considerations

- Industry-grade pneumatic components have low leakage, but high friction. So, low-friction, low-pressure components are required for better efficiency
- Electromagnetic generators can be used with higher efficiency, but cost and safety issues have to be considered
- R&D and field trials are required to develop guidelines for optimum design, safety (child-proof!) and comfort issues, weather-proofing, and so on
- Educational value of raising energy and environmental awareness, esp. among children



NEW FRENCH EXERCISING MACHINES

Two ingenious exercising machines, both of which are operated after the manner of a bicycle and bring the same muscles into play, have recently been brought out in France. One of these combines exercise with utility, while the other is designed to oppose a definite and uniform resistance to the action of the muscles. In the first machine the flywheel is connected with a small dynamo, so that the user, while getting good exercise out of it, is at the

Exercising Machine That Also Stores Up Electrical Energy for Household Use

With This Machine the Resistance is Adjusted to Suit The User's Health

January 1914 Issue

1914, France

2003, Laos

HPC, like fuel cells,
is a *new* technology that is 100 years old!

THANK YOU!