VITRUVIAN ENERGY

FOR THE **FIRST** TIME
HUMAN BEINGS
PRODUCE ENERGY
BY **THEMSELVES**

*Despite being an internationally recognized icon, the drawing of the **Vitruvian Man,** symbolizes the correlations of ideal human proportions with geometry described by the ancient Roman architect Vitruvius in his Book III of his treatise De Architectura, where he exposes that a structure must exhibit the three qualities of firmitas, utilitas, venustas – that is, it must be solid, useful, beautiful.*

***Da Vinci** believed the workings of the human body to be an analogy for the workings of the universe. That is why our team was inspired by the iconic work of **Da Vinci**, since it demonstrates the blend of art.*

CONTENT TABLE

USED ICONS

Wearable technologies


Wrist band
(harvest kinetic energy)


Wrist band
(harvest thermal energy)


Textile product
“smart shirt”


“Smart shoes”


Textile product
“Smart hat”


Textile product


Electrodynamic
Converter


Textile product


Textile product


Harvest energy


Store Energy


Convert Energy


Share Energy


Use Energy


Currency


Charge
the device


Solar Energy


Thermal Energy


Kinetic Energy


Chemical Energy

Vitruvian Energy project, Toronto, Canada, 2014

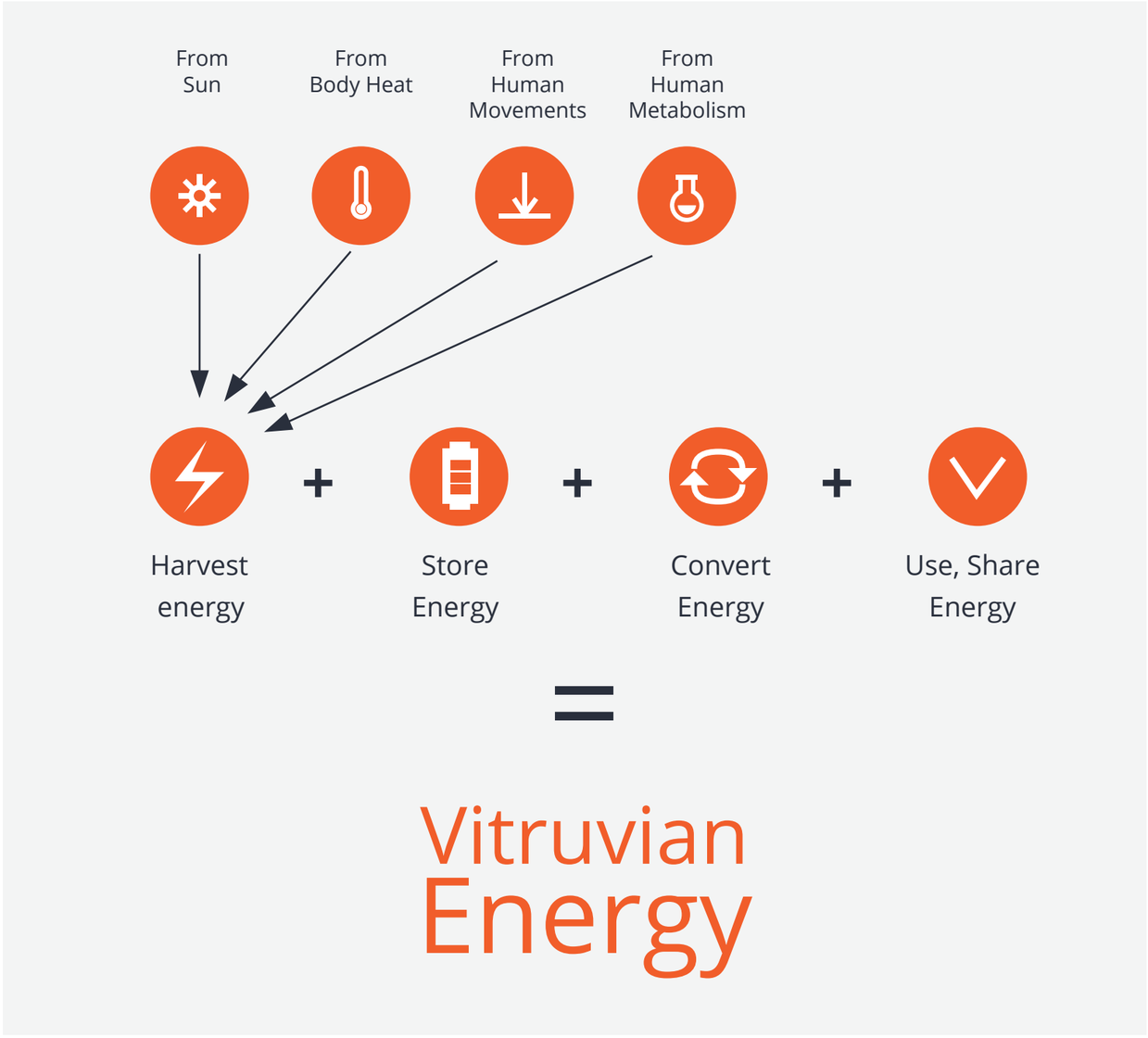
THE VITRUVIAN ENERGY CONCEPT

Vitruvian Energy Team believes that Human Beings can produce more energy by themselves with the help of to their bodies.

Vitruvian Energy transforms human body energy into electric energy by using different kinds of technologies (energy harvesters). The law of energy states that "Energy can neither be created nor destroyed" but it can be converted from one form to another.
According to the law of energy conversion we can convert this energy into electricity and store it.

Vitruvian Energy embraces and redefines all the existing technologies that can harvest energy from the human body. Wearable devices are the key factor to gather Vitruvian energy produced by thermoelectric, electro magnetic and kinetic technologies; which will be embedded in fabrics and textiles. Imagine our clothes, belts, caps, pants, winter jackets, shirts along with smart devices such as wristbands and watches harvesting electricity from heat and movement.

In addition the human body surface is likely to welcome additive energy converters such as photovoltaics cells.



Vitruvian Energy project, Toronto, Canada, 2014

THE VITRUVIAN ENERGY GOAL

Energy can be found all around us.

We obviously need alternative sources of energy to solve the energy crisis we are facing today. We know that energy can be found all around us, and we believe that instead of going big, we should start with something simple, something essential. That is why we designed a solution involving the human body - The Vitruvian Energy.

Researchers from the Department of Electrical Engineering, Columbia University, New York [1p.] have conducted an exhaustive study about kinetic energy. The most common human activities, such as walking, biking, writing, taking a book off a shelf, opening a door or simply just moving produce free energy. Indeed, except for those living the most sedentary lifestyles, we all move around enough to produce kinetic energy. According to the law of energy conversion we can convert this energy into electricity and store it.

FOR THE **FIRST** TIME

HUMAN BEINGS WILL

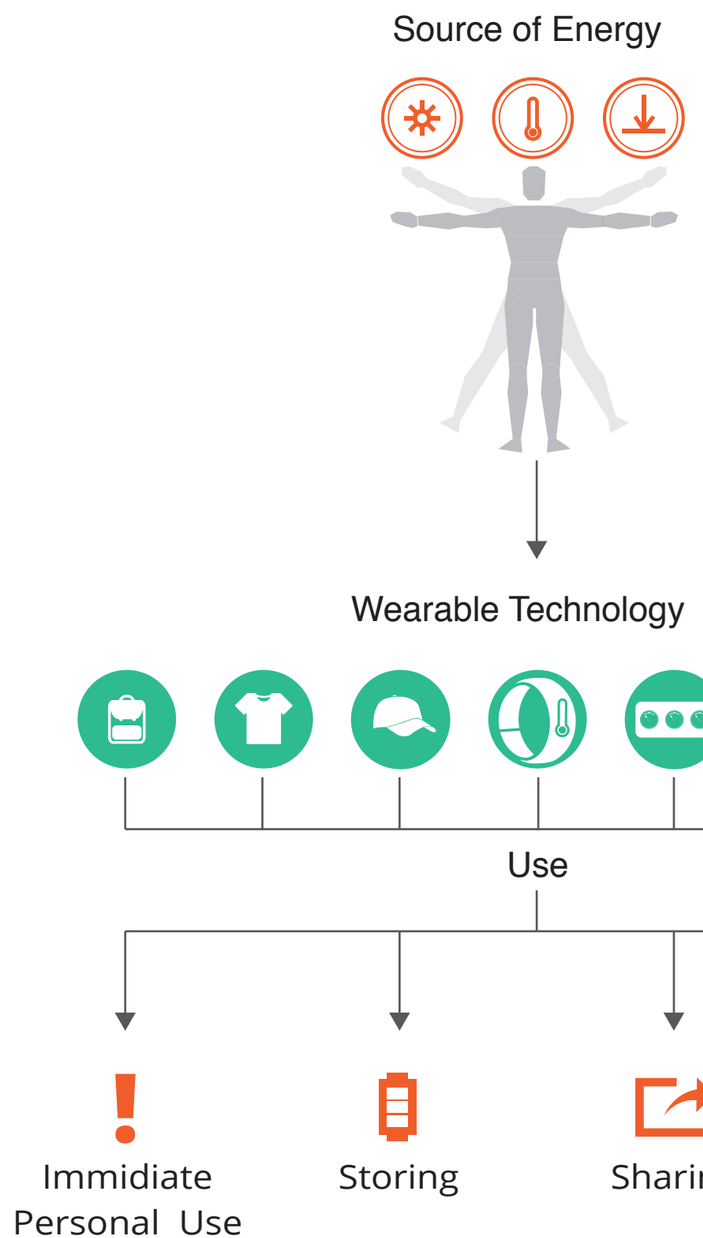
PRODUCE ENERGY

BY **THEMSELVES**

Vitruvian Energy project, Toronto, Canada, 2014

THE VITRUVIAN ENERGY VISION

Vitruvian Energy helps people harvest energy from their daily activities.



Vitruvian Energy helps people harvest energy from their daily activities.

It works with wearable technologies that gather energy (electricity and heat) from the human body. This energy can be used in 4 different ways:

1) IMMEDIATE personnal use (the most energy efficient scenario due to the amount of energy produced).

2) STORING the produced energy in temporary wearable batteries for later personal uses and/or powering the Vitruvian Power Station (VPS).The VPS is the storage device, which can be installed in your home, public places, stores, or other common facilities. With the help of VPS people can power the elec-trinical device or share the energy.

3) SHARING your collected energy with friends, family or the community.

4) CURRENCY : Users can exchange the energy they have produced to feed the Electrical Grid **[13w.]** and be granted for vitruvian credits - Vitruvian Energy Point System (VEPS). VEPS - system that turns produced energy in to the certain amount of points (Vitruvian Points). Later on users can exchage the Vitruvian Points to particular services or products.

By offering a complementary way to produce energy Vitruvian Energy is reshaping our relationship to and usage of energy in our everyday life. We believe that people will be more aware of and more invested in alternative energies when they become individual generators.

Vitruvian Energy project, Toronto, Canada, 2014

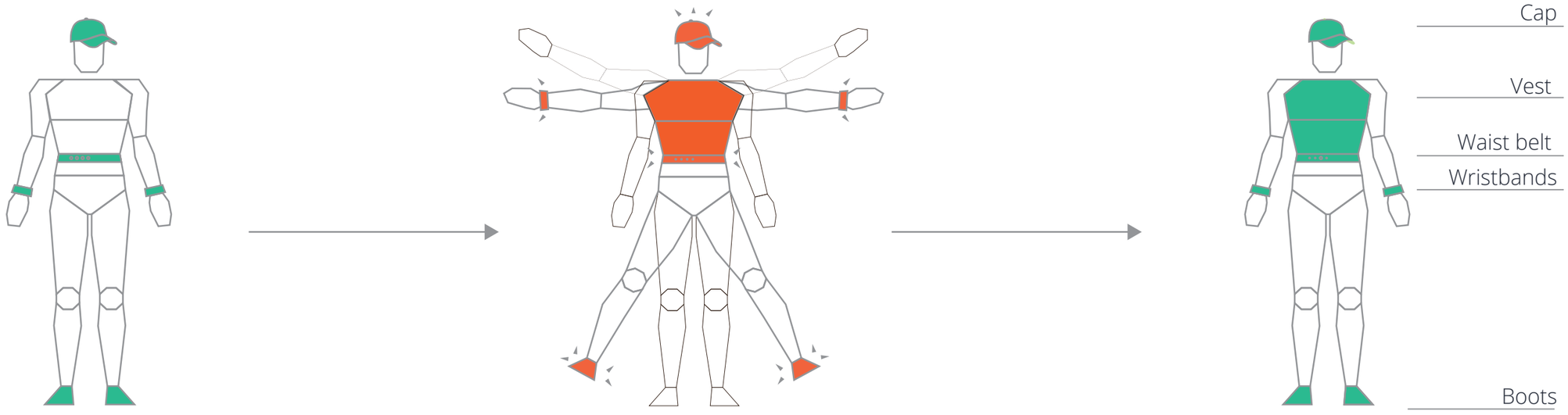
THE VITRUVIAN ENERGY

Idea of embracing different kinds technologies that transforms human body energy into electricity.

Vitruvian Energy helps people to harvest energy from their daily day activities. With this concept people will have the opportunity to contribute and become more responsible of the energy consumption in our society. At the same time energy will have a new meaning of value.

By offering a complementary way to produce energy Vitruvian Energy is reshaping our relationship to and usage of energy in our everyday life.

We believe that people will be more aware of and more invested in alternative energies when they become individual generators.



Human is a source of energy

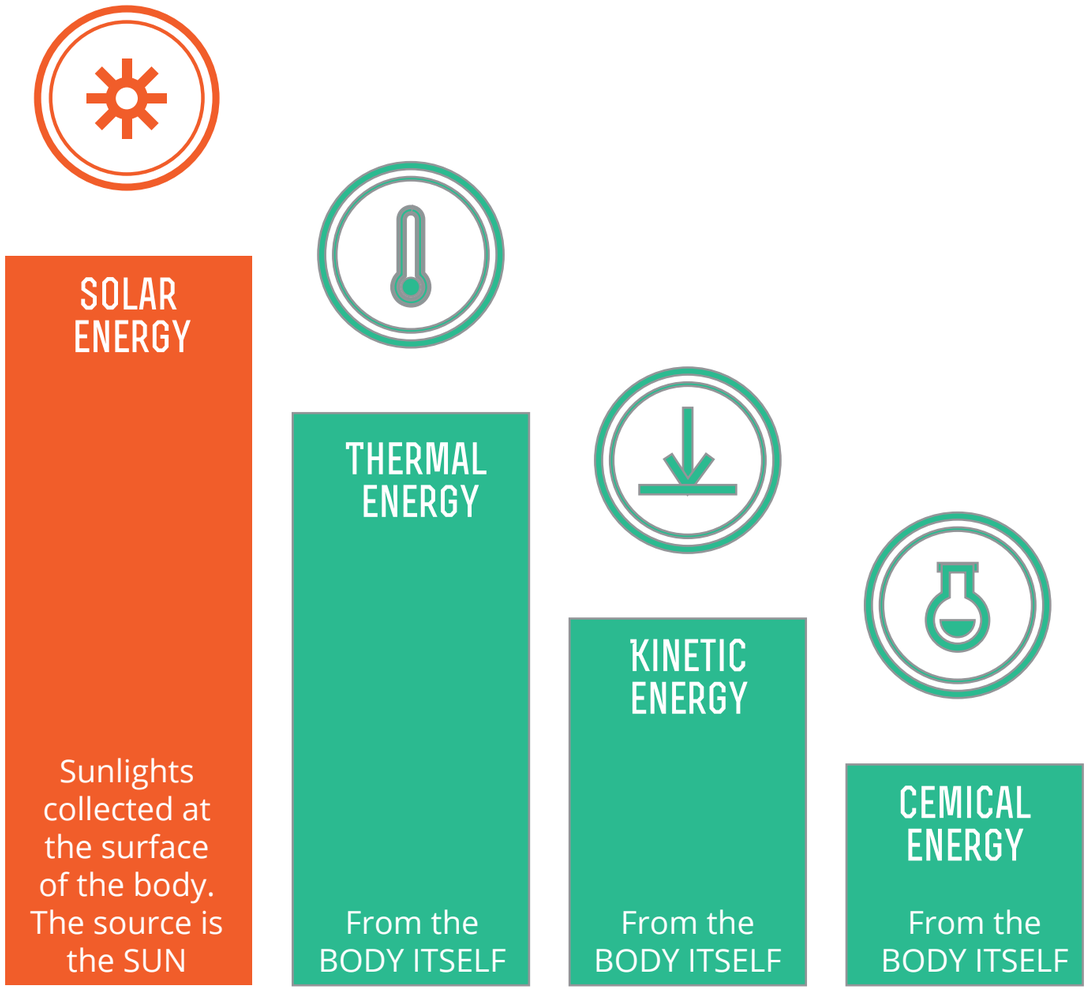
Generate,harvest energy from human movements

Vitruvian wearable products

Vitruvian Energy project, Toronto, Canada, 2014

FORMS OF ENERGY

The human body contains enormous quantities of energy. Our bodies, like all living organisms, are energy conversion machines.



Solar energy

Solar power is produced by collecting sunlight and converting it into electricity. Solar module efficiency is 16,4%. For a received sunlight power of 1000 watts per square meter, a module of one square meter will produce 164 Watts.

Thermal energy

The average human consumes approximately 2000 Calories per day. This means that the average person expends ~8.37 x 106 joules of energy per day. Assuming most of this energy leaves us in the form of heat ~350,000 J of energy per hour. This is roughly equal to energy given off by a 100 Watt light bulb

Kinetic energy

Human movement produces kinetic energy, which can be converted into power. In the past, devices that turned human kinetic energy into electricity, such as hand-cranked radios, computers and flashlights, involved a person's full participation. But a growing field is tapping into our energy without our even noticing it.

Chemical energy

Conservation of energy implies that the chemical energy stored in food is converted into thermal energy.

Vitruvian Energy concept

Is the mix of two sources : SUN + BODY ITSELF is generating energy at the surface of the human body.

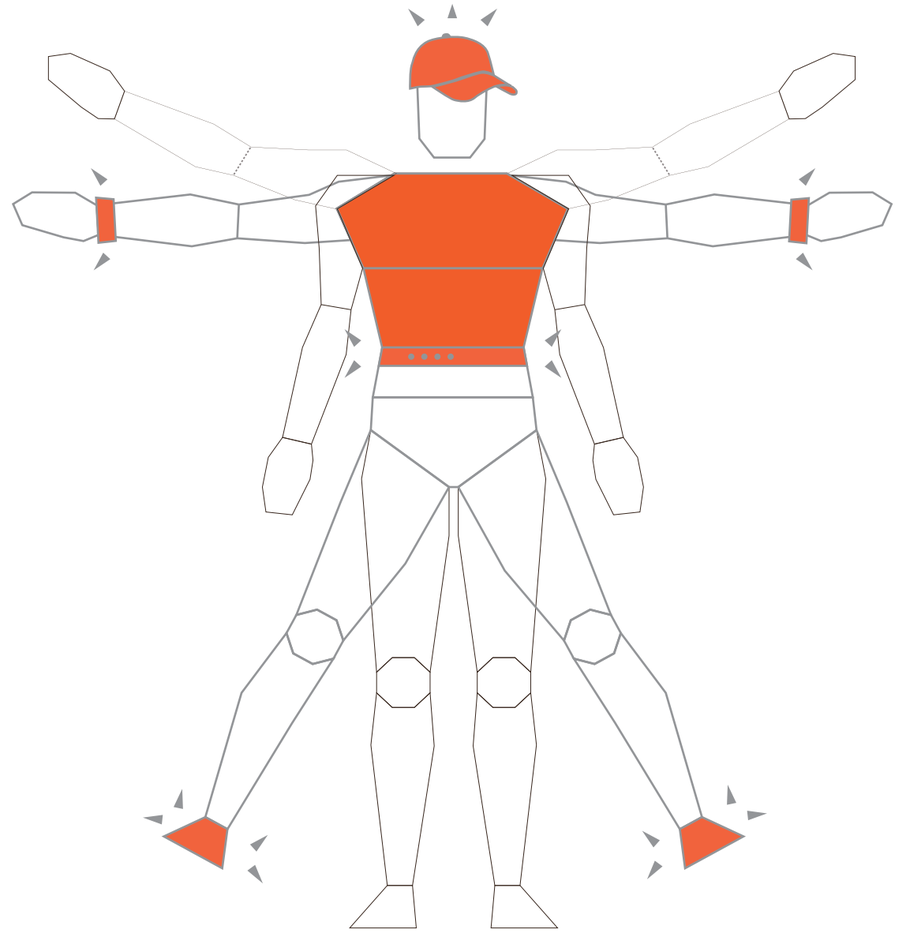
Vitruvian Energy project, Toronto, Canada, 2014

THERMAL ENERGY. THEORETICAL BASES OF BODY-POWERED ELECTRONICS

A human body constantly generates heat as a useful side effect of metabolism.

Vladimir Leonov, senior scientist at imec (Interuniversity Microelectronics Centre) said **[4p.]** "A human body constantly generates heat as a useful side effect of metabolism. However, only a part of this heat is dissipated into the ambient as a heat flow and infrared radiation, the rest of it is rejected in a form of water vapor. Furthermore, only a small fraction of the heat flow can be used in a wearer's friendly and unobtrusive energy scavenger. (For example, nobody would accept a large device on his/her face. Therefore, the heat flow from it practically cannot be used. At last, due to the laws of thermodynamics, the heat flow cannot be effectively converted it into electricity. However, a human being generates more than 100 W of heat; therefore, a quite useful electrical power still can be obtained using a person as a heat generator.

The tool for converting heat flow into electricity is a thermoelectric generator TEG, the heart of which is a thermopile. Typically, only a few watts of heat flow can be harvested unobtrusively on a person and thermoelectrically converted into several milliwatts in a form of electricity. If we recall that watches consume 1000 times less, it is fairly good power."



Vitruvian Energy project, Toronto, Canada, 2014

REFERENCES:

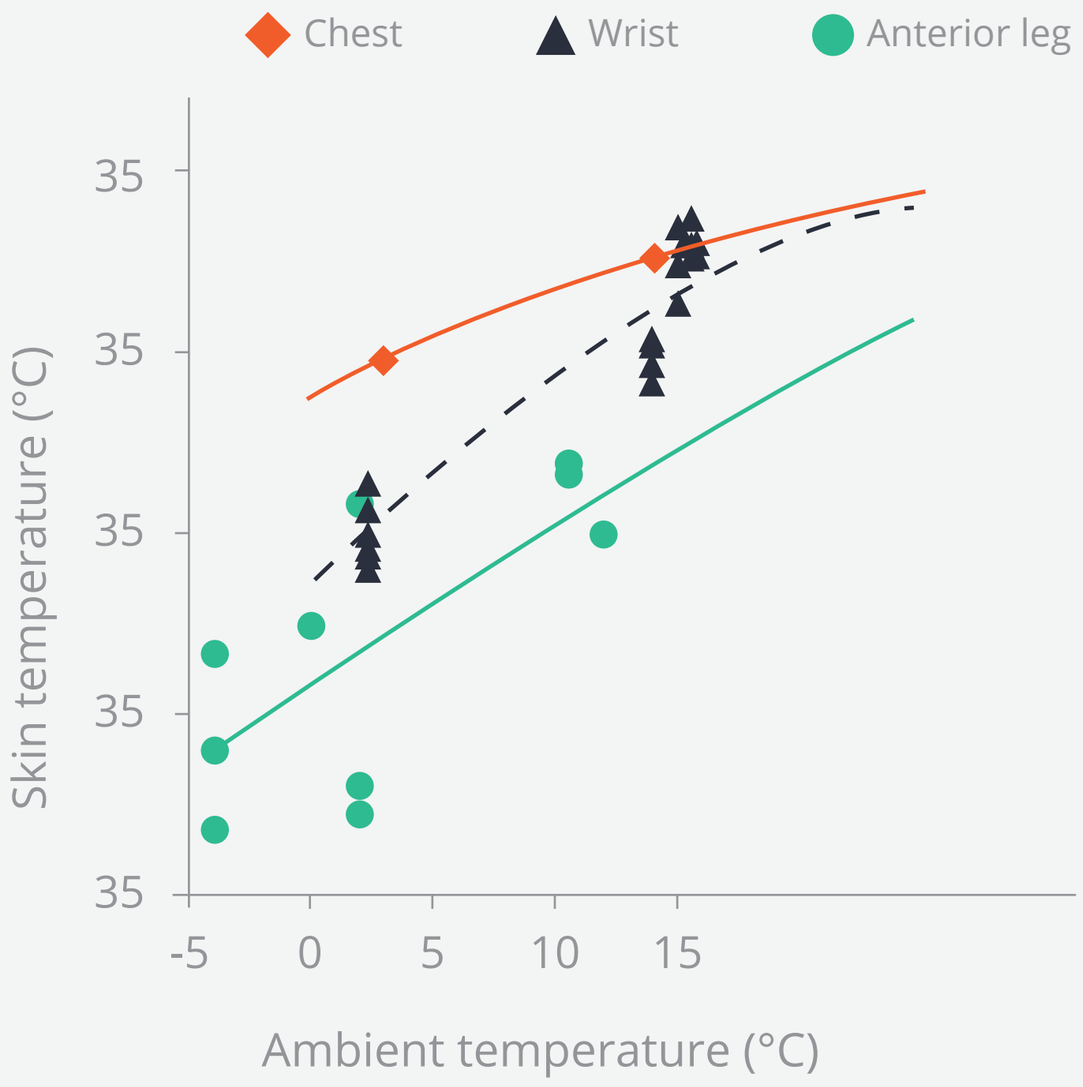
[4 p.] V. Leonov and R. J. M. Vullers, "Wearable electronics self-powered by using human body heat: The state of the art and the perspective," J. Renew. Sustainable Energy, vol. 1, no. 6, p. 062701, Nov. 2009.

HUMAN BODY HEAT

Thermoelectric Energy Harvesting

The study of **thermoelectric energy harvester (TEH)** of human body heat shows that "although power generation is affected by many factors such as ambient temperature, wind speed, clothing thermal insulation, and a person's activity, it does not directly depend on metabolic rate as shown in the experiment. The relevant thermal properties of humans measured at different ambient conditions are reported. Several thermopiles are either attached with a strap directly to the skin or integrated into garments in different locations on human body, and power generation is extensively studied at different ambient conditions. Textile covering thermopiles is found not to essentially decrease power generation. Therefore, a hidden energy harvester is integrated into an office-style shirt and tested on people in real life. It generated power in 5–0.5 mW range at ambient temperatures of 15 °C–27°C, respectively. The thermoelectric shirt with such an energy harvester produces more energy during nine months of use (if worn 10 h/day) than the energy stored in alkaline batteries of the same thickness and weight."

In Vladimir Leonov's research ***Thermoelectric Energy Harvesting of Human Body Heat for Wearable Sensors*** illustrates dependence of skin temperature of a person on ambient temperature in three different locations (see the graph on the right). At ambient temperature of 25 °C, the skin temperature closely approaches body core temperature of 36.8 °C (in this experiment). Typically, the chest, head and warmest zone of the wrist (close to the radial artery) approach it. Therefore, these body parts are good for energy harvesting. The chest is however more sensitive to local cooling in cold weather, and for comfort of the person, heat flow must be substantially limited. Therefore, in the experiment at low ambient temperatures, maximum power was obtained in a TEH worn on the wrist despite lower skin temperature.



Dependence of skin temperature under a TEH on ambient temperature in different locations.

REFERENCES:
[2 p.] V. Leonov and R. J. M. Vullers, "Thermoelectric Energy Harvesting Of Human Body Heat" Ieee Sensors Journal, Vol. 13, No. 6, June 2013.

KINETIC ENERGY HARVESTING

The harvesting of "free" energy from common human activities, such as walking, writing with a pencil, taking a book off a shelf, or opening a door.

Researchers at Columbia University **[1p.]** have conducted the first exhaustive study into kinetic energy harvesting — the harvesting of "free" energy from common human activities, such as walking, writing with a pencil, taking a book off a shelf, or opening a door. Surprisingly, except for those living the most sedentary lifestyles, we all move around enough that a kinetic energy harvester.

As you can imagine, some human movements produce more harvestable energy than others, with periodic motions — i.e. repetitive left/right, up/down, back/forth motions — in particular being the key. This is illustrated by the researchers' finding that writing with a pencil or opening a drawer produces more harvestable energy (10-30 microwatts) than a plane flight at its most turbulant intervals (5 microwatts). For comparison, walking produces somewhere in the region of 100-200 microwatts. The researchers found that intentionally shaking an object, as demonstrated by shake flashlights, creates more

In the table#2, the microwatt (μW) figures are from the point of view of the object; as in, the object itself is equipped with an inertial energy harvester. As you can see, except for writing with a pencil (periodic movements), opening a drawer (a strong pull), or shaking an object, most of our interactions with the environment do not produce a lot of energy. According to the researchers this is exacerbated by objects, such as doors and drawers, being dampened for human comfort. If the inertial harvester could be placed in the damper, at the time of production, much more energy could be produced.

The table#1 below shows the amount of energy that humans produce as they go about their everyday lives, relaxing, walking, running, and cycling. Again, you see that the vigorous periodic motion of walking and running produces a lot of energy. The cycling figure, which is very low (10 μW), would be much higher if the harvester was placed lower on the leg.

TABLE #1

Activity	Sensing Unit Placement	μW
Relaxing	Trouser pocket	4.8
	Waist belt	4.8
	Trouser pocket	5.9
Walking	Shirt pocket	186.0
	Waist belt	200.3
	Trouser pocket	274.5
Running	Shirt pocket	910.0
	Waist belt	752.8
	Trouser pocket	727.4
Cycling	Shirt pocket	72.3
	Waist belt	59.2
	Trouser pocket	59.5

TABLE #2

Scenarios	μW
Taking book off a shelf	<10
Putting on reading glasses	<10
Reading a book	<10
Writing with a pencil	10-15
Opening a drawer	10-30
Spinning in aswivel chair	<10
Opening a buiding door	<1
Shaking an object	>3.000

SOLAR ENERGY

Solar power is the conversion of sunlight into electricity, either directly using photovoltaics (PV), or indirectly using concentrated solar power (CSP).

A **Solar Cell**, or **Photovoltaic Cell (PV)**, is a device that converts light into electric current using the photoelectric effect. The first solar cell was constructed by *Charles Fritts* in the 1880s.

Solar cell efficiency is the ratio of the electrical output of a solar cell to the incident energy in the form of sunlight. The energy conversion efficiency (η) of a solar cell is the percentage of the solar energy to which the cell is exposed that is converted into electrical energy. This is calculated by dividing a cell's power output (in watts) at its maximum power point (Pm) by the input light (E, in W/m2) and the surface area of the solar cell (Ac in m2).

$$\eta = \frac{P_m}{E \times A_c}$$

By convention, solar cell efficiencies are measured under standard test conditions (STC) unless stated otherwise. STC specifies a temperature of 25 °C and an irradiance of 1000 W/m2 with an air mass 1.5 (AM1.5) spectrum. These conditions correspond to a clear day with sunlight incident upon a sun-facing 37°-tilted surface with the sun at an angle of 41.81° above the horizon. Under these test conditions a **solar cell of 16-22%** efficiency with a **100 cm2** ((10 cm)2) surface area would produce **2.0 W**.

In terms of implementation of solar cells into clothing the efficiency will be considered less, because the biggest and convenient parts on human's body are back and chest and the angle is much less than 41.8°.

Tommy Hilfiger Solar Clothing

Pvilion has partnered with Tommy Hilfiger to design and produce a Solar Powered Jacket exclusively for the 2014 holiday season. The product features removable solar panels that provide energy to power electronic devices.

The detachable Pvilion solar panels snap easily on and off the back of the jackets, while a cable running discreetly through the garment's lining connects the panels to a removable battery pack in the jacket's front pocket. A special snap-flap closure provides access to the battery pack, and its double USB port allows the user to connect it with up to two mobile phones or tablets via USB cord.

The water resistant, lightweight removable solar panel unit is made with flexible amorphous silicon technology developed by Pvilion. When exposed to full sunlight, the high output solar cells can fully charge the battery pack which, in turn, can fully charge a standard **1500mAh** mobile device up to four times.

Vitruvian Energy project, Toronto, Canada, 2014

ENERGY CONSUMPTION

Average electricity consumption by electrical appliance and equipment. These figures are approximate representations. The actual power consumption of your appliances may vary substantially from these figures.

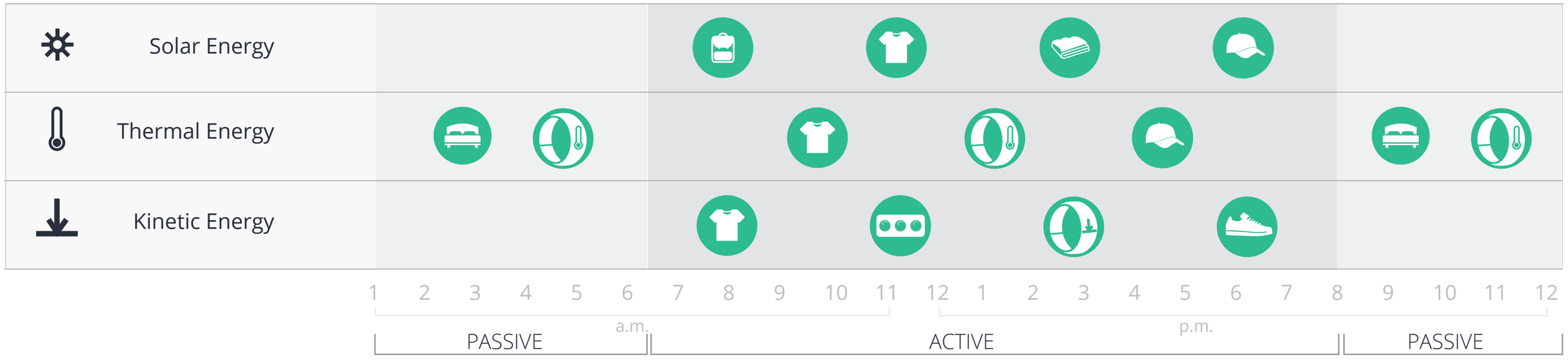
	appliance	watts/hour	Ave hrs/day inuse
	Smartphone	2	24
	Tablet	6	24
	Laptop	50	1.5
	TV set	300	2
	Washing Machine	400-1300	0,75/load
	Refrigerator	100-400	5
	Microwave oven	1 230	0 0,8
	Coffee machine	670	0.5
	Toaster	1 010	0,3

References : The daily energy values listed here are for the most efficient units in their class and the infromation was obtained from Consumer Guide to Home, Energy Savings by Alex Wilson and John Morrill.

HARVESTING ENERGY FROM HUMAN BODY

Smart textile, wearable devices and products with solar cells that can harvest, store, convert energy from human body.

Head+Chest+Back+Shoulders+Waist	**Textile products** with Electro Textile System (nanogenerator + textopolymers / conductive yarns)
Feet+Knee	**Electrodynamic Converter** for generating electricity during human walking
Head+Chest+Back+Waist	**Textile products** Solar Cells based on Photovoltaic Technologies
Feet	**Smart Shoes** for storing the mechanical-vibrational energy from walking
Wrist	**Wearable Accessories** for harvesting and storing energy including Thermoelectric Generator



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TRANSFERRING ENERGY

Different ways of transfering energy.

Electromagnetic induction

eCoupled's System

The first **Wireless Powering System** to market is an inductive device, which looks like a mouse pad and can send power through the air, over a distance of up to a **few inches**. A powered coil inside that pad creates a magnetic field induces current to flow through a small secondary coil that's built into any portable device, such as a flashlight or a phone. The electrical current that then flows in that secondary coil charges the device's onboard rechargeable battery.

WiTricity

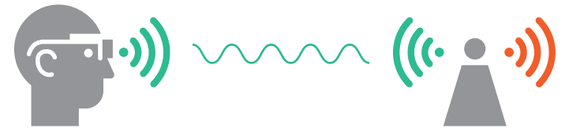
WiTricity uses two coils — one powered, one not. They depend on so-called magnetic resonance. Magnetic resonance can launch an energetic response in **far away**. In this case, the response is the flow of electricity out of the receiving coil and into the device to which it's connected.

Cable Transferring

The **Cables** are the primary means of transferring energy from one device to another. There are several different types of cable, each type made from different metals, and each type can tolerate a different maximum EUP, usually referred to as Voltage. If an applied Voltage exceeds a cable's maximum, the cable will instantly melt. This is NOT to be confused with (EU/t), usually referred to as Current; all cables can handle an infinite amount of current.

All cables suffer from energy losses over distance. Long cables will lose energy in the process of transferring it. There are several ways to reduce losses - Transformers , insulation, and daisy-chaining storage devices.

Radio Frequency



Radio Frequency (RF) work across distances of up to **85 feet**. In these systems, electricity is transformed into radio waves, which are transmitted across a room, then received by so-called power harvesters and translated back into low-voltage direct current.

This technology is already being used by the Department of Defense. This year, it will be available to consumers in the form of a few small appliances and wireless sensors.

ENERGY VISUALIZATION

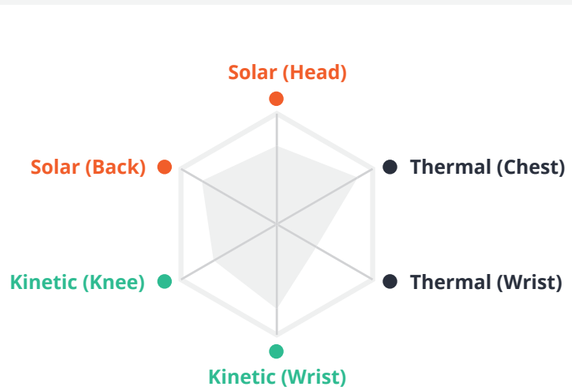
Vitruvian Energy Visualization Application

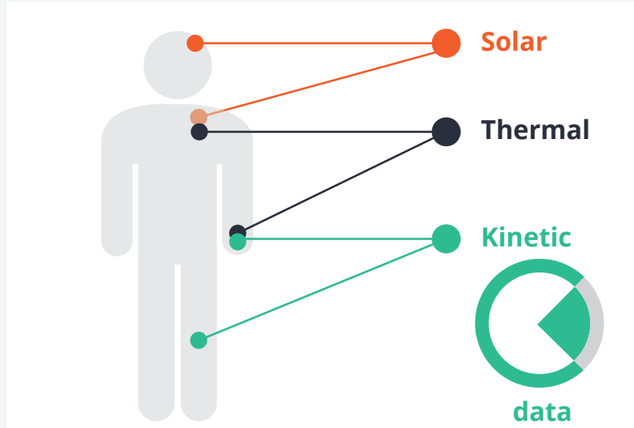
Everybody wants to know the amount of energy their body is producing. By detecting and measuring individual energy production the senor installed in the Viturvian wearable products reads the blink and sends the data to a server on Internet, then the system analyze the data and send the result in real-time to the Vitruvian Energy Visualization Application. The real-time information shows the users in a clear way when the amount of harvested energy is high. In this case the users know by doing what kind of activites they can produce more energy.

With the help of Energy Visualization Application users have the option to transfer the genrated energy with the smart Electric Grid and share their energy.

As a part of the concept Vitruvian Energy Visualization Application would be firstly accessible on the user's smartphone (and other electronic devices) and later on directly on textile screen on the shirt itself.

Visualization Application Interface Concept





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ENERGY VISUALIZATION

Electric Grid

Utilities are beginning to modernize the electric grid through the gradual development of a "smart grid" that uses information and communication technologies to manage electricity more efficiently. Due to the complexity, number and scale of the systems and devices involved in a smarter grid, interoperability between the various systems is key to successful implementation. Research can address interoperability issues while furthering innovation in grid modernization efforts.

Field Force Mobile App an application for phones and tablets that allows utility crews—known as field forces—to visualize electricity system components' data on a real time basis. When holding their mobile device up to a component, a utility worker sees the component's data through "augmented reality," and can query options for the state of switches, outages and device tags.

IntelliGrid® research program focuses on the best ways to create a smart grid and incorporate it into the operations of individual utilities.

Field Force Mobile App

IntelliGrid®

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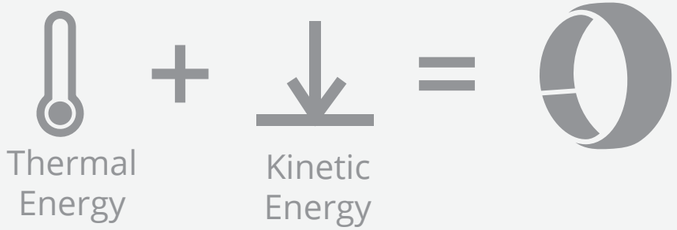
PROTOTYPE

Vitruvian Smart Bands



Tools / Technologies

– Thermoelectric Generator

– Biomechanical Energy Harvesting

– Thermoreactive Minerals used in fiber to convert body heat Into Infrared Energy

Thermoelectric Generator allows you to recharge electronic devices from your own body heat!

A human body constantly generates heat as a useful side effect of metabolism. Typically, the chest, head and warmest zone of the wrist approach it first on the person in the office. Therefore, these body parts are good for energy harvesting. The chest is however more sensitive to local cooling in cold weather. Therefore, maximum power was obtained on the wrist despite lower skin temperature.

Biomechanical Energy Harvester using the force created at the end of each step, generates electricity as you walk.

At normal walking speed the device can generate about 5W of constant electricity — meaning a single minute of walking could power a cellphone for 10 minutes or an MP3 player for 40.

Thermoreactive Minerals

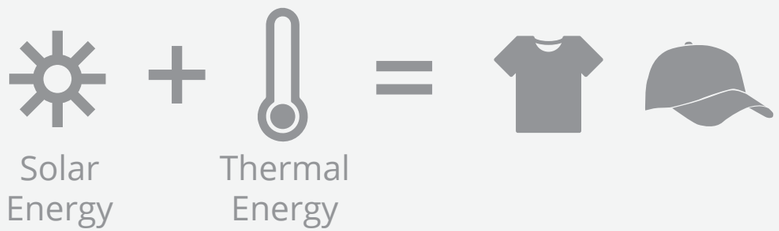
Ring Powered using *Peltier Unit*

Carbon Smart Watch

Vitruvian Energy project, Toronto, Canada, 2014

PROTOTYPE

Vitruvian Smart Hat and Shirt



Tools/Technologies:

- Thermoelectric generator TEG
- Electroencephalography EEG - battery-free body-powered devices
- Solar photovoltaic cells
- Hybrid materials
- Advanced lightweight batteries

The human body produces heat equivalent to the heat dissipated by a few laptops. Thermoelectric generator TEG converts heat flow into electricity.

Several tens of watts out of the produced heat are dissipated as a heat flows from the skin, depending on ambient conditions

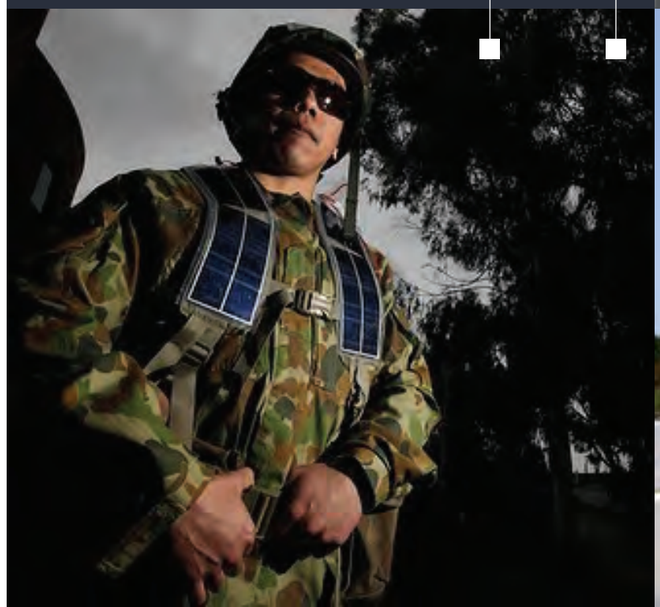
Hybrid material that combines flexible photovoltaic materials, which harness solar energy, with flexible piezoelectric fibers and generate electricity through movement.

20cmx20cm square of this hybrid material is expected to generate about one watt of energy

battery-free headband-harvester

solar powered dress

power-harvesting uniforms



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USER SCENARIO

Persona#1

- use, sharing, transfering energy
- generating energy

Alejandro Gonzalez
male
40 years
Canada
Human Resources Manager

Backstory:

He likes bike, volunteering in social in-stitutions. He likes classic music. He is vegetarian.

Motivation:

Equality between humans (human rights, freedom of speech, happiness of him and the others, buying a bigger house).

Frustrations:

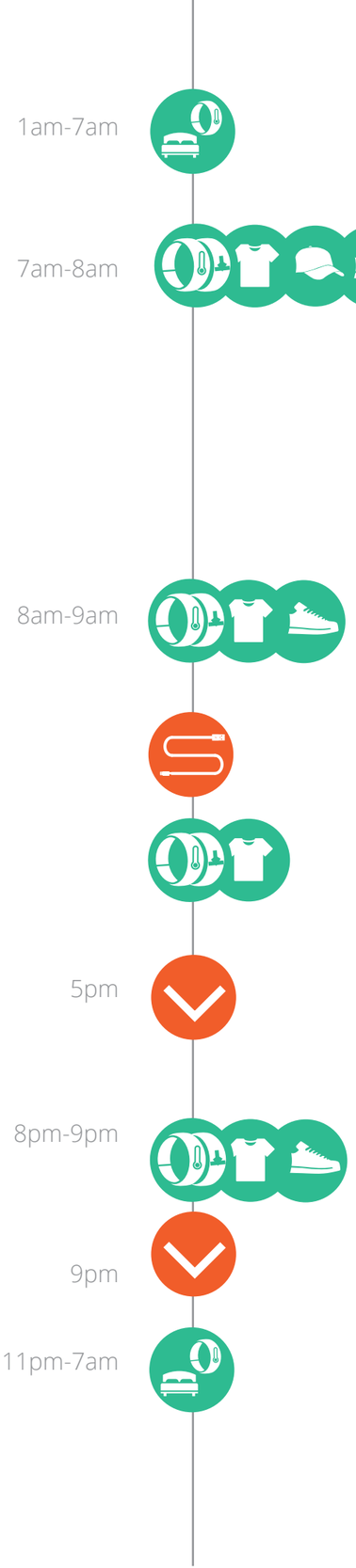
Finding alternative kinds of energy.
Save the environment, protection.

Ideal Experience:

He uses Vitruvian energy to share with others and for personal purposes.

Quote:

The best invention for generating and sharing energy.



Alejandro is slepping. He is generating termal energy by usingtextile products with electro textile system (nanogenerator + textopolymers/ conductive yarns) .

Alejandro wakes up. He likes jogging and and he does it every morning. He is generating kinetic energy by wearing Smart Shoes for storing the mechanical-vibrational energy from walking.

Alejandro also wears a smart heat (Textile products Solar Cells based on Photovoltaic) to capture solar power. He wears smart T-shirt and Wearable Accessories for harvesting and storing energy.

Alejandro biking to his office. He wears Smart Shoes, smart T-shirt and Wearable Accessories for harvesting and storing energy.

At the office Alejandro charging his devices by using generated energy.

After work Alejandro visit annual Vitruvian Parade. He is doing activities during the Vitruvian Parade and generating energy.

He shares his energy with the Public Power Station (Vitruvian Power Station).

Alejandro biking home. He wears Smart Shoes, smart T-shirt and Wearable Accessories for harvesting and storing energy.

He trasfer energy to the electrical grid and that allows his to reduce his electricity bill.

Alejandro goes to bed, he is generating termal energy by usingtextile products with electro textile system (nanogenerator + textopolymers/conductive yarns) .

Vitruvian Energy project, Toronto, Canada, 2014

USER SCENARIO

Persona #2

- use, sharing, transfering energy
- generating energy

Patricia Kimbel
25 years
English
Master Degree Student at Business

Backstory:
She is egocentric, likes to party and being the best of the class. Likes to do tennis and tanning in Ibiza.

Motivation:
Having luxury life, always searching for the best offers, very self-confident the others, buying the bigger house.

Frustrations:
Doesn't accept any compromises.Hates not making the right decision. Hates loosing her target.

Ideal Experience:
She uses Vitruvian energy to save money and get currency benefits.

Quote:
Overachieving people knows how to administrate their energy.

12 a.m. – 9 a.m.	While Patricia is sleeping she is generating Thermal Energy by using Textile Products with Electro Textile System (nano-generator + textopolymers / conductive yarns)
9 a.m. – 10 a.m.	After waking up Patricia is spending some time in bed, browsing the internet and charging her laptop.
11 a.m. – 11.30 a.m.	After a while she is taking her car and charging her phone while she is driving.
12 p.m. – 2 p.m.	Patricia is heading to the Tennis Class. She is wearing Smart T-shirt, Wrist Bands, Knee Bands and Hat. Smart Textile and Wearable Accessories allow her to harvest, store and con-vert Solar, Thermal and Kinetic Energy.
2 p.m. – 3p.m.	After finish Tennis Class Patricia is going to the Gas Station where she is exchanging her generated energy in the kiosk for her personal assumptions.
3 p.m. – 5 p.m.	Then she is meeting her girlfriend at restaurant and after an hour her friend's cell phone battery dies. Patricia is sharing some of her energy charging the cell phone battery.
5 p.m. – 6 p.m.	After the dinner Patricia is driving home and charging her phone using the rest of Generated Energy.

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Web Sources[1] = **[w.]** in the content
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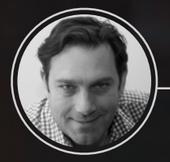
VITURVIAN TEAM



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IMAGINE ONE DAY WE CAN MAKE COFFEE
USING THE ENERGY HARVESTED FROM OUR BODIES!