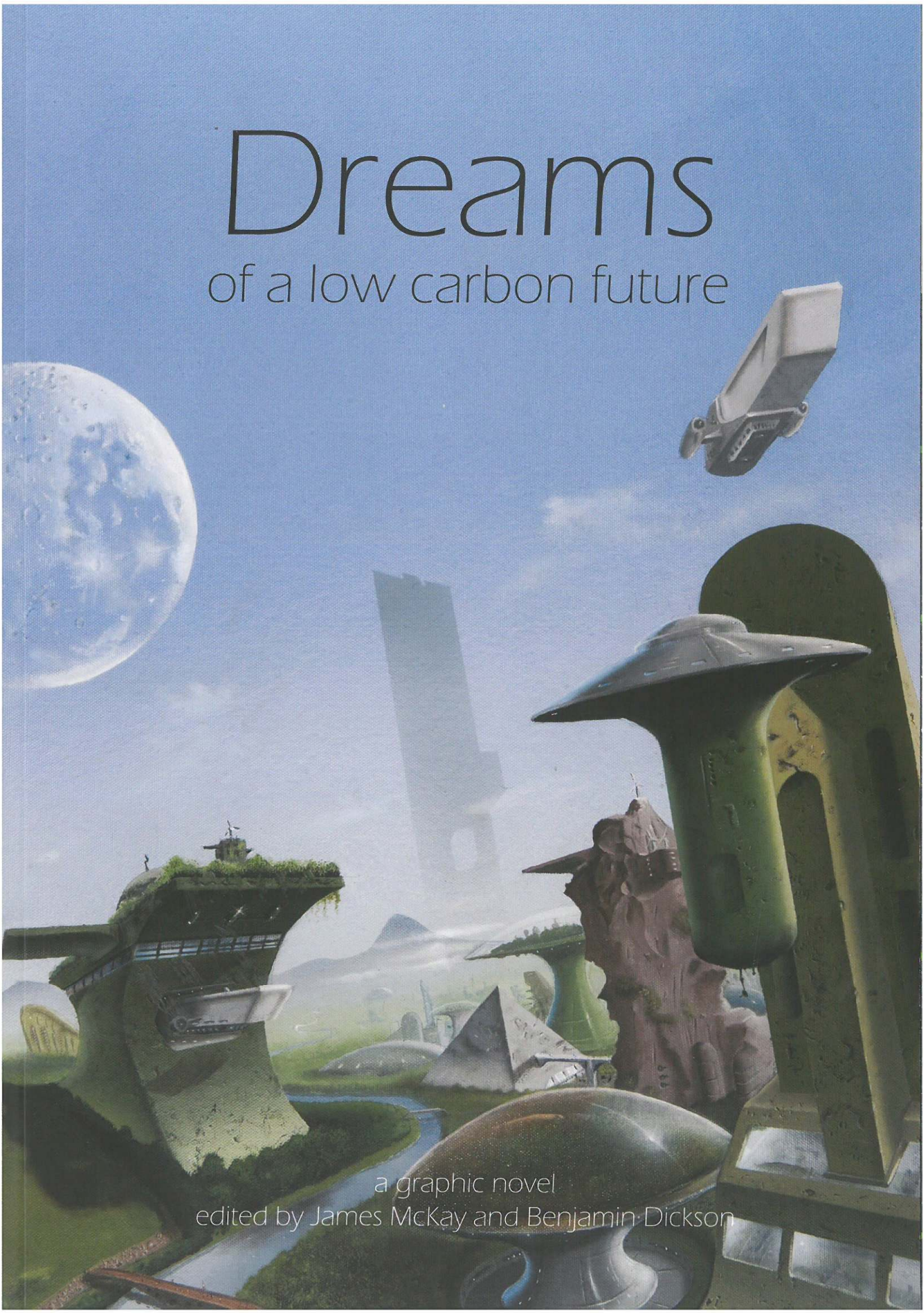
Dreams

of a low carbon future



a graphic novel

edited by James McKay and Benjamin Dickson

Ever wondered what the future will look like?

Concerned about humanity's impact on the planet?

We asked 370 school children, 40 Engineering PhD researchers, dozens of world-leading academics and 25 comic artists, designers, and writers to visualise their ideas. This book is the result.

"A graphic novel that gets to the heart of the important challenges we need to address for the future."

- Paul Gravett, author of "1001 Graphic Novels You Must Read Before You Die"

"A remarkable book - I love the fact that children, artists, engineers, scientists, writers and others all came together to produce a graphic novel that cuts across the boundaries of art and science."

- Pat Mills, creator of 2000AD

"Some say developing Low Carbon Technologies is the key challenge of our age - almost like a new race for the moon. Others say we must radically change our lifestyles. When I'm teaching problem-solving to science students I always say 'first, draw a picture'. Read this book, and explore the possibilities!"

- From the foreword by Prof David Mackay, author of Sustainable Energy Without the Hot Air

Cover art by Mark Wilkinson - Low Carbon Technotopia
Cover design by Benjamin Dickson

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STORY/ART/CONCEPTS

** NOTE: UNLESS HAND-DRAWN, ALL LETTERING, COMPOSITION AND DESIGN IS BY BENJAMIN DICKSON*

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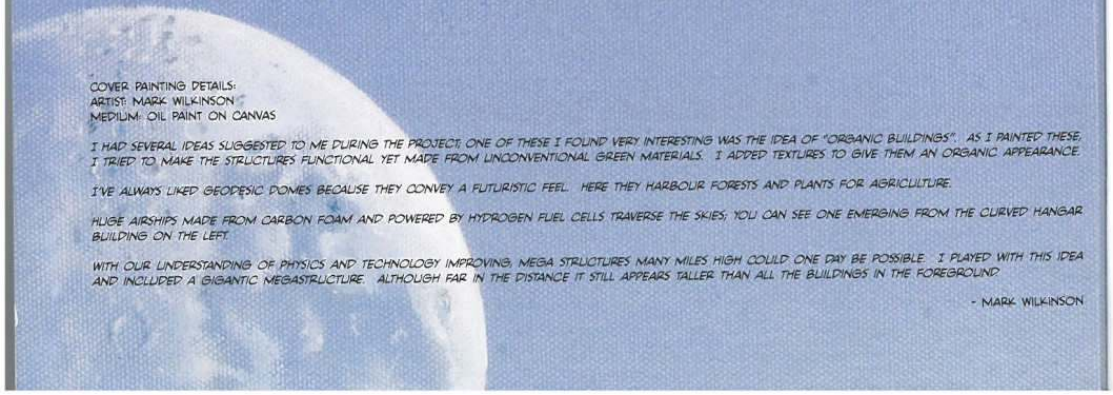
MANY OF THE ABOVE CREATORS WERE SCHOOL CHILDREN AGED 10-13, BASED AT THE FOLLOWING SCHOOLS:
KING JAMES SCHOOL, KNARESBOROUGH
DAVID YOUNG ACADEMY, LEEDS
MIRFIELD GRAMMAR, MIRFIELD
WAKEFIELD CITY ACADEMY, WAKEFIELD
NICHOLAS HAWKSMOOR PRIMARY SCHOOL, TOWCESTER
HORIZON COMMUNITY COLLEGE, BARNSLEY
SKIPTON GIRLS HIGH SCHOOL, SKIPTON
KIRKSTALL GUIDES GROUP, LEEDS

SOME CHILDREN ALSO CONTRIBUTED AT AN ACTIVITY SESSION HOSTED BY LEEDS CITY MUSEUM.

THE EDITORS APOLOGISE TO THE CREATORS ABOVE FOR ANY OMISSIONS OR MISTAKES.



COVER PAINTING DETAILS:
ARTIST: MARK WILKINSON
MEDIUM: OIL PAINT ON CANVAS

I HAD SEVERAL IDEAS SUGGESTED TO ME DURING THE PROJECT, ONE OF THESE I FOUND VERY INTERESTING WAS THE IDEA OF "ORGANIC BUILDINGS". AS I PAINTED THESE, I TRIED TO MAKE THE STRUCTURES FUNCTIONAL YET MADE FROM UNCONVENTIONAL GREEN MATERIALS. I ADDED TEXTURES TO GIVE THEM AN ORGANIC APPEARANCE.

I'VE ALWAYS LIKED GEODESIC DOMES BECAUSE THEY CONVEY A FUTURISTIC FEEL. HERE THEY HARBOUR FORESTS AND PLANTS FOR AGRICULTURE.

HUGE AIRSHIPS MADE FROM CARBON FOAM AND POWERED BY HYDROGEN FUEL CELLS TRAVERSE THE SKIES; YOU CAN SEE ONE EMERGING FROM THE CURVED HANGAR BUILDING ON THE LEFT.

WITH OUR UNDERSTANDING OF PHYSICS AND TECHNOLOGY IMPROVING, MEGA STRUCTURES MANY MILES HIGH COULD ONE DAY BE POSSIBLE. I PLAYED WITH THIS IDEA AND INCLUDED A GIGANTIC MEGASTRUCTURE. ALTHOUGH FAR IN THE DISTANCE IT STILL APPEARS TALLER THAN ALL THE BUILDINGS IN THE FOREGROUND.

- MARK WILKINSON

Dreams
of a low carbon future

a graphic novel
edited by James McKay
and Benjamin Dickson

"The oldest task in human history – to live on a piece of land without spoiling it"
- Aldo Leopold

"Unless you change direction, you'll end up where you're heading"
- Old Chinese proverb

EPSRC
Pioneering research and skills
(Supported by the RCUK Energy Programme)

ROYAL ACADEMY OF ENGINEERING

UNIVERSITY OF LEEDS

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THERE IS UNFORTUNATELY NOT ENOUGH SPACE TO THANK SUFFICIENTLY ALL THE OTHERS WHO VOLUNTEERED THEIR TIME, EFFORT AND IDEAS TO THE PROJECT:

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FOR DETAILS OF THE ENGINEERING PHD RESEARCHERS AT THE UNIVERSITY OF LEEDS AND SHEFFIELD WHO CONTRIBUTED, SEE *'MEET THE TEAM'* AT THE BACK OF THE BOOK.

AT TYNDALL CENTRE FOR CLIMATE CHANGE RESEARCH: PROF KEVIN ANDERSON, DR BEA JEFFERSON, DR SARAH MANDER, ANDREW WELFLE, CONOR WALSH, STEVE WALLBRIDGE, CHRIS JONES AND MICHAEL TRAUT

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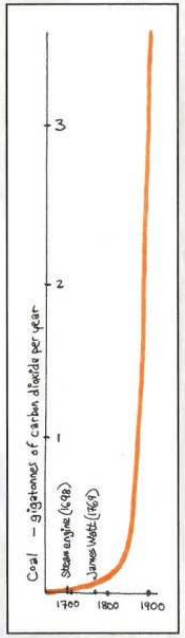
KIERAN WILSON -- MIRFIELD GRAMMAR, MIRFIELD
DAVID STEAD -- WAKEFIELD CITY ACADEMY
SARAH BARTON -- LEEDS CITY MUSEUM
JENNY JEFFERY, LOUISE TSERONIS, RICHARD EDWARDS -- NICHOLAS HAWKSMOOR PRIMARY SCHOOL, TOWCESTER
BEN GILDER, LUCIA GRANT AND ANTHONY COUPLAND -- HORIZON COMMUNITY COLLEGE, BARNSLEY
PHIL GORSE, ROD DYSON AND THE TEAM AT SKIPTON GIRLS HIGH SCHOOL, SKIPTON
ALISON HUGHES - KIRKSTALL GUIDES

FOREWORD
BY PROFESSOR DAVID MACKAY

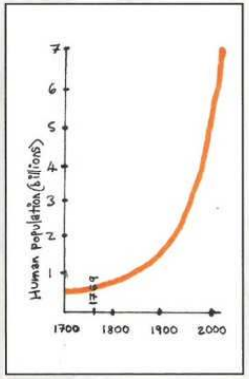
"WE TALK FAR TOO MUCH. WE SHOULD TALK LESS AND DRAW MORE. I PERSONALLY SHOULD LIKE TO RENOUNCE SPEECH ALTOGETHER AND, LIKE ORGANIC NATURE, COMMUNICATE EVERYTHING I HAVE TO SAY IN SKETCHES."

- GOETHE QUOTED IN THE DOORS OF PERCEPTION BY ALDOUS HUXLEY

GLOBAL FOSSIL FUEL CONSUMPTION



GLOBAL POPULATION GROWTH



IT'S EASY TO PICTURE THE FUTURE. EVERYBODY KNOWS THERE WILL BE FLYING CARS, GIANT GRAVITY-DEFYING SKYSCRAPERS, ROBOT SERVANTS, AND FASHIONABLE CLOTHING. GEODESIC DOMES ARE A SURE THING IN ANY FUTURE.

EVERYBODY ALSO ANTICIPATES A POST-APOCALYPTIC WASTELAND POPULATED BY MUTANTS AND FUTURE WARRIORS PACKING SOME IMPRESSIVE LOOKING WEAPONRY; A WASTELAND DEVOID OF WATER - OR PERHAPS A WATERWORLD DEVOID OF LAND.

BUT ARE THESE FUTURES INEVITABLE, OR EVEN REALISTIC? THIS PROJECT AIMS TO EXPLORE WHAT WE KNOW ABOUT PREDICTED CLIMATE CHANGE IMPACTS AND TO PICTURE WHAT HAPPENS TO OUR WORLD IF SOME OF OUR KEY RESOURCES RUN OUT.

IT IS INTERESTING THAT THERE IS (AS FAR AS I KNOW) NOT A SINGLE HOLLYWOOD MOVIE THAT TRIES ACCURATELY TO DEPICT A FUTURE SUSTAINABLE SOCIETY. IT IS VERY HARD; AS THOSE WHO WORKED ON THIS PROJECT CAN ATTEST, TO VISUALISE SUCH A SOCIETY, BUT IT IS AN IMPORTANT EXERCISE TO TRY.

20 ARTISTS AND WRITERS; A DOZEN ACADEMICS; 40 ENGINEERING PHD RESEARCHERS; 370 SCHOOL CHILDREN AGED 10-14; AND A HOST OF PUBLIC ENGAGEMENT FACILITATORS, COORDINATORS AND TEACHERS CONTRIBUTED TO THE UNIQUE VISIONS YOU WILL SEE ON THE FOLLOWING PAGES - A TRUE MARRIAGE OF SCIENCE AND THE MEDIUM OF COMIC ART.

HUMAN PROGRESS SINCE THE INDUSTRIAL REVOLUTION HAS IN MANY WAYS BEEN AWE-INSPIRING. BUT WHEN I LOOK AT GRAPHS OF GLOBAL POPULATION...

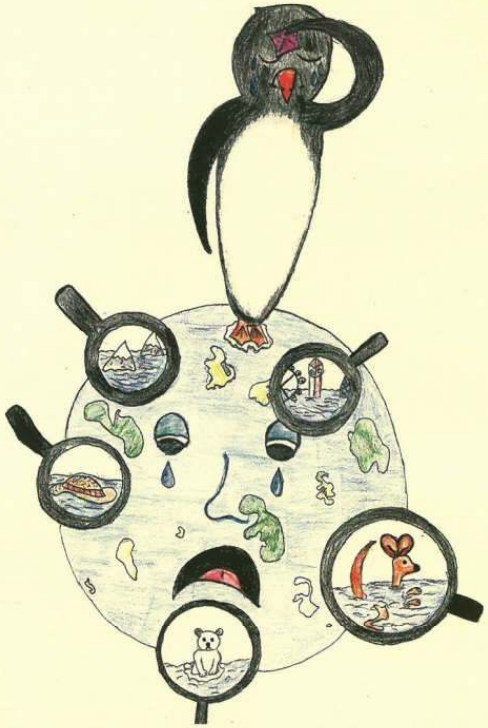
...AND OF GLOBAL FOSSIL FUEL CONSUMPTION*...

...I DO ANXIOUSLY WONDER WHERE WE ARE GOING.

SOME SAY DEVELOPING LOW CARBON TECHNOLOGIES IS THE KEY CHALLENGE OF OUR AGE - ALMOST LIKE A NEW RACE FOR THE MOON. OTHERS SAY WE MUST RADICALLY CHANGE OUR LIFESTYLES. WHEN I'M TEACHING PROBLEM-SOLVING TO SCIENCE STUDENTS I ALWAYS SAY "FIRST, DRAW A PICTURE". READ ON, AND EXPLORE THE POSSIBILITIES!

PROF DAVID MACKAY,
CHIEF SCIENTIFIC ADVISOR TO UK DEPARTMENT OF ENERGY AND CLIMATE CHANGE
AND AUTHOR OF "SUSTAINABLE ENERGY - WITHOUT THE HOT AIR

** TO SHOW WHAT HAPPENED TO FOSSIL FUEL CONSUMPTION FROM 1960 TO 2015, THE PAGE WOULD NEED TO BE ONE METRE TALL!*



IF YOU WOULD LIKE TO FIND OUT MORE ABOUT THIS PROJECT, PLEASE CONTACT JAMES MCKAY AT J.MCKAY@LEEDS.AC.UK

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OTTERS SUPPLIED BY HOLLY EDWARDS

PENGUINS SUPPLIED BY CLARE LINTON

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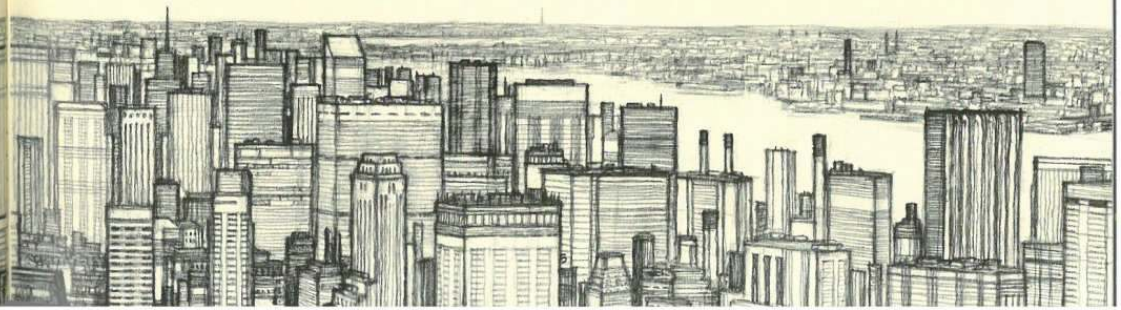
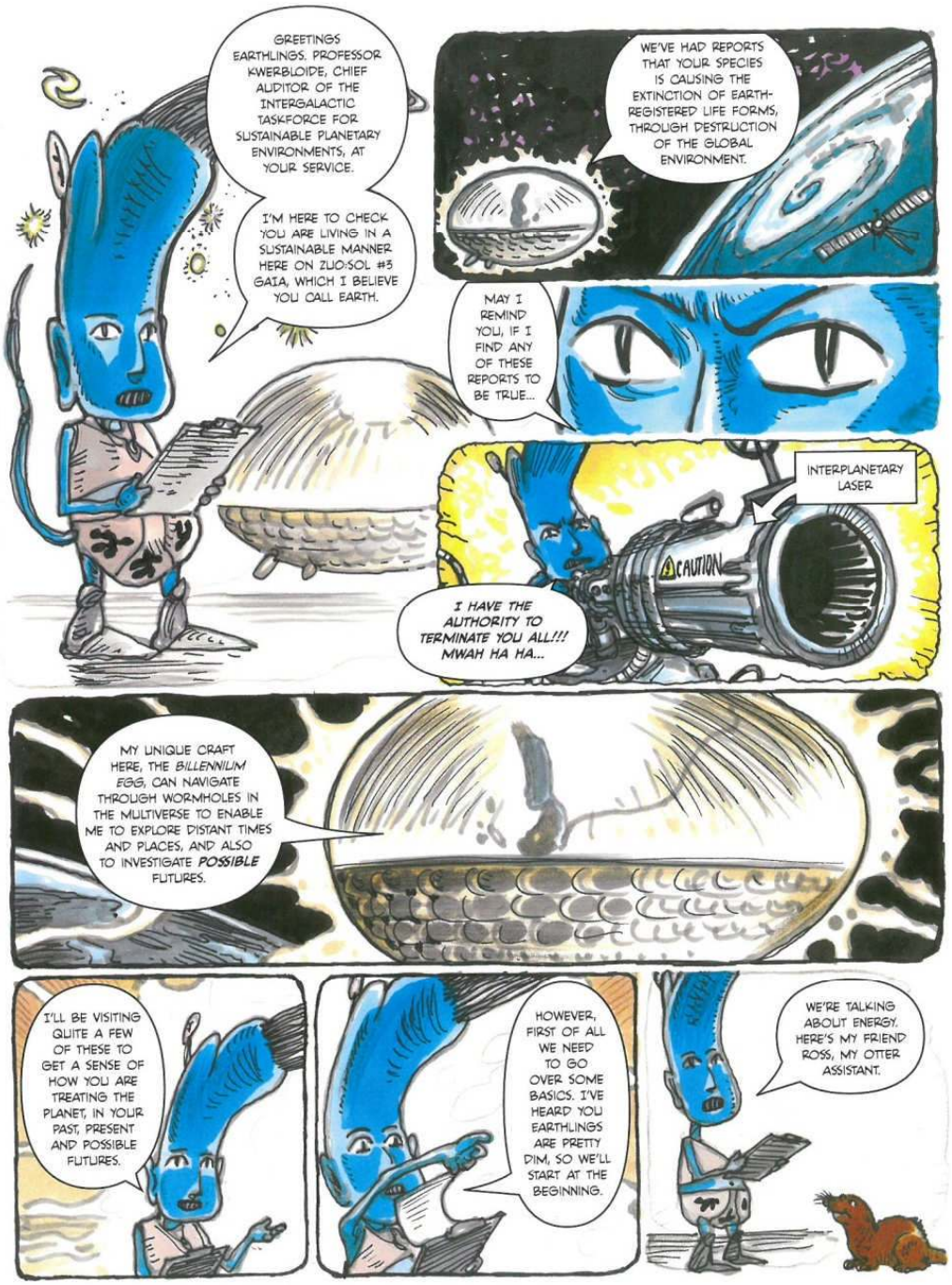


INTRODUCTION: PROFESSOR KWERBLOIDE'S GUIDE TO ENERGY



MOVING ON. WHAT DO YOU NEED TO STAY ALIVE? IMAGINE YOU'RE STUCK ON A DESERT ISLAND.

ER...FOOD?

WATER?

SHELTER?

ANYTHING ELSE? WHAT ABOUT ON A COLD WINDY DAY?

OOH... HEAT!

CORRECT. ALL OF THESE THINGS REQUIRE ENERGY. YOU CAN'T ***NOT*** USE ENERGY. THE QUESTION IS: HOW MUCH DO YOU NEED, WHERE DOES IT COME FROM AND WHAT ARE THE CONSEQUENCES?

WHAT OTHER THINGS DO YOU LIKE TO HAVE?

OK.

OK, WELL, ALL THESE THINGS REQUIRE A LOT MORE ENERGY THAN JUST WHAT IS NEEDED TO KEEP YOU ALIVE.

MY SMARTPHONE, TO KEEP IN TOUCH WITH THE KIDS.

MY HOLOGRAPHIC TV! CAN'T MISS AN EPISODE OF SUSPENDERS...

A HOLIDAY TO THE MALDIVES...

SELF-ESTEEM, CREATIVITY...

HEALTH, FAMILY, SECURITY

FOOD, WATER, SHELTER

SOME WOULD SAY THERE IS A KIND OF PYRAMID OF NEEDS -- THE BASIC STUFF AT THE BOTTOM AND THE MORE FANCY THINGS AT THE TOP.*

*BASED ON MASLOW'S HIERARCHY OF NEEDS

WHAT DO YOU REALLY NEED TO HAVE A HAPPY, FULFILLED LIFE? SHOULD I BE ALLOWED TO DICTATE HOW MUCH YOU HAVE, OR USE? SHOULD YOU BE ABLE TO USE MORE ENERGY THAN OTHERS?

THESE ARE ALL QUESTIONS WE SHALL PONDER.

FAIR ENOUGH.

SO, WE'VE WORKED OUT THAT ALL ENERGY COMES FROM THE SUN. BUT YOU EARTHLINGS CAN'T PHOTOSYNTHESISE LIKE PLANTS IN ORDER TO ACCESS THAT ENERGY DIRECTLY.

ONLY NOW ARE YOU LEARNING TO USE SOLAR PANELS -- AND THEY'RE NOT VERY EFFICIENT!

SO, THROUGHOUT HISTORY, HUMANS HAVE WORKED OUT WAYS OF GETTING ENERGY INDIRECTLY, FROM BURNING PLANTS, BUILDING WINDMILLS, BURNING COAL TO PRODUCE STEAM, PUTTING WATER WHEELS IN RIVERS....

...RIGHT THROUGH TO SPLITTING THE ATOM TO CREATE NUCLEAR ENERGY.

EACH METHOD IS DIFFERENT, AND EACH METHOD HAS SIDE EFFECTS -- SOME VERY BAD. LET'S GO AND FIND OUT.

HMM...I'M NOT SURE I CAN HANDLE A SCIENCE LESSON.... IT'S LOVELY AND WARM AND I'M FEELING RATHER SLEEPY...

COME ON! MY UNIQUE CRAFT, THE *BILLENIUM EGG*, WILL TAKE US ON AN EXCITING JOURNEY THROUGH A VARIETY OF POTENTIAL FUTURES TO SHOW HOW THESE TECHNOLOGIES DEVELOPED AND HOW THEY WILL AFFECT OUR FUTURE.

THE FIRST PLACE I'VE DECIDED TO VISIT IS SOUTHERN AFRICA 1.6 MILLION YEARS AGO. PLEASE TURN TO PAGE 42 OR ALTERNATIVELY YOU CAN READ THE HISTORY OF ENERGY AND CLIMATE CHANGE COMING UP NEXT...*

*NOTE: YOU CAN READ THE STORIES IN THIS BOOK IN ANY ORDER

A VERY SHORT HISTORY OF HUMAN ENERGY USAGE

YOUR GUIDE

How did we get to this point?

Of course, since humans were humans (and even before),

FOOD

ENERGY CONVERTED THROUGH DIGESTION

we've used ENERGY.

PRODUCES HEAT, MOVEMENT ETC.

In most circumstances all of our energy comes, ultimately, from THE SUN.

Giving plants the energy to grow.

Which we and other animals can then unlock.

MUNCH

Then came the first energy revolution.

FWOOMF

THUNK

ERK.

You guessed it.

The first time we learned to unleash energy in the form of heat and light.

Energy production EXTERNAL to our own bodies,

and probably VITAL to our evolutionary and societal development.

SNIP SNIP SNIP

But we've got a long way to go.

In the ancient world empires emerged and grew to fantastic sizes.

What does it take to sustain an empire?

Mass agriculture.

Building and maintenence.

Transport.

The extraction of raw materials

Communication.

All of this is ACTION that requires ENERGY. But there was no steam power, no electricity...

Horses and other animals were essential for their strength and speed.

More sinister: SLAVES were used in EVERY ancient empire to expend the energy needed to move material, operate machinery and fulfill domestic chores.

If only their carts and plows could have run on an EXTERNAL energy source.

AT LEAST WE HAVE THE WHEEL.

And there were advances.

OIL

Roman central heating and aqua ducts were stunning innovations.

In fact, the Greeks came tantalisingly close to developing a steam engine.

Hero of Alexandria demonstrated that by heating a chamber partially filled with water,

high-pressure steam would shoot out of the angled exhausts, causing the apparatus...

PSSS

PSSS

to SPIN.

SHHHHH

SHHHHH

APPLAUSE

But despite Ancient Greece actually having railways for transporting ships over land,

the leap of imagination required to consider attaching wheels to the contraption was too much.

INTO THE TRASH IT GOES.

BANG

Hero's design, known as an aeolipile was considered a useless novelty.

PFF

The ancient empires fell for lots of reasons.

But when sustaining something on that scale there are only so many slaves you can take.

CLANK

Only so many colonies you can control.

REVOLT!

Only so many resources you can go to war over.

PILLAGE!

But what if they could have supported their growing population with a new energy source? What if they'd had fast transport? Efficient agriculture? Instant communication?

To find out we'll have to go forward eighteen centuries.

Ladies and gentlemen...

RICHARD TREVITHICK

The Puffing Devil!

(The first demonstration of steam transportation, in 1801.)

In so many ways it was steam power that kicked off the modern era.

ROBERT STEPHENSON'S FAMOUS 'ROCKET' STEAM ENGINE: 1829

The FUTURE

Now industry could use steam-driven machines to massively increase the output of goods such as textiles.

Western society left behind the feudal status-quo of small-scale agriculture and cottage industry. The era of modern capitalism began.

CHG CHG CHG CHG CHG CHG

And soon, scientists began to harness the production and use of electrical currents.

ALESSANDRO VOLTA

'VOLTAIC PILE' THE FIRST BATTERY

Two complementary energy revolutions in quick succession.

MICHAEL FARADAY

whrrrrrrrr

Could these technologies be the key to avoiding the fate of the ancient empires?

FIRST GENERATOR

Well, travel times fell to a fraction of what they had been for thousands of years.

THAT'S ME OUT OF A JOB.

The telegraph utilised patterns of electrical pulses to send messages along wires in the specially-created Morse code.

TAP TAP T-TAP TAP

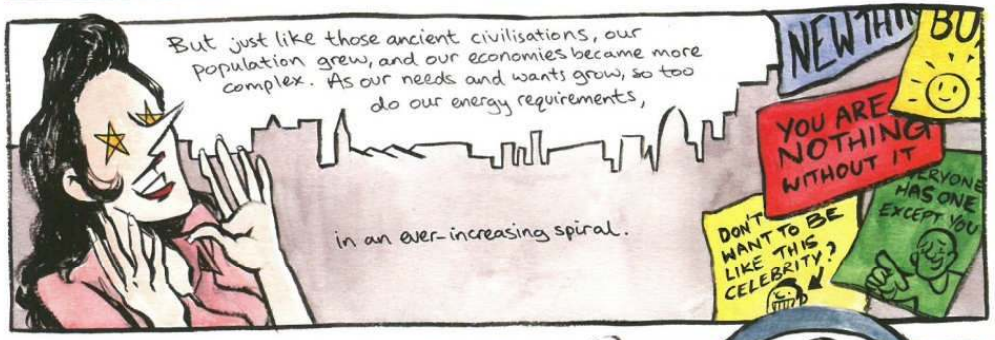
PRESSING DOWN COMPLETES CIRCUIT, SENDING PULSE

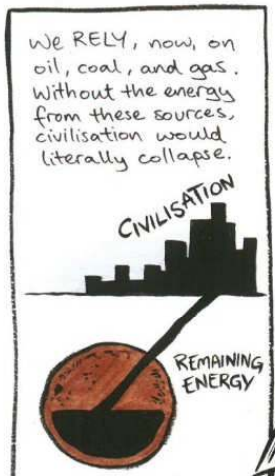
And although for the 19th century, steam was king, the DIESEL engine changed the game again.

NEW


Surely we have it all now?


Surely all of our problems are solved forever!
Hmmmm
BZZZZ
MMMMM


But just like those ancient civilisations, our population grew, and our economies became more complex. As our needs and wants grow, so too do our energy requirements,
in an ever-increasing spiral.
NEW THI
BU
YOU ARE NOTHING WITHOUT IT
EVERYONE HAS ONE EXCEPT YOU
DON'T WANT TO BE LIKE THIS CELEBRITY?

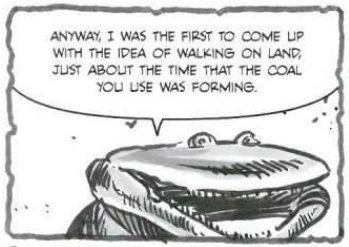

We RELY, now, on oil, coal, and gas. Without the energy from these sources, civilisation would literally collapse.
CIVILISATION
REMAINING ENERGY
These sources WILL run out eventually. There is no way to deny that.


And our energy needs continue to grow!
Either we have to start living within our means,
FOOOOM


or we need...
Another energy revolution.
NUCLEAR FUSION

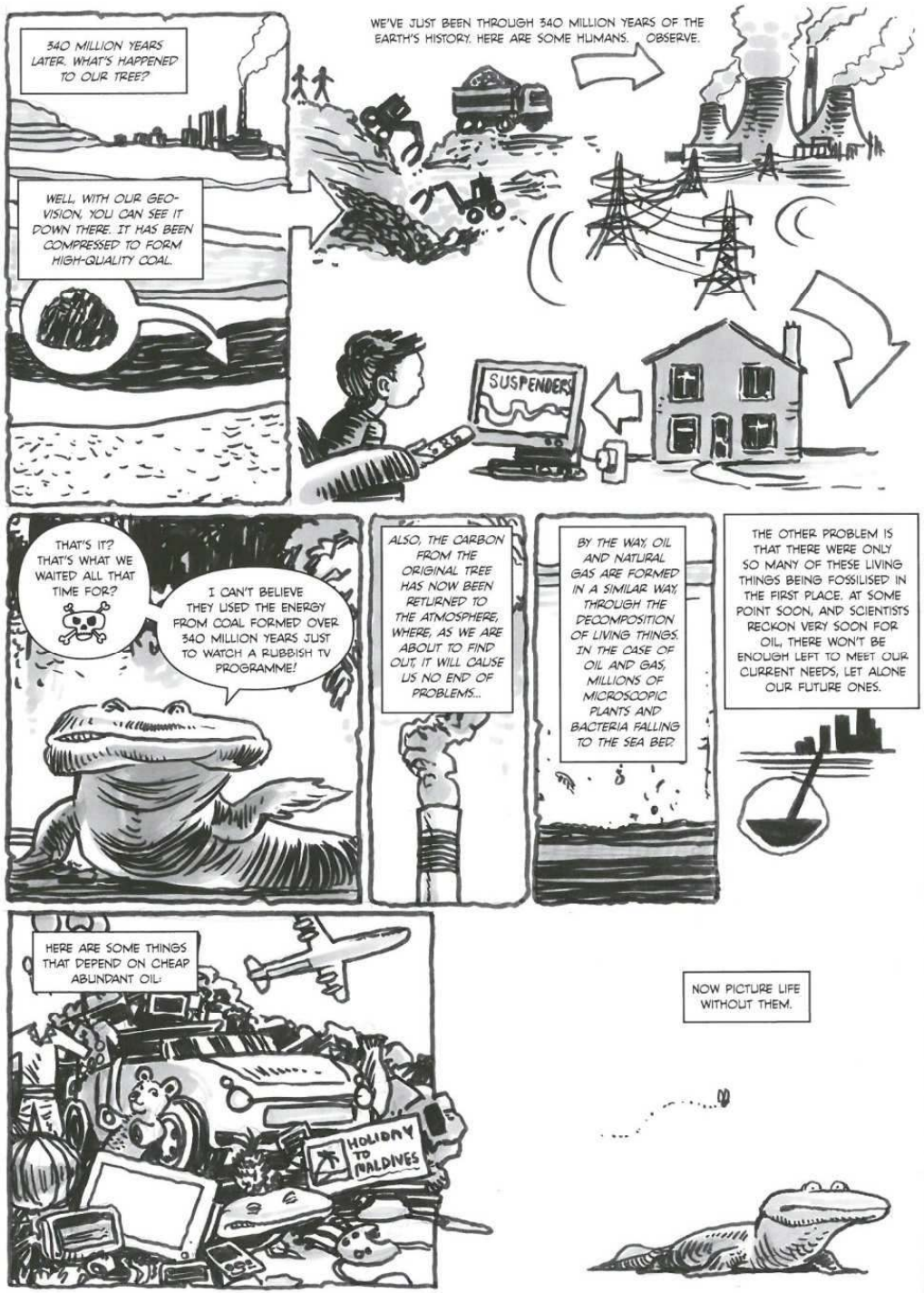

FOSSIL FUELS: WHERE IT ALL BEGAN
"PRACTICALLY EVERYTHING WE DO, FROM EATING AN ICE-CREAM TO CROSSING THE ATLANTIC, AND FROM BAKING A LOAF TO WRITING A NOVEL, INVOLVES THE USE OF COAL, DIRECTLY OR INDIRECTLY. FOR ALL THE ARTS OF PEACE, COAL IS NEEDED; IF A WAR BREAKS OUT IT IS NEEDED ALL THE MORE. IN TIME OF REVOLUTION, THE MINER MUST GO ON WORKING OR THE REVOLUTION WILL STOP, FOR THE REVOLUTION AS MUCH AS REACTION NEEDS COAL. WHATEVER MAY BE HAPPENING ON THE SURFACE, THE HACKING AND SHOVELLING HAVE GOT TO CONTINUE WITHOUT A PAUSE." *
*GEORGE ORWELL, THE ROAD TO WIGAN PIER


THANKS GEORGE. MY NAME'S TIKTAALIK. CALL ME GRANDMA TIK -- IT'S TRUE, I'M YOUR GREAT-GREAT-GREAT ANCESTOR TO THE NTH DEGREE.

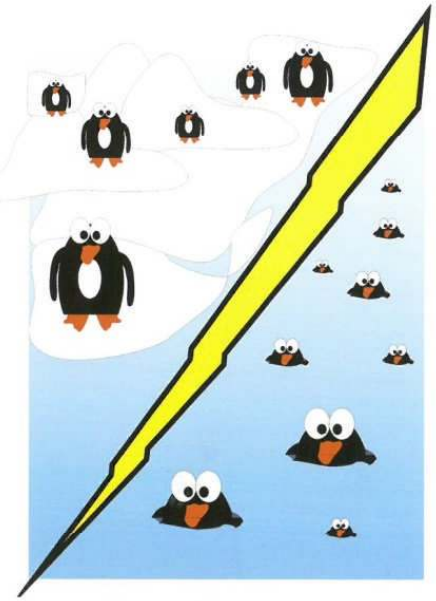

ANYWAY, I WAS THE FIRST TO COME UP WITH THE IDEA OF WALKING ON LAND, JUST ABOUT THE TIME THAT THE COAL YOU USE WAS FORMING.


HAD A CHAT WITH PROF KWERBLOIDE JUST NOW. HE ASKED ME TO TAKE YOU THROUGH THE PROCESS OF A TREE TURNING INTO COAL. REALLY EXCITED! LET'S GO!

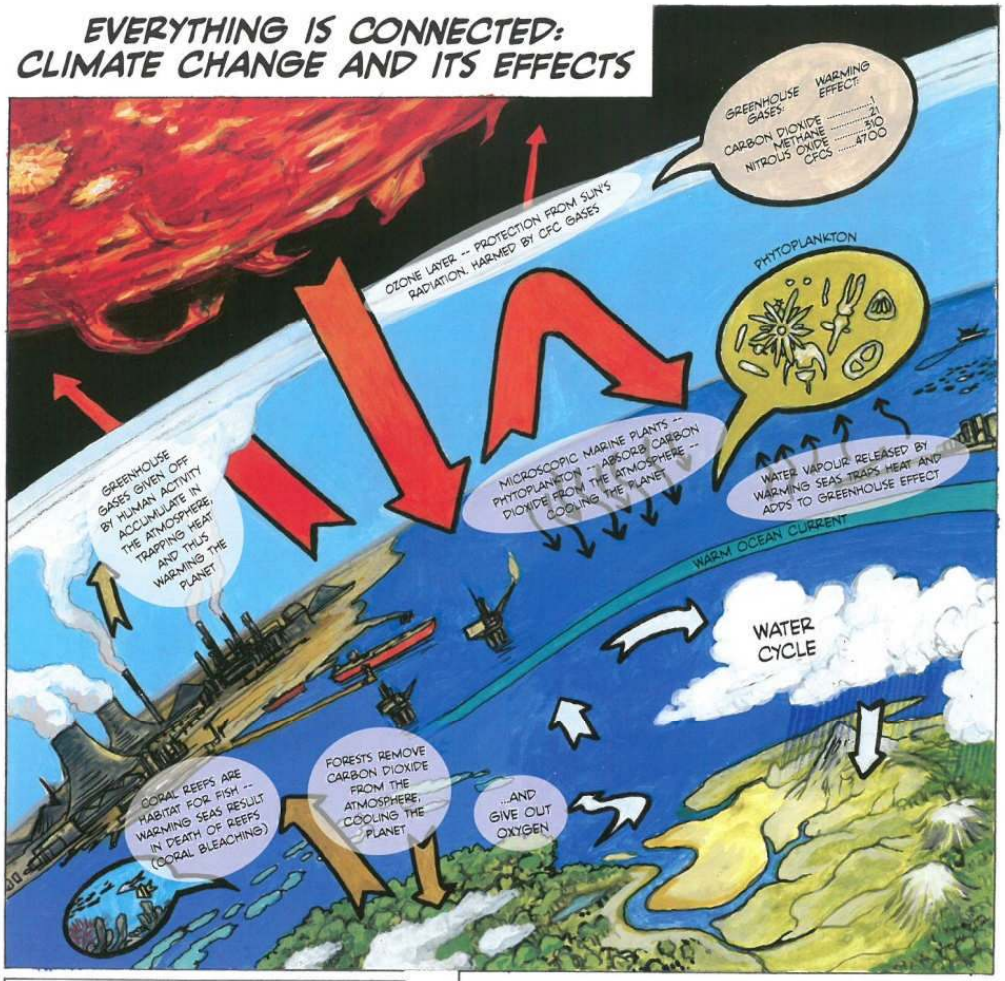

A TREE DIES AND FALLS INTO THE SWAMP.
20 YEARS LATER -- PEAT
20 MILLION YEARS LATER -- BROWN COAL
200 MILLION YEARS LATER -- LIGNITE



GLOBAL WARMING

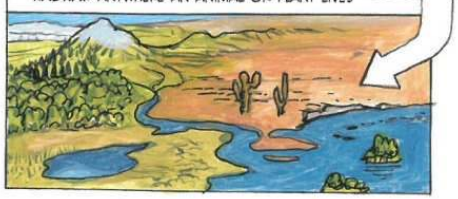


EVERYTHING IS CONNECTED: CLIMATE CHANGE AND ITS EFFECTS



BIODIVERSITY: THE VARIETY OF LIFE IN THE WORLD

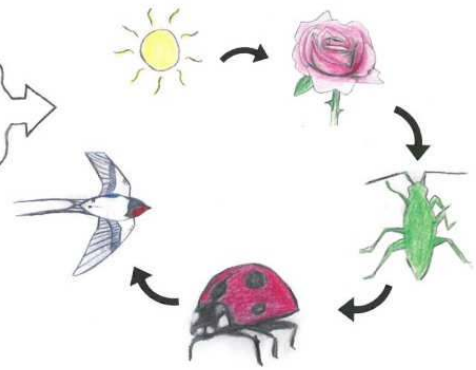
HABITAT: ANYWHERE AN ANIMAL OR PLANT LIVES

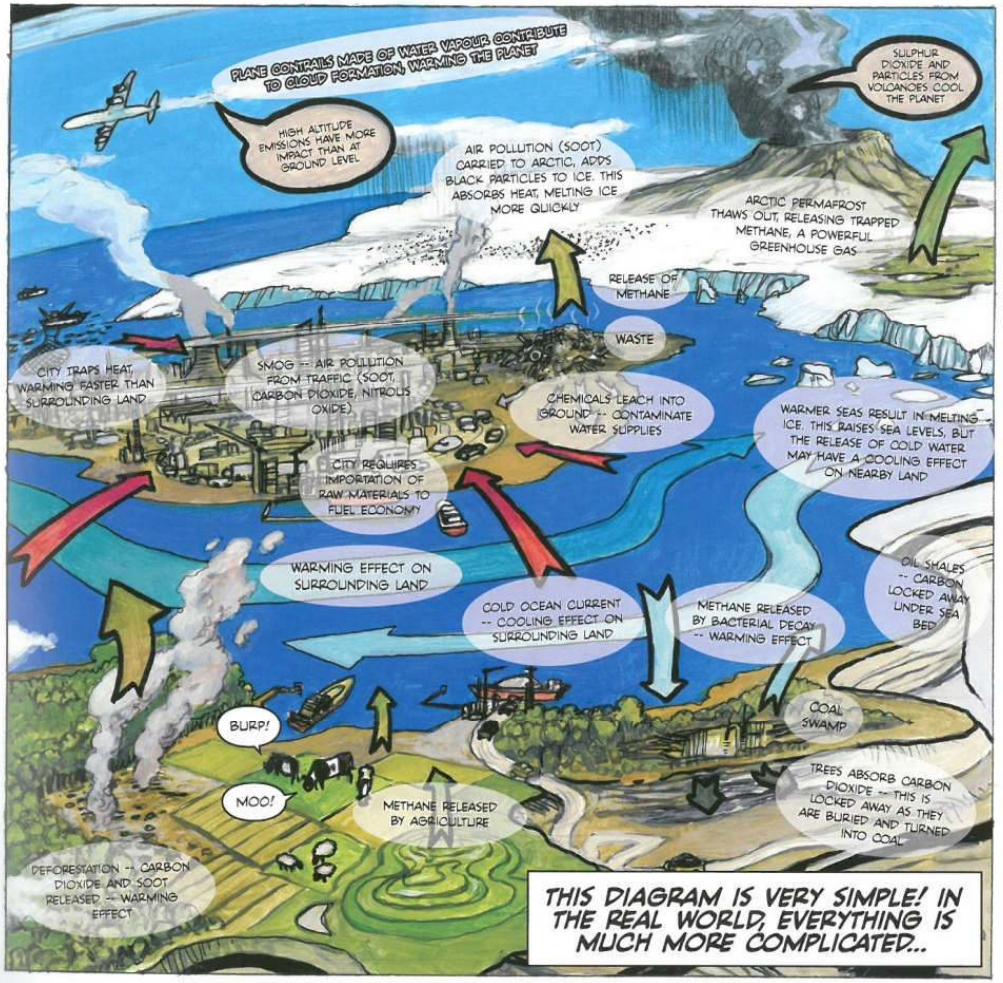


ANY CHANGE ABOVE WILL AFFECT ALL OF THESE!

ECOSYSTEM: THE RELATIONSHIP BETWEEN LIVING THINGS

AN EXAMPLE IS THE FOOD CHAIN BELOW





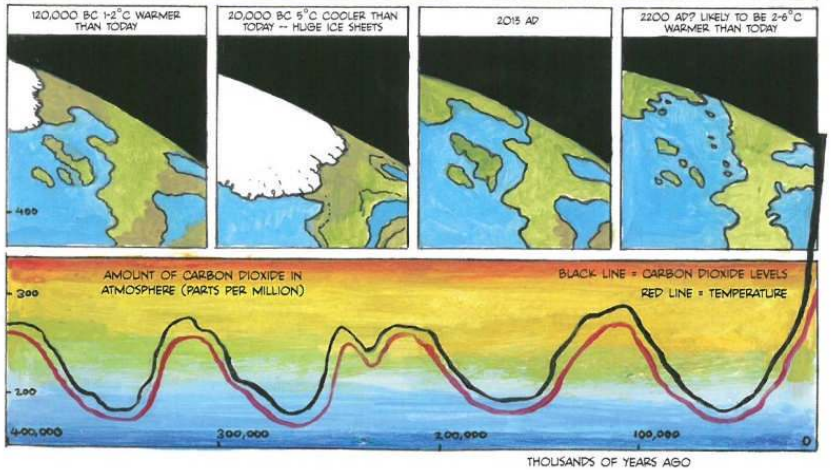
IMAGINE IF IT WAS TOO HOT FOR ROSES TO GROW

THIS WOULD AFFECT THE AMOUNT OF FOOD AVAILABLE TO GREENFLIES

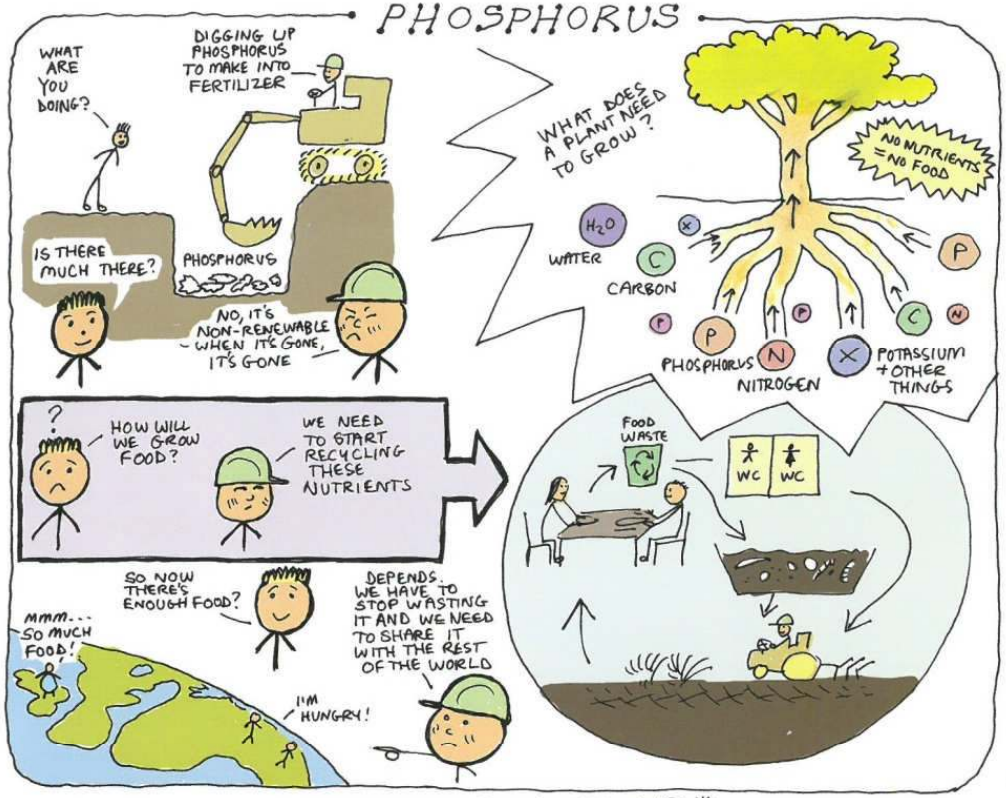
WHICH AFFECTS HOW MUCH LADYBIRDS HAVE TO EAT

WHICH AFFECTS SWALLOWS

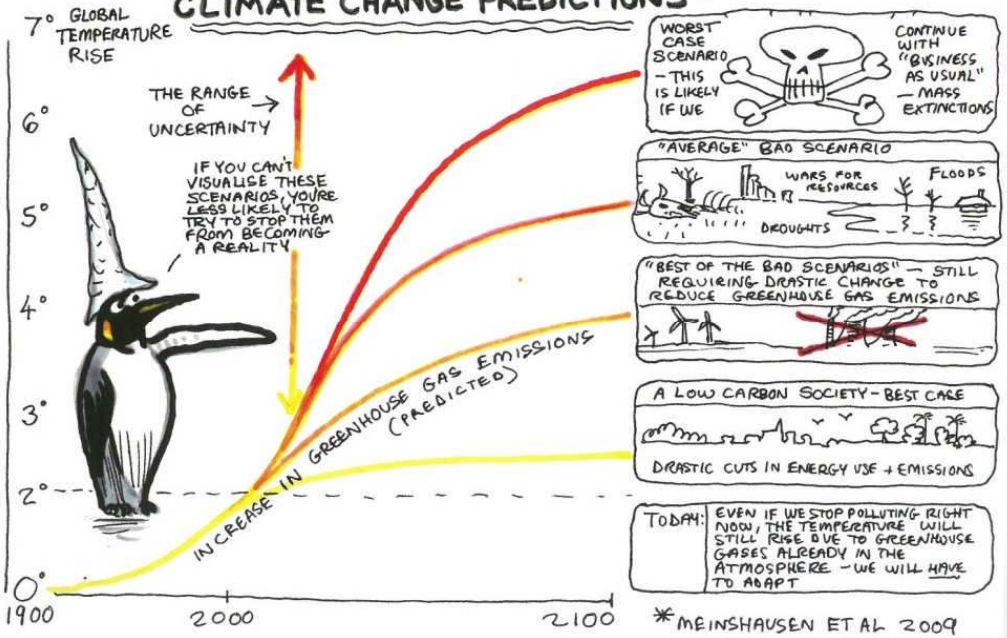
SO ALTHOUGH ONLY ONE SPECIES IS DIRECTLY AFFECTED BY CLIMATE CHANGE, IT HAS A KNOCK-ON EFFECT ON ALL THE SPECIES IN THE ECOSYSTEM



PHOSPHORUS



CLIMATE CHANGE PREDICTIONS *



*MEINSHAUSEN ET AL 2009

A TRULY SUSTAINABLE CULTURE? AUSTRALIA 35,000 B.C.

WE DON'T HAVE ANY POSSESSIONS SO LIFE IS EASY. GETTIN'FOOD ONLY TAKES ABOUT A THIRD OF THE DAY.

WE SPEND A BIT MORE TIME BURNING BUSH TO CLEAR THE UNDERGROWTH AND MAKE IT EASIER TO HUNT.

WE BEEN DOIN' THAT A LONG TIME -- 10,000 YEARS I RECKON.

THE REST WE SPEND MESSIN' ABOUT -- WE SING, WE DANCE, WE MEET FRIENDS AND RELATIVES, AND WE WALK THE LAND. IT NEED'S REGULAR WALKIN'.

YES, LIFE IS GOOD. WE KEEP HEALTHY THROUGH THE WALKIN' AND DANCIN' AND TALKIN' TO THE ANCESTORS.

OUR FAMILIES ARE ALL AROUND US. OUR FRIENDS ARE A COUPLE OF DAY'S WALK OVER THAT HILL. WHAT MORE DO YOU NEED?

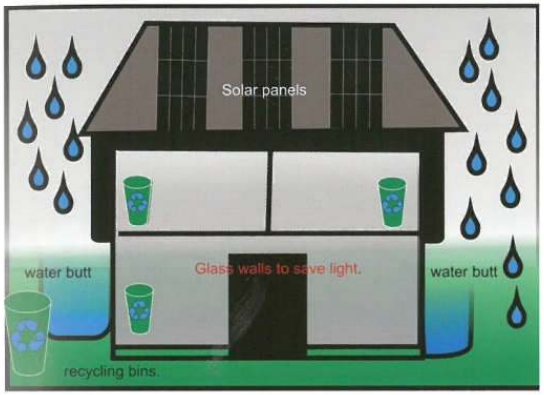
THE ONLY THING WE WORRY ABOUT IS SOMETHING WARRANGARRAJUK SAW FOR THE FUTURE WHEN HE WAS DOING THE WOMBAT CEREMONY.

HE SAID SOME ODD-LOOKIN' PEOPLE GOIN' TO COME FROM ACROSS THE SEA AND MESS THINGS UP FOR US...

TECHNOTOPIA

2100 A.D.

LOW CARBON ECO-HOUSE



TECHNOTOPIA CLOTHING

TAGS IN CLOTHES WIRELESSLY CONNECT TO THE WASHING MACHINE. THIS PROGRAMMES THE CORRECT CYCLE.

THE BRACELET TAKES ENERGY FROM THE BELT THAT HASN'T BEEN USED. IT SENDS THIS TO THE NATIONAL GRID.

THE SHOES LINK THROUGH THE FLOOR TO THE ENERGY GENERATED BY BUILDINGS TO POWER MESSAGES AND FLASH LIGHTS. THE BUILDINGS USE 'ENERGY FLOORS' WHICH CAPTURE THE ENERGY GENERATED BY THOUSANDS OF PEOPLE'S FEET WALKING ACROSS THEM.

A SOLAR BELT THAT POWERS GADGETS VIA A CHARGING PAD.

A COLLAR MEMBRANE MADE OF GRAPHENE WHICH FILTERS THE SURROUNDING AIR. THIS HELPS REDUCE PERSONAL CARBON DIOXIDE EMISSIONS.

IN THE UK WE THROW AWAY 32.5 MILLION TONNES OF HOUSEHOLD WASTE EACH YEAR. THAT'S THE SAME SIZE AS OVER 200 EMPIRE STATE BUILDINGS!

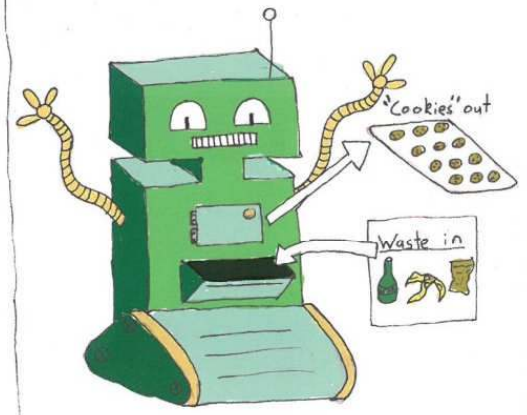
HALF OF THIS IS DUMPED IN HOLES IN THE GROUND, CAUSING POLLUTION AND GIVING OFF GREENHOUSE GASES LIKE METHANE WHICH LEAD TO GLOBAL CLIMATE CHANGE. HOWEVER, MOST WASTE CAN BE RECYCLED.

RECYCLING ONE GLASS BOTTLE SAVES ENOUGH ENERGY TO POWER A LIGHT BULB FOR 24 HOURS.

ALUMINIUM CAN BE RECYCLED INTO NEW CANS USING ONLY 5% OF THE ENERGY OF MANUFACTURING. IN TECHNOTOPIA, ENGINEERS TURN WASTE PLASTIC INTO CARBON NANO-TUBES. THEY ARE WORTH 20 TIMES MORE THAN GOLD AND CAN BE USED IN TOUCH-SCREEN DEVICES LIKE IPADS.

Refuse-bot-5000

Now Plutonium free!

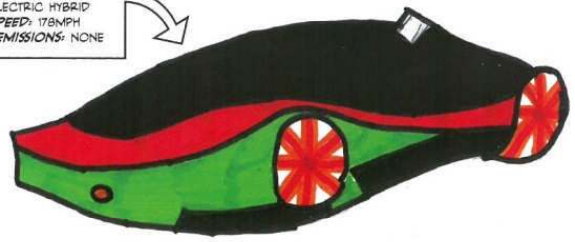


- Our unique design runs by burning waste
- CO_2 produced is turned into sugars using our 'Ratio-synthesis' process
- Refuse-bot then uses these sugars to bake "edible" cookies
- Equipped to help with all your household chores
- New model is 20% less likely to rebel against its human masters

'More than just an expensive footrest' Einstein's Ghost

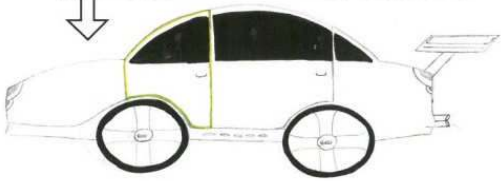
TECHNOTOPIA TRANSPORT SYSTEMS

PEELEVANS 3000 V8
FUEL: ELECTRIC HYBRID
TOP SPEED: 178MPH
EXHAUST EMISSIONS: NONE



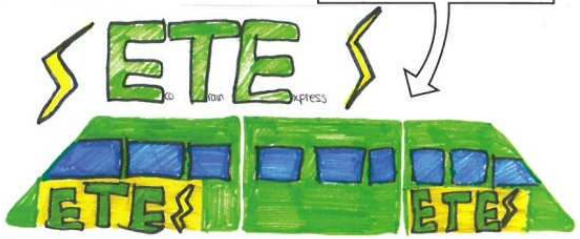
SCHOFIELD DELOREAN
FUEL: HYDROGEN PRODUCED BY PHOTOCATALYSIS POWERED BY WIND ENERGY
TOP SPEED: MACH 3.2
EXHAUST EMISSIONS: WATER

FORD TURPMOBILE 3XI
FUEL: TOMATO KETCHUP AND WASTE COOKING OIL
TOP SPEED: 150MPH
EXHAUST EMISSIONS: CARBON DIOXIDE, NITROUS OXIDE, SOOT



JORDAN BIO-RACER
FUEL: BIOGAS PRODUCED FROM ALGAE. CAN DETER HIJACKERS BY BLOWING BIOGAS AT THEM.
TOP SPEED: 159MPH
EXHAUST EMISSIONS: CARBON DIOXIDE, NITROUS OXIDE, SOOT

ECO TRAIN EXPRESS
FUEL: POWERED BY DEARMAN LIQUID-AIR ENGINE
EXHAUST EMISSIONS: NONE

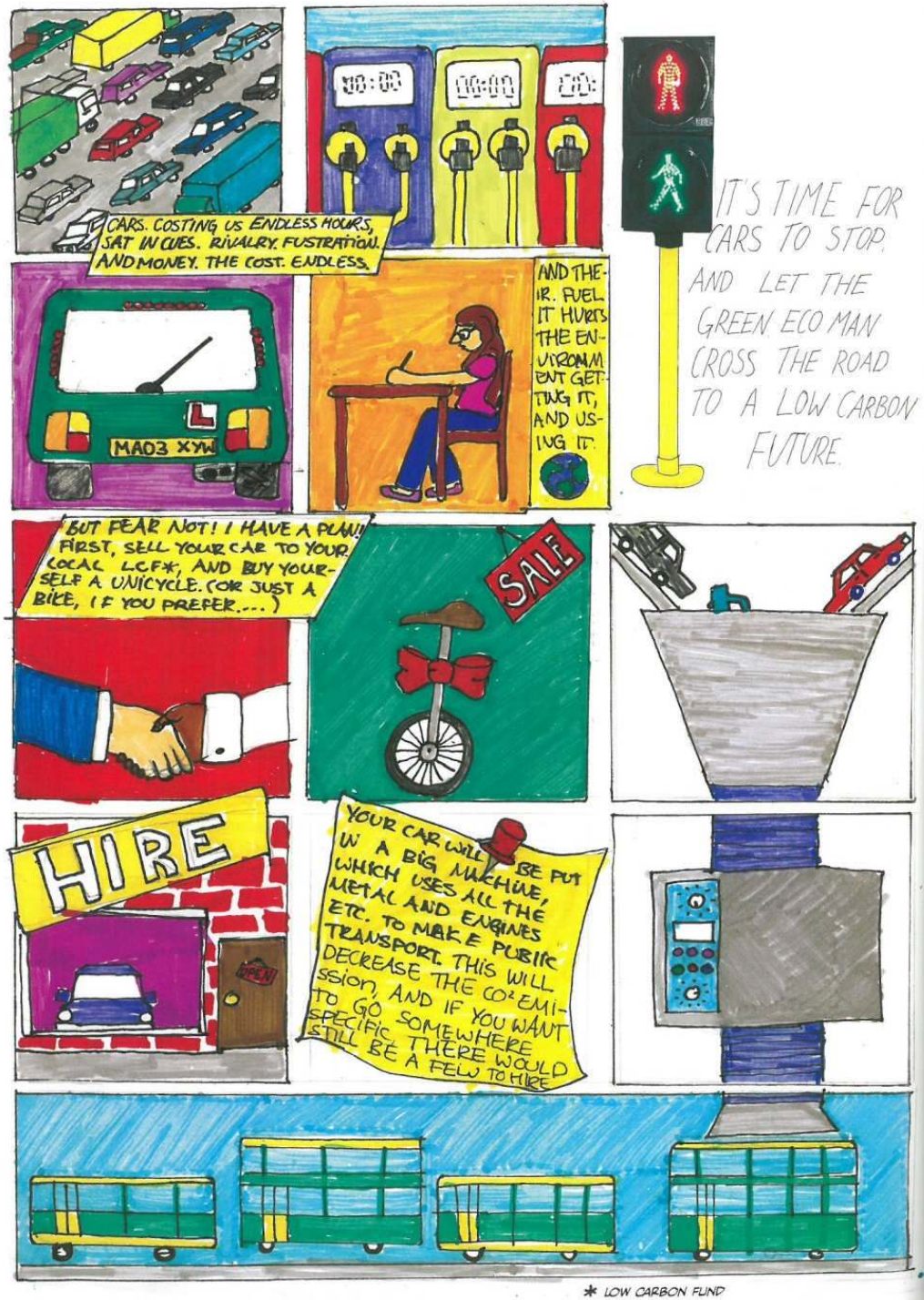


Giant dandelion

You cling onto the dandelion whilst it flys in the air with the wind pushing you

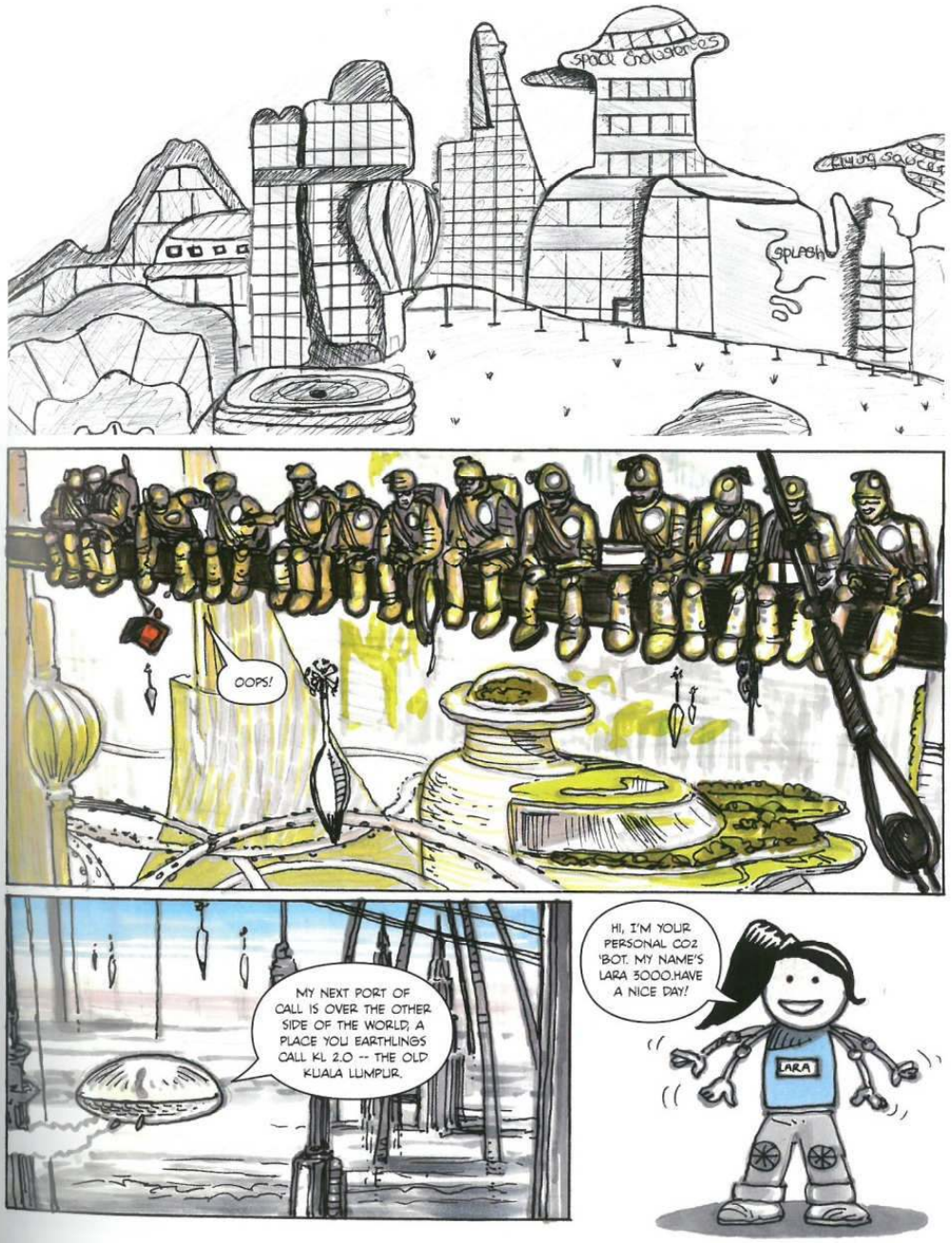
Runs off banana skins + fruit waste

A bus with seperate pods so that every one is in their own space.



* LOW CARBON FUND

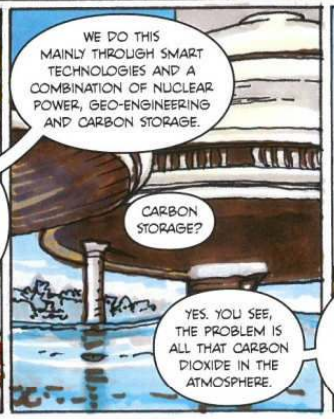
TOUR OF KL2.O: 2098 A.D.

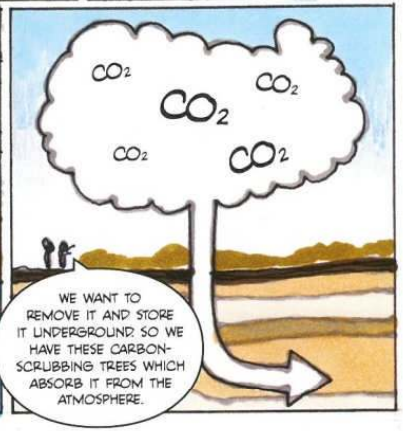


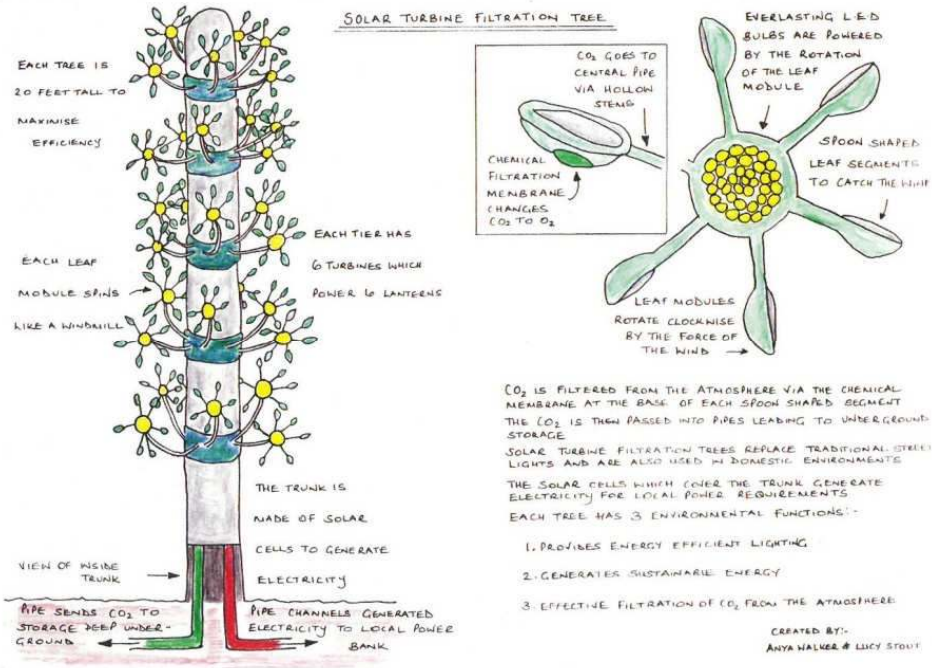

OK....
SO, TELL ME ABOUT YOUR CITY. IMPRESSIVE LOOKING PLACE.


YES, WE PRIDE OURSELVES THAT KL 2.0 IS A ZERO GHG* CITY.
*GHG = GREENHOUSE GASES (CARBON DIOXIDE, METHANE, NITROUS OXIDE AND OTHERS...)


ZERO-GHG? YOU MEAN YOU DON'T EMIT ANY CARBON DIOXIDE OR OTHER GREENHOUSE GASES INTO THE ATMOSPHERE? HOW DO YOU MANAGE THAT?
YES, ALTHOUGH WE ARE STILL USING SOME FOSSIL FUELS, WE USE ADVANCED TECHNOLOGIES TO NEGATE THE BAD EFFECTS.


WE DO THIS MAINLY THROUGH SMART TECHNOLOGIES AND A COMBINATION OF NUCLEAR POWER, GEO-ENGINEERING AND CARBON STORAGE.
CARBON STORAGE?
YES. YOU SEE, THE PROBLEM IS ALL THAT CARBON DIOXIDE IN THE ATMOSPHERE.


CO_2
CO_2
CO_2
CO_2
WE WANT TO REMOVE IT AND STORE IT UNDERGROUND. SO WE HAVE THESE CARBON-SCRUBBING TREES WHICH ABSORB IT FROM THE ATMOSPHERE.


SOLAR TURBINE FILTRATION TREE
EACH TREE IS 20 FEET TALL TO MAXIMISE EFFICIENCY
EACH LEAF MODULE SPINS LIKE A WINDMILL
EACH TIER HAS 6 TURBINES WHICH POWER 6 LANTERNS
THE TRUNK IS MADE OF SOLAR CELLS TO GENERATE ELECTRICITY
VIEW OF INSIDE TRUNK
PIPE SENDS CO_2 TO STORAGE DEEP UNDER-GROUND
PIPE CHANNELS GENERATED ELECTRICITY TO LOCAL POWER BANK
CO_2 GOES TO CENTRAL PIPE VIA HOLLOW STEMS
CHEMICAL FILTRATION MEMBRANE CHANGES CO_2 TO O_2
EVERLASTING L.E.D BULBS ARE POWERED BY THE ROTATION OF THE LEAF MODULE
SPOON SHAPED LEAF SEGMENTS TO CATCH THE WIND
LEAF MODULES ROTATE CLOCKWISE BY THE FORCE OF THE WIND
CO_2 IS FILTERED FROM THE ATMOSPHERE VIA THE CHEMICAL MEMBRANE AT THE BASE OF EACH SPOON SHAPED SEGMENT
THE CO_2 IS THEN PASSED INTO PIPES LEADING TO UNDERGROUND STORAGE
SOLAR TURBINE FILTRATION TREES REPLACE TRADITIONAL STREET LIGHTS AND ARE ALSO USED IN DOMESTIC ENVIRONMENTS
THE SOLAR CELLS WHICH COVER THE TRUNK GENERATE ELECTRICITY FOR LOCAL POWER REQUIREMENTS
EACH TREE HAS 3 ENVIRONMENTAL FUNCTIONS:-
1. PROVIDES ENERGY EFFICIENT LIGHTING
2. GENERATES SUSTAINABLE ENERGY
3. EFFECTIVE FILTRATION OF CO_2 FROM THE ATMOSPHERE
CREATED BY:-
ANYA WALKER & LUCY STOUT


CLEVERLY, WE THEN CONVERT THE CARBON TO SOLID FORM AND USE IT AS A BUILDING MATERIAL -- WE CAN BUILD ANYTHING WE WANT THROUGH 3D PRINTING.
CARBON FOAM -- LIGHTER THAN AIR BUT VERY STRONG -- ENABLES US TO BUILD GIANT SKYSCRAPERS SO LIGHT THEY HAVE TO BE TIED TO THE EARTH TO STOP THEM FROM FLOATING AWAY INTO SPACE.
CUBIC CARBON -- HARDER THAN DIAMOND.
GRAPHENE -- VITAL TO OUR NEW ELECTRONICS.


THE STUFF THAT IS LEFT OVER IS LIQUEFIED AND PUMPED UNDERGROUND INTO THE PLACES WHERE WE USED TO EXTRACT OIL.
IT'S A FORM OF GEO-ENGINEERING.


EXPLAIN.


WELL, GEO-ENGINEERING MEANS LOOKING AT THE WHOLE EARTH AND TRYING TO ADJUST THE CLIMATE BASED ON OUR KNOWLEDGE OF HOW THE SYSTEMS WORK.

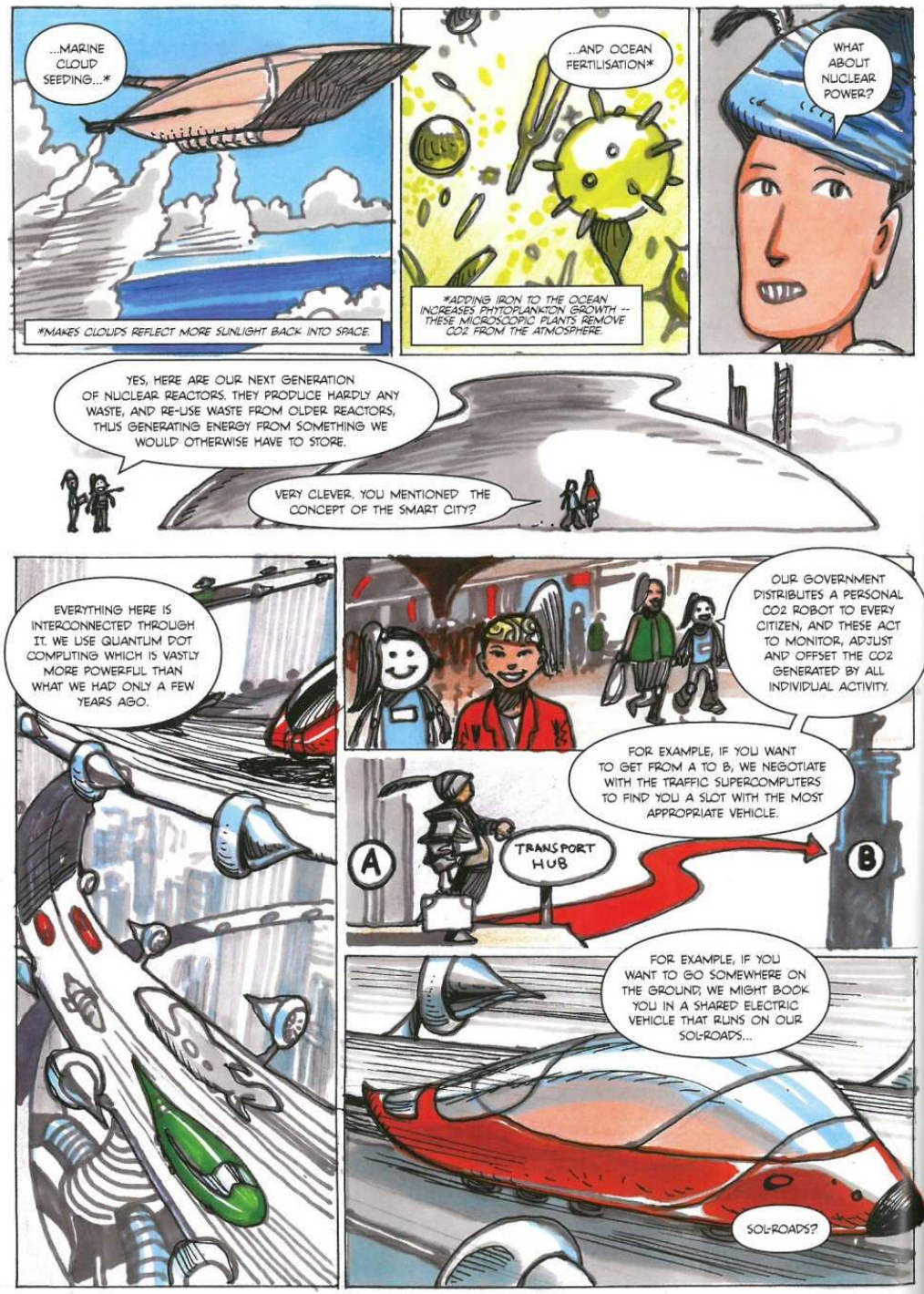

HMMM... SOUNDS A BIT COMPLICATED TO ME. AFTER ALL, YOU HUMANS ARE PRIMITIVE ORGANISMS, AND EVEN MY LOT HAVEN'T DONE THIS SUCCESSFULLY. PLANETS DON'T WORK LIKE CAR ENGINES.

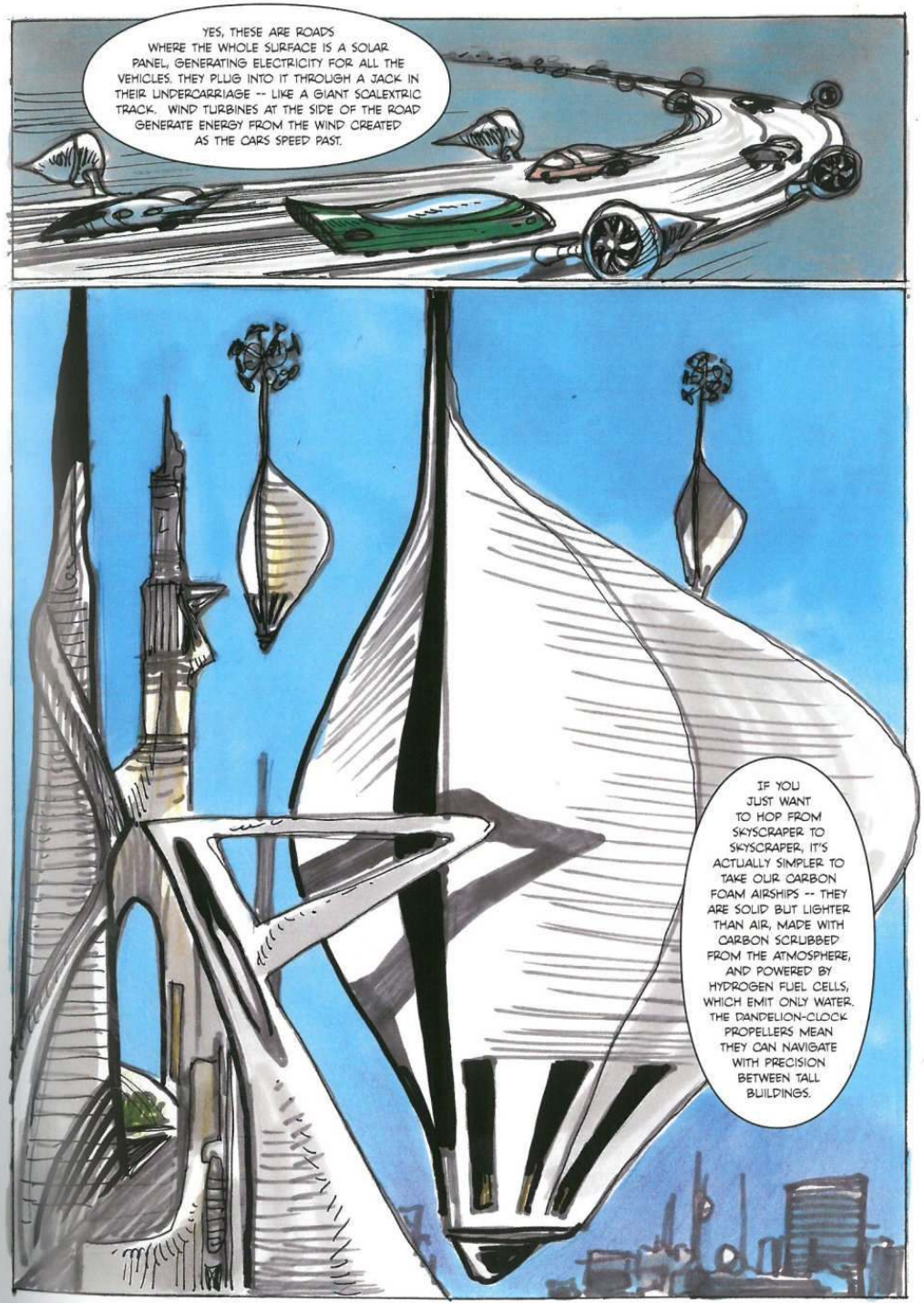

WE TRIED IT IN ANTARCTICA. WE PUT REFLECTIVE TIN HATS ON PENGUINS SO THAT MORE OF THE SUN'S LIGHT WOULD BE REFLECTED.
RESULTS?

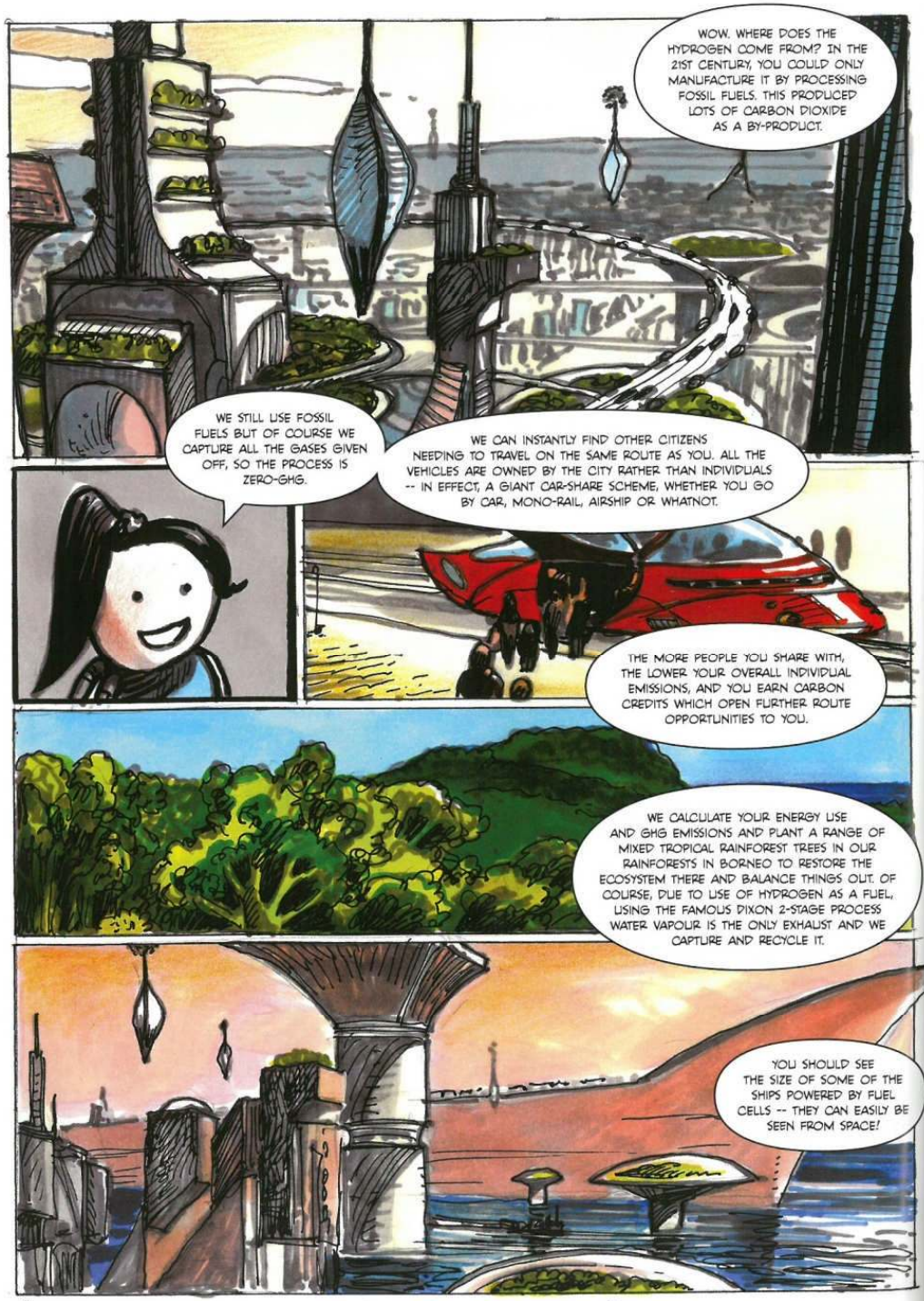

ER... MIXED, I WOULD SAY...


HMM. CARRY ON LARA.


WE USE A COMBINATION OF GIANT SPACE MIRRORS TO REFLECT THE SUN'S LIGHT...


...MARINE CLOUD SEEDING...*
*MAKES CLOUDS REFLECT MORE SUNLIGHT BACK INTO SPACE.
...AND OCEAN FERTILISATION*
*ADDING IRON TO THE OCEAN INCREASES PHYTOPLANKTON GROWTH -- THESE MICROSCOPIC PLANTS REMOVE CO2 FROM THE ATMOSPHERE.
WHAT ABOUT NUCLEAR POWER?
YES, HERE ARE OUR NEXT GENERATION OF NUCLEAR REACTORS. THEY PRODUCE HARDLY ANY WASTE, AND RE-USE WASTE FROM OLDER REACTORS, THUS GENERATING ENERGY FROM SOMETHING WE WOULD OTHERWISE HAVE TO STORE.
VERY CLEVER. YOU MENTIONED THE CONCEPT OF THE SMART CITY?
EVERYTHING HERE IS INTERCONNECTED THROUGH IT. WE USE QUANTUM DOT COMPUTING WHICH IS VASTLY MORE POWERFUL THAN WHAT WE HAD ONLY A FEW YEARS AGO.
OUR GOVERNMENT DISTRIBUTES A PERSONAL CO2 ROBOT TO EVERY CITIZEN, AND THESE ACT TO MONITOR, ADJUST AND OFFSET THE CO2 GENERATED BY ALL INDIVIDUAL ACTIVITY.
FOR EXAMPLE, IF YOU WANT TO GET FROM A TO B, WE NEGOTIATE WITH THE TRAFFIC SUPERCOMPUTERS TO FIND YOU A SLOT WITH THE MOST APPROPRIATE VEHICLE.
A
TRANSPORT HUB
B
FOR EXAMPLE, IF YOU WANT TO GO SOMEWHERE ON THE GROUND, WE MIGHT BOOK YOU IN A SHARED ELECTRIC VEHICLE THAT RUNS ON OUR SOL-ROADS...
SOL-ROADS?


YES, THESE ARE ROADS WHERE THE WHOLE SURFACE IS A SOLAR PANEL, GENERATING ELECTRICITY FOR ALL THE VEHICLES. THEY PLUG INTO IT THROUGH A JACK IN THEIR UNDERCARRIAGE -- LIKE A GIANT SCALEXTRIC TRACK. WIND TURBINES AT THE SIDE OF THE ROAD GENERATE ENERGY FROM THE WIND CREATED AS THE CARS SPEED PAST.
IF YOU JUST WANT TO HOP FROM SKYSCRAPER TO SKYSCRAPER, IT'S ACTUALLY SIMPLER TO TAKE OUR CARBON FOAM AIRSHIPS -- THEY ARE SOLID BUT LIGHTER THAN AIR, MADE WITH CARBON SCRUBBED FROM THE ATMOSPHERE, AND POWERED BY HYDROGEN FUEL CELLS, WHICH EMIT ONLY WATER. THE DANDELION-CLOCK PROPELLERS MEAN THEY CAN NAVIGATE WITH PRECISION BETWEEN TALL BUILDINGS.


WOW. WHERE DOES THE HYDROGEN COME FROM? IN THE 21ST CENTURY, YOU COULD ONLY MANUFACTURE IT BY PROCESSING FOSSIL FUELS. THIS PRODUCED LOTS OF CARBON DIOXIDE AS A BY-PRODUCT.
WE STILL USE FOSSIL FUELS BUT OF COURSE WE CAPTURE ALL THE GASES GIVEN OFF, SO THE PROCESS IS ZERO-GHG.
WE CAN INSTANTLY FIND OTHER CITIZENS NEEDING TO TRAVEL ON THE SAME ROUTE AS YOU. ALL THE VEHICLES ARE OWNED BY THE CITY RATHER THAN INDIVIDUALS -- IN EFFECT, A GIANT CAR-SHARE SCHEME, WHETHER YOU GO BY CAR, MONO-RAIL, AIRSHIP OR WHATNOT.
THE MORE PEOPLE YOU SHARE WITH, THE LOWER YOUR OVERALL INDIVIDUAL EMISSIONS, AND YOU EARN CARBON CREDITS WHICH OPEN FURTHER ROUTE OPPORTUNITIES TO YOU.
WE CALCULATE YOUR ENERGY USE AND GHG EMISSIONS AND PLANT A RANGE OF MIXED TROPICAL RAINFOREST TREES IN OUR RAINFORESTS IN BORNEO TO RESTORE THE ECOSYSTEM THERE AND BALANCE THINGS OUT. OF COURSE, DUE TO USE OF HYDROGEN AS A FUEL, USING THE FAMOUS DIXON 2-STAGE PROCESS WATER VAPOUR IS THE ONLY EXHAUST AND WE CAPTURE AND RECYCLE IT.
YOU SHOULD SEE THE SIZE OF SOME OF THE SHIPS POWERED BY FUEL CELLS -- THEY CAN EASILY BE SEEN FROM SPACE!


VERY INTERESTING. SOMETHING BOTHERS ME THOUGH -- WHERE ARE ALL THE MATERIALS AND ENERGY FOR ALL THIS COMPUTING COMING FROM?
IN THE 1980S, A MOBILE PHONE USED ABOUT 10 RARE EARTH MINERALS IN ITS CONSTRUCTION.
IN 2010, SMARTPHONES WERE USING 60 RARE EARTH MINERALS.
IN 2050, PERSONAL INTERNET DEVICES WERE USING UP TO 1600! HEAVEN KNOWS WHAT THE DEMAND WILL BE NOW.
DEPARTURES
INTERNATIONAL SPACE STATION
THAT HAS ALL BEEN SOLVED! OBSERVE OUR SPACE ELEVATOR.
AT THE TOP, A SPACE STATION IS THE LAUNCH PAD FOR ROCKETSHIPS THAT HEAD OUT TO ASTEROIDS AND MINE THEM FOR ALL THE MATERIALS WE NEED!
WE HAVE SIMILAR CONSTRUCTIONS THAT TAKE US DOWN TO THE BOTTOM OF THE OCEAN WHERE WE HAVE MINES ON THE FLOOR OF THE CHALLENGER TRENCH -- THE DEEPEST PLACE ON EARTH.
WOW!


YES, IT'S ALL VERY IMPRESSIVE AND A TESTAMENT TO HUMAN INGENUITY.
UM. ONE LAST THING: EVERYTHING SEEMS TO BE TAKEN CARE OF WHAT DO THE ACTUAL CITIZENS DO ALL DAY?

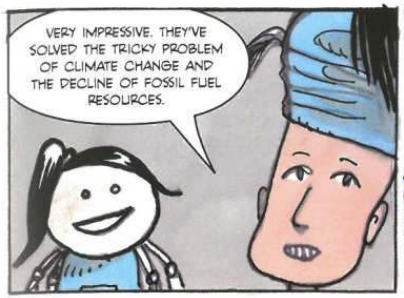

THEY SPEND THEIR TIME AT THE BEACH, OR DIVING OUR ARTIFICIAL CORAL REEFS, OR PLAYING IN VIRTUAL REALITY ENVIRONMENTS TRADING WITH THE MONEY BUNNIES.


THE CITY YOU CAN SEE IS ONLY THE TIP OF THE ICEBERG - -PEOPLE LIVE 90% OF THEIR LIVES IN THE WORLD THEY THEMSELVES CREATE ONLINE.


EVEN WHEN THEY DIE, THEIR MEMORIES ARE BACKED UP ON THE NETWORK, AND THEIR ONLINE AVATAR KEEPS GOING. A DEAD PERSON CAN EVEN JUMP BACK INTO THE REAL WORLD BY HAVING THEIR AVATAR INTEGRATED INTO A ROBOT EXOSKELETON.


GOSH! HOW INTERESTING!


WHY, THANK YOU.


VERY IMPRESSIVE. THEY'VE SOLVED THE TRICKY PROBLEM OF CLIMATE CHANGE AND THE DECLINE OF FOSSIL FUEL RESOURCES.

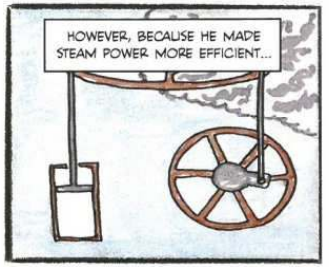

HOWEVER, I HAVE SOME CONCERNS. CLEARLY THE FACT THAT THEY ARE MINING OFF-WORLD FOR NECESSARY MATERIALS INDICATES A REBOUND EFFECT (SEE BELOW) AND THAT THIS SOCIETY IS NOT SUSTAINABLE.
LARA

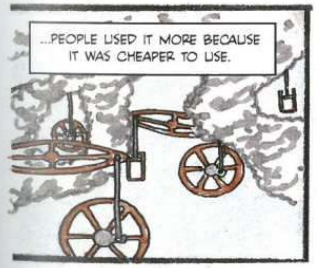

The Rebound Effect


IN THE 1700S, JAMES WATT HAD AN IDEA:

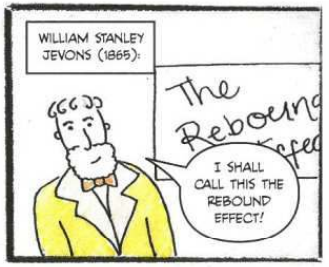

I'M GOING TO MAKE STEAM POWER MORE EFFICIENT!


IT WILL SAVE MONEY AND COAL!


HOWEVER, BECAUSE HE MADE STEAM POWER MORE EFFICIENT...


...PEOPLE USED IT MORE BECAUSE IT WAS CHEAPER TO USE.

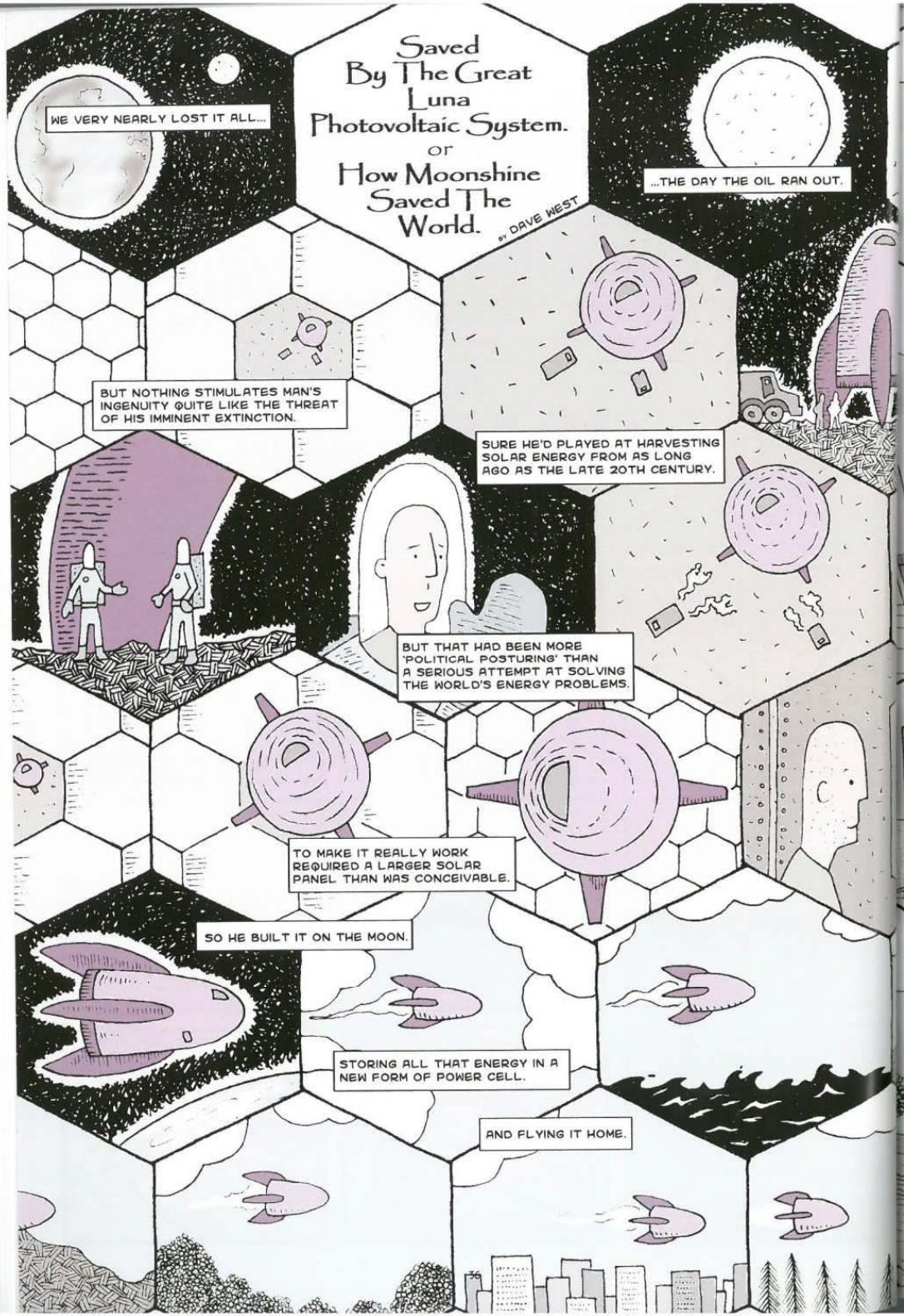

THUS MORE COAL WAS USED.
THIS ISN'T WHAT I INTENDED!

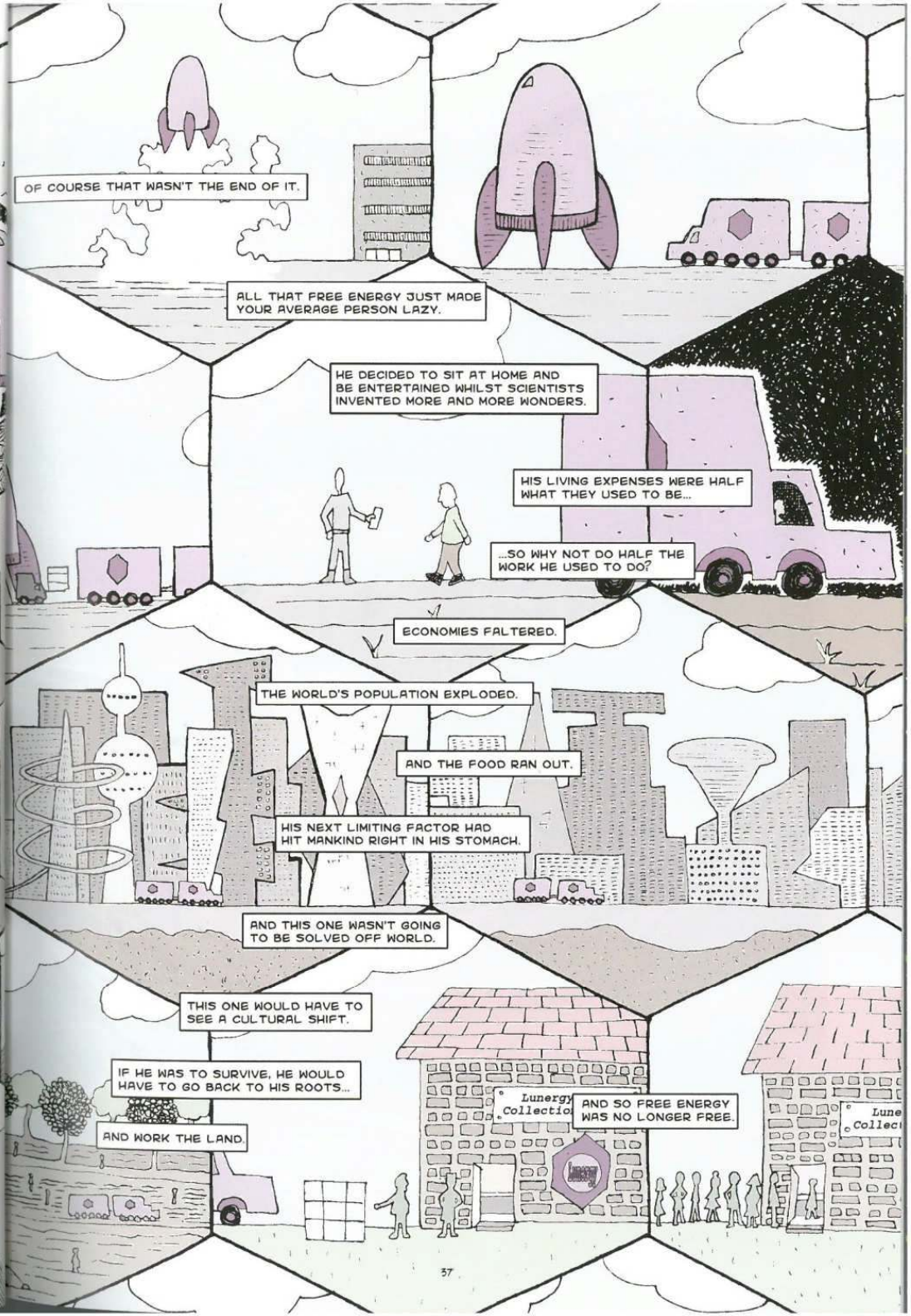

WILLIAM STANLEY JEVONS (1865):
The Rebound
I SHALL CALL THIS THE REBOUND EFFECT!

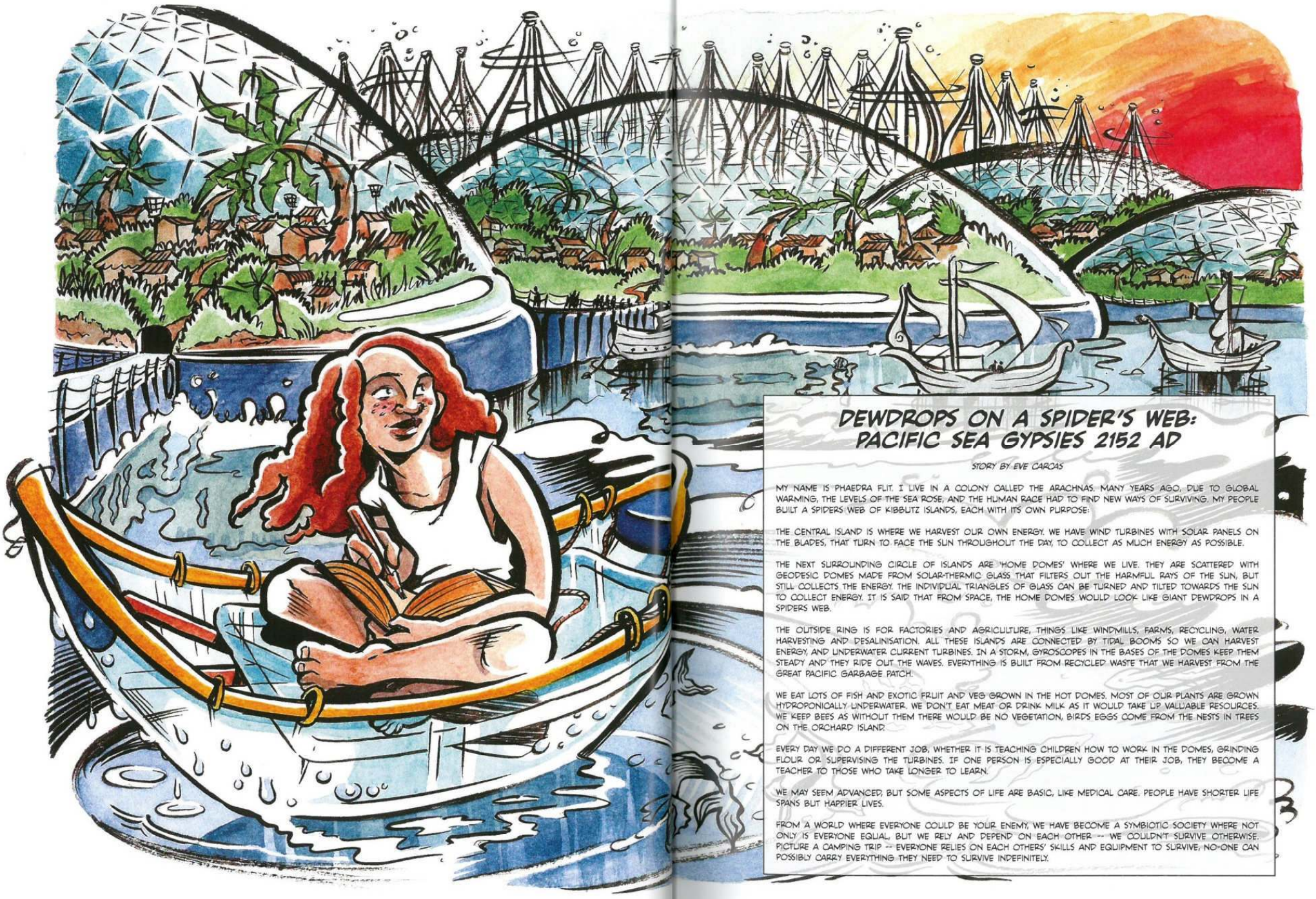

IMAGINE A CAR THAT IS WELL DESIGNED, SO THAT IT IS VERY EFFICIENT, USES LESS FUEL, AND CREATES LESS POLLUTION...


BECAUSE IT USES LESS FUEL, IT'S CHEAPER TO RUN, SO PEOPLE DRIVE FURTHER AND MORE OFTEN.


OVERALL, THE DRIVER DOESN'T SAVE MONEY AND THE AMOUNT OF POLLUTION REMAINS THE SAME, OR MAY EVEN INCREASE!


Saved By The Great Luna Photovoltaic System. or How Moonshine Saved The World.
BY DAVE WEST
WE VERY NEARLY LOST IT ALL...
...THE DAY THE OIL RAN OUT.
BUT NOTHING STIMULATES MAN'S INGENUITY QUITE LIKE THE THREAT OF HIS IMMINENT EXTINCTION.
SURE HE'D PLAYED AT HARVESTING SOLAR ENERGY FROM AS LONG AGO AS THE LATE 20TH CENTURY.
BUT THAT HAD BEEN MORE 'POLITICAL POSTURING' THAN A SERIOUS ATTEMPT AT SOLVING THE WORLD'S ENERGY PROBLEMS.
TO MAKE IT REALLY WORK REQUIRED A LARGER SOLAR PANEL THAN WAS CONCEIVABLE.
SO HE BUILT IT ON THE MOON.
STORING ALL THAT ENERGY IN A NEW FORM OF POWER CELL.
AND FLYING IT HOME.


OF COURSE THAT WASN'T THE END OF IT.
ALL THAT FREE ENERGY JUST MADE YOUR AVERAGE PERSON LAZY.
HE DECIDED TO SIT AT HOME AND BE ENTERTAINED WHILST SCIENTISTS INVENTED MORE AND MORE WONDERS.
HIS LIVING EXPENSES WERE HALF WHAT THEY USED TO BE...
...SO WHY NOT DO HALF THE WORK HE USED TO DO?
ECONOMIES FALTERED.
THE WORLD'S POPULATION EXPLODED.
AND THE FOOD RAN OUT.
HIS NEXT LIMITING FACTOR HAD HIT MANKIND RIGHT IN HIS STOMACH.
AND THIS ONE WASN'T GOING TO BE SOLVED OFF WORLD.
THIS ONE WOULD HAVE TO SEE A CULTURAL SHIFT.
IF HE WAS TO SURVIVE, HE WOULD HAVE TO GO BACK TO HIS ROOTS...
AND WORK THE LAND.
AND SO FREE ENERGY WAS NO LONGER FREE.



DEWDROPS ON A SPIDER'S WEB: PACIFIC SEA GYPSIES 2152 AD

STORY BY EVE CARDAS

MY NAME IS PHAEDRA FLIT. I LIVE IN A COLONY CALLED THE ARACHNAS. MANY YEARS AGO, DUE TO GLOBAL WARMING, THE LEVELS OF THE SEA ROSE, AND THE HUMAN RACE HAD TO FIND NEW WAYS OF SURVIVING. MY PEOPLE BUILT A SPIDERS WEB OF KIBBLITZ ISLANDS, EACH WITH ITS OWN PURPOSE:

THE CENTRAL ISLAND IS WHERE WE HARVEST OUR OWN ENERGY. WE HAVE WIND TURBINES WITH SOLAR PANELS ON THE BLADES, THAT TURN TO FACE THE SUN THROUGHOUT THE DAY, TO COLLECT AS MUCH ENERGY AS POSSIBLE.

THE NEXT SURROUNDING CIRCLE OF ISLANDS ARE 'HOME DOMES' WHERE WE LIVE. THEY ARE SCATTERED WITH GEODESIC DOMES MADE FROM SOLAR-THERMIC GLASS THAT FILTERS OUT THE HARMFUL RAYS OF THE SUN, BUT STILL COLLECTS THE ENERGY. THE INDIVIDUAL TRIANGLES OF GLASS CAN BE TURNED AND TILTED TOWARDS THE SUN TO COLLECT ENERGY. IT IS SAID THAT FROM SPACE, THE HOME DOMES WOULD LOOK LIKE GIANT DEWDROPS IN A SPIDERS WEB.

THE OUTSIDE RING IS FOR FACTORIES AND AGRICULTURE, THINGS LIKE WINDMILLS, FARMS, RECYCLING, WATER HARVESTING AND DESALINISATION. ALL THESE ISLANDS ARE CONNECTED BY TIDAL BOOMS SO WE CAN HARVEST ENERGY, AND UNDERWATER CURRENT TURBINES. IN A STORM, GYROSCOPES IN THE BASES OF THE DOMES KEEP THEM STEADY AND THEY RIDE OUT THE WAVES. EVERYTHING IS BUILT FROM RECYCLED WASTE THAT WE HARVEST FROM THE GREAT PACIFIC GARBAGE PATCH.

WE EAT LOTS OF FISH AND EXOTIC FRUIT AND VEG GROWN IN THE HOT DOMES. MOST OF OUR PLANTS ARE GROWN HYDROPONICALLY UNDERWATER. WE DON'T EAT MEAT OR DRINK MILK AS IT WOULD TAKE UP VALUABLE RESOURCES. WE KEEP BEES AS WITHOUT THEM THERE WOULD BE NO VEGETATION, BIRDS EGGS COME FROM THE NESTS IN TREES ON THE ORCHARD ISLAND.

EVERY DAY WE DO A DIFFERENT JOB, WHETHER IT IS TEACHING CHILDREN HOW TO WORK IN THE DOMES, GRINDING FLOUR OR SUPERVISING THE TURBINES. IF ONE PERSON IS ESPECIALLY GOOD AT THEIR JOB, THEY BECOME A TEACHER TO THOSE WHO TAKE LONGER TO LEARN.

WE MAY SEEM ADVANCED, BUT SOME ASPECTS OF LIFE ARE BASIC, LIKE MEDICAL CARE. PEOPLE HAVE SHORTER LIFE SPANS BUT HAPPIER LIVES.

FROM A WORLD WHERE EVERYONE COULD BE YOUR ENEMY, WE HAVE BECOME A SYMBIOTIC SOCIETY WHERE NOT ONLY IS EVERYONE EQUAL, BUT WE RELY AND DEPEND ON EACH OTHER -- WE COULDN'T SURVIVE OTHERWISE. PICTURE A CAMPING TRIP -- EVERYONE RELIES ON EACH OTHERS' SKILLS AND EQUIPMENT TO SURVIVE, NO-ONE CAN POSSIBLY CARRY EVERYTHING THEY NEED TO SURVIVE INDEFINITELY.

AS I'M WRITING THIS, AN EMPTY OUTRIGGER IS BOBBING GENTLY IN THE WAVES NEXT TO THE COLONY. NEXT TO IT, A GROUP OF TALL FIGURES ARE STRIDING TOWARDS A GROUP OF MY PEOPLE WHO CAME TO MEET THEM. I'M NOT SUPPOSED TO LEAVE MY DOME AT THIS TIME, SO I SIMPLY TILT THE NEAREST TILE, AND PRESS MY EAR CLOSE. "BUT, BUT I DON'T UNDERSTAND! HOW DID YOU GET HERE? HOW DID YOU FIND US?"

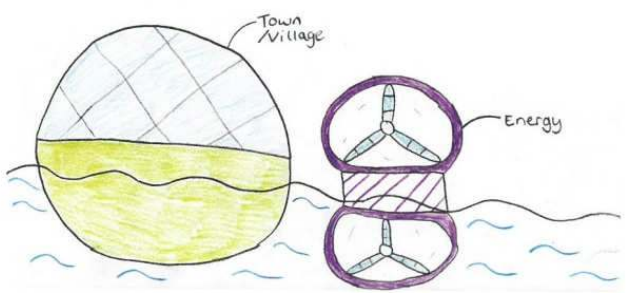
I HEAR A BIT OF MUMBLING, THE TALLEST MAN GRABS THE COLLAR OF THE SHORTEST BOY, PUTS HIS FACE INTO HIS AND THEN A DEEP GRUFF VOICE SAYS: "NOW LISTEN GOOD. FROM NOW ON, YOU'RE GONNA GIVE US HALF YOUR FOOD. OUR FARMING AIN'T TOO GOOD, SO WE GOTTA GET FOOD, DON' WE?"

"BUT, IT IS IN OUR NATURE TO SHARE AND BARTER! WE BELIEVE ALL PEOPLE MUST WORK TOGETHER TO SURVIVE-" "RUBBISH. WE'RE NOT LETTING YOU HAVE ANYTHING OF OURS. IF YOU DON' GIVE US FOOD, WE'LL SEND YOU VIRUSES, DEADLY VIRUSES, AND YOU WON'T BE ABLE TO PROTECT YOURSELVES. GET IT? COURSE YOU DO. WE'LL BE BACK FIRST THING IN THE MORNING TO COLLECT OUR BREAKFAST. COME ON BOYS, GET THE BOAT READY!"

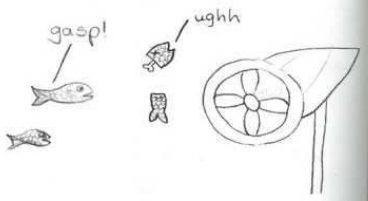
AND HE WAS GONE.

JUST LIKE THAT.

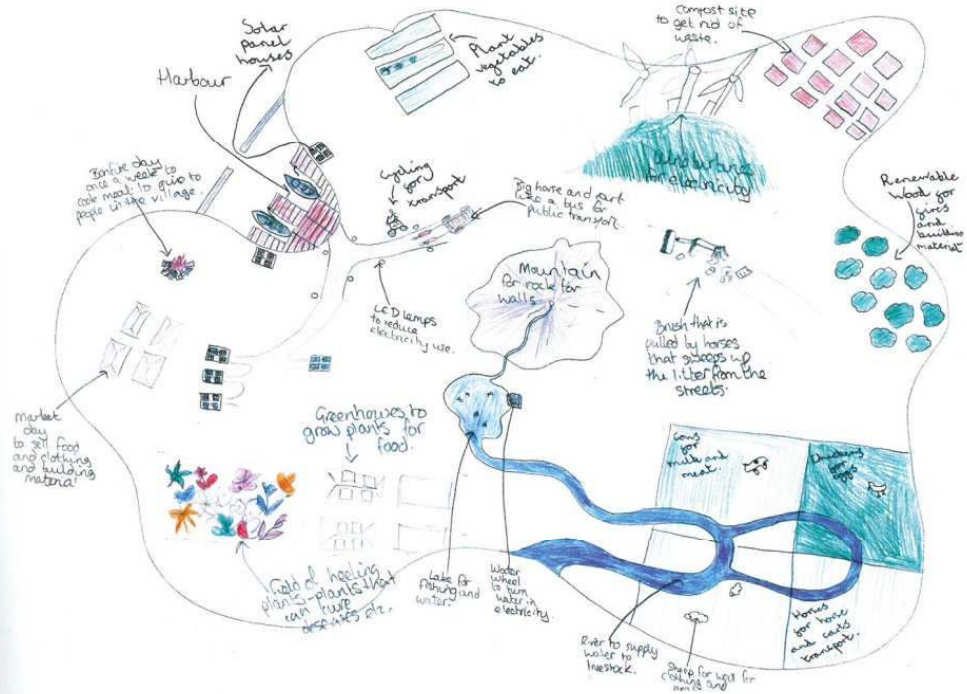
AND OUR UTOPIA ENDED.

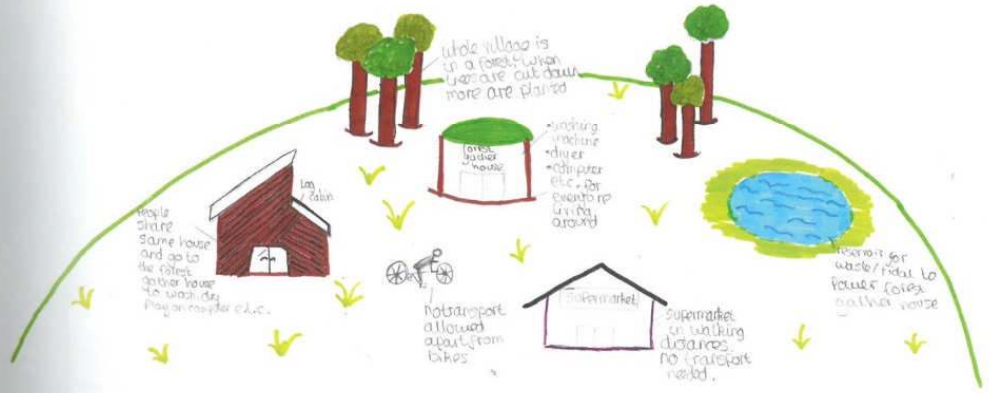


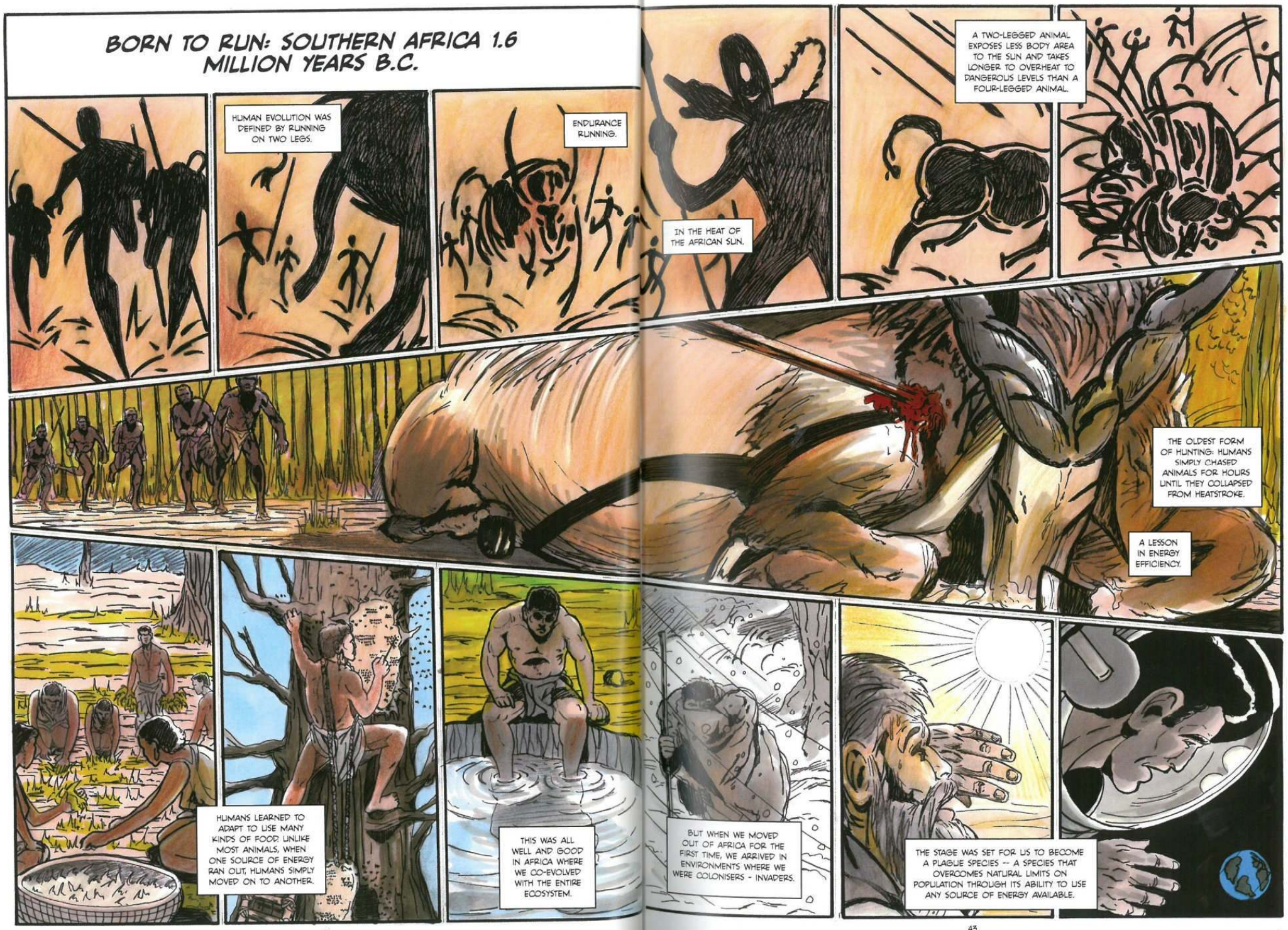
THE DOWNSIDE OF TIDAL ENERGY

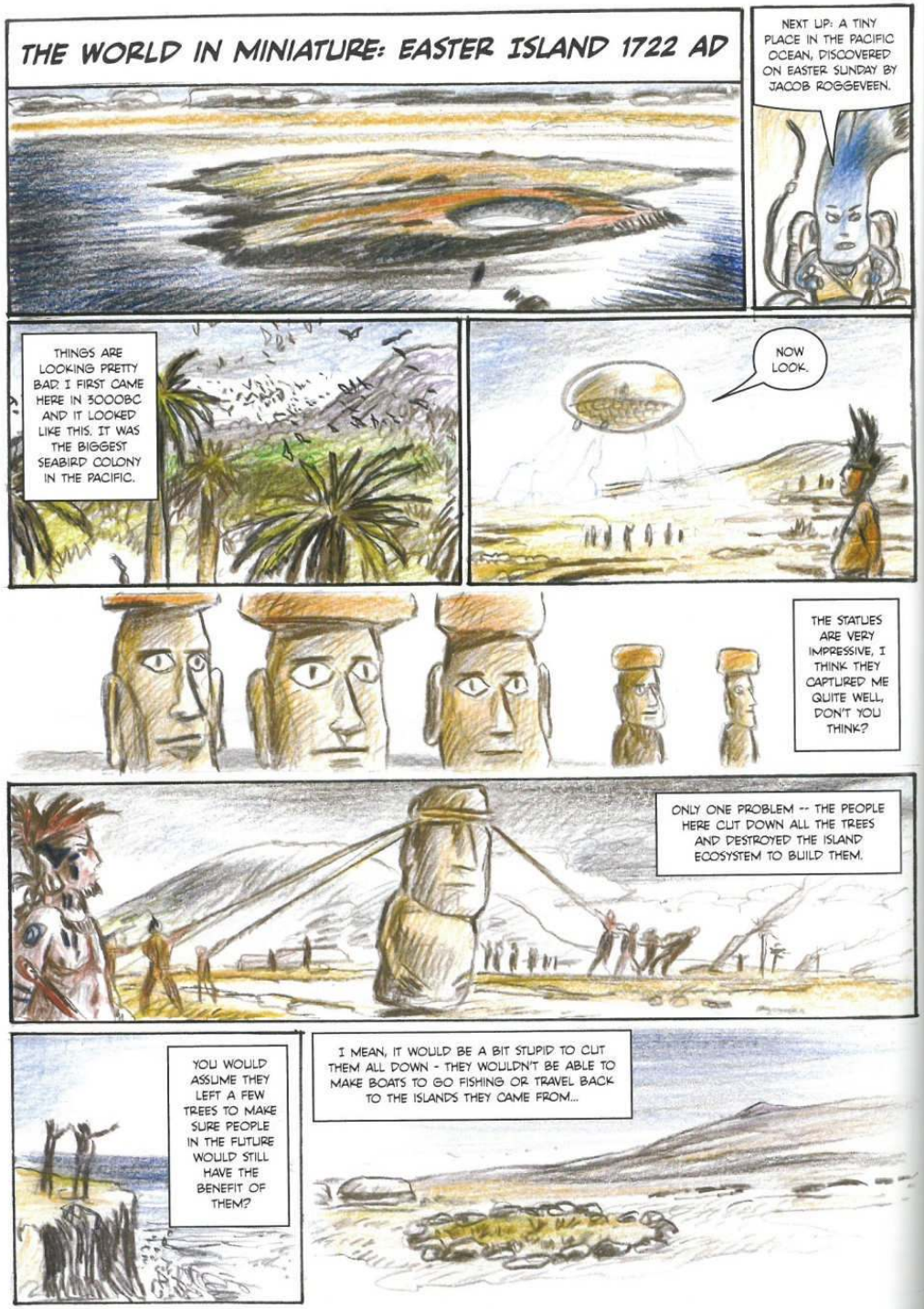


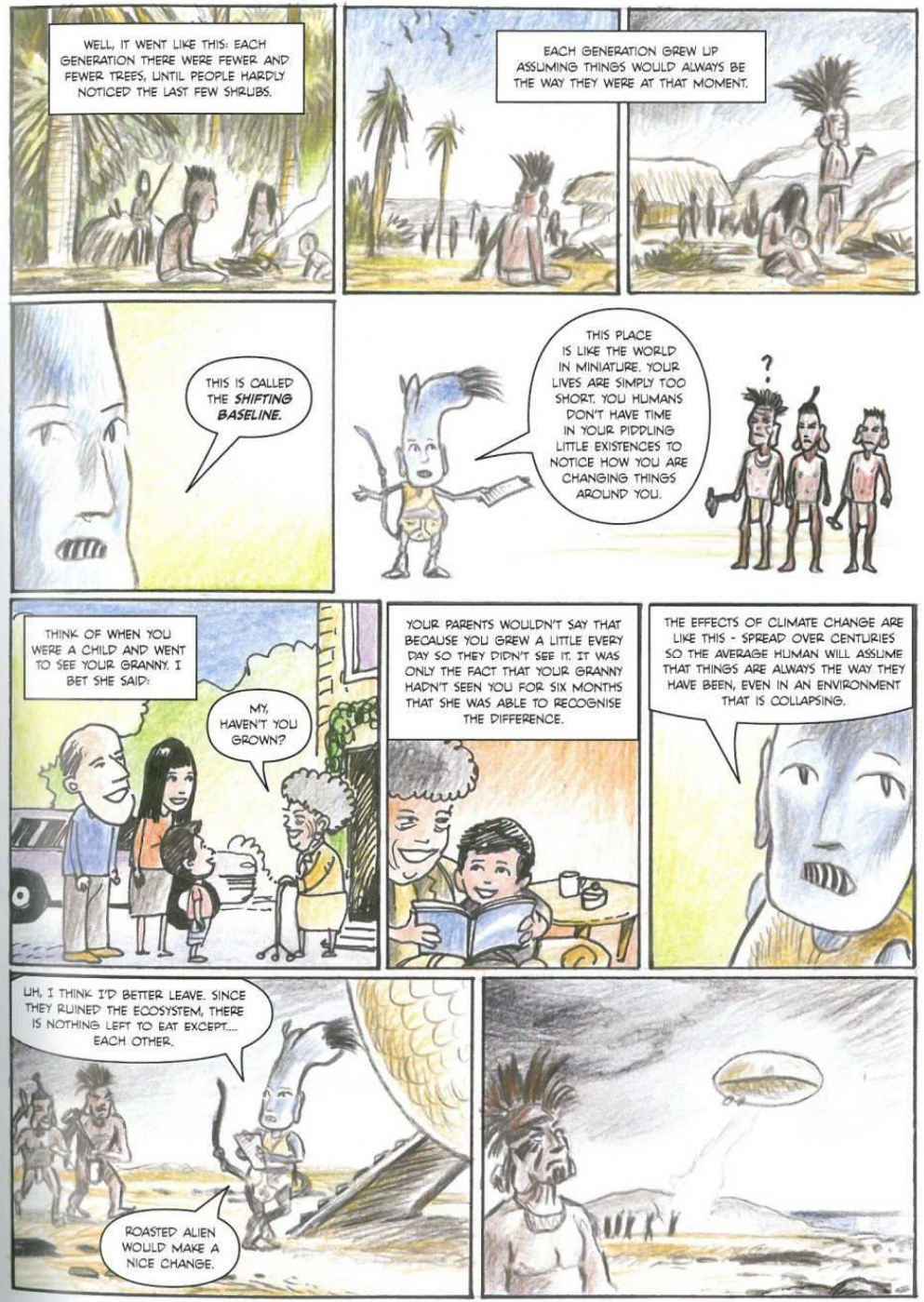
ECO-ISLANDS, 2100AD



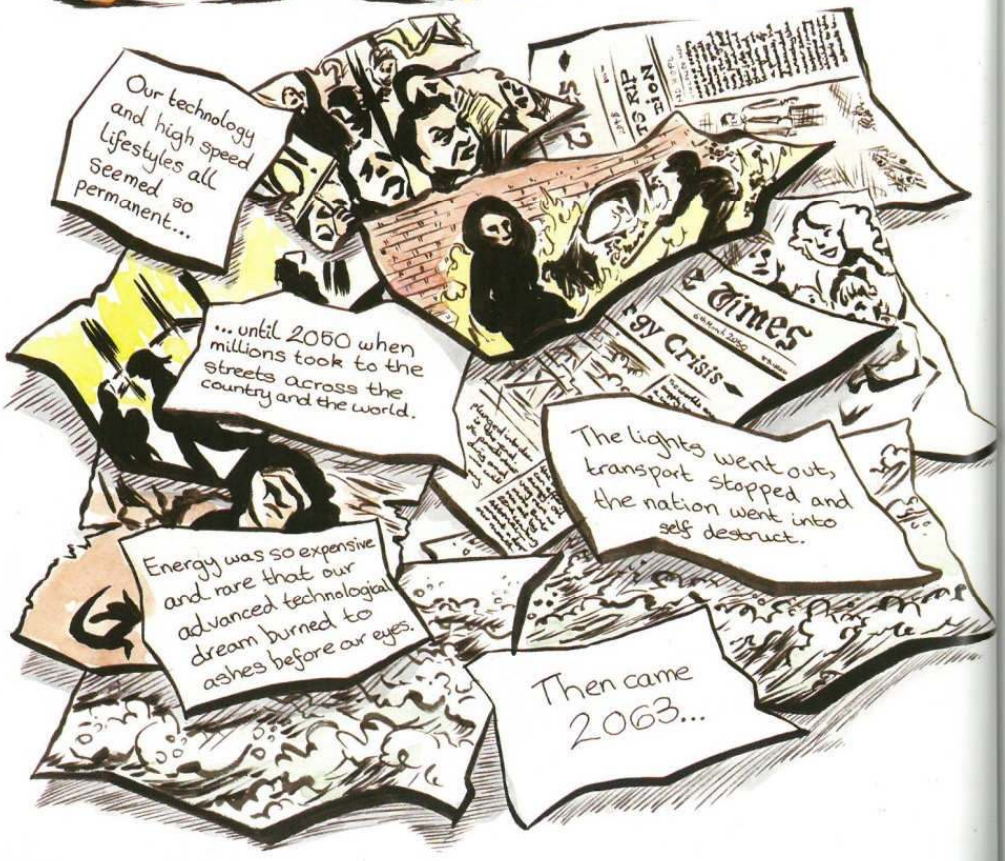



BORN TO RUN: SOUTHERN AFRICA 1.6 MILLION YEARS B.C.
HUMAN EVOLUTION WAS DEFINED BY RUNNING ON TWO LEGS.
ENDURANCE RUNNING.
IN THE HEAT OF THE AFRICAN SUN.
A TWO-LEGGED ANIMAL EXPOSES LESS BODY AREA TO THE SUN AND TAKES LONGER TO OVERHEAT TO DANGEROUS LEVELS THAN A FOUR-LEGGED ANIMAL.
THE OLDEST FORM OF HUNTING: HUMANS SIMPLY CHASED ANIMALS FOR HOURS UNTIL THEY COLLAPSED FROM HEATSTROKE.
A LESSON IN ENERGY EFFICIENCY.
HUMANS LEARNED TO ADAPT TO USE MANY KINDS OF FOOD. UNLIKE MOST ANIMALS, WHEN ONE SOURCE OF ENERGY RAN OUT, HUMANS SIMPLY MOVED ON TO ANOTHER.
THIS WAS ALL WELL AND GOOD IN AFRICA WHERE WE CO-EVOLVED WITH THE ENTIRE ECOSYSTEM.
BUT WHEN WE MOVED OUT OF AFRICA FOR THE FIRST TIME, WE ARRIVED IN ENVIRONMENTS WHERE WE WERE COLONISERS - INVADERS.
THE STAGE WAS SET FOR US TO BECOME A PLAGUE SPECIES -- A SPECIES THAT OVERCOMES NATURAL LIMITS ON POPULATION THROUGH ITS ABILITY TO USE ANY SOURCE OF ENERGY AVAILABLE.


THE WORLD IN MINIATURE: EASTER ISLAND 1722 AD
NEXT UP: A TINY PLACE IN THE PACIFIC OCEAN, DISCOVERED ON EASTER SUNDAY BY JACOB ROGGEVEEN.
THINGS ARE LOOKING PRETTY BAD. I FIRST CAME HERE IN 3000BC AND IT LOOKED LIKE THIS. IT WAS THE BIGGEST SEABIRD COLONY IN THE PACIFIC.
NOW LOOK.
THE STATUES ARE VERY IMPRESSIVE, I THINK THEY CAPTURED ME QUITE WELL, DON'T YOU THINK?
ONLY ONE PROBLEM -- THE PEOPLE HERE CUT DOWN ALL THE TREES AND DESTROYED THE ISLAND ECOSYSTEM TO BUILD THEM.
YOU WOULD ASSUME THEY LEFT A FEW TREES TO MAKE SURE PEOPLE IN THE FUTURE WOULD STILL HAVE THE BENEFIT OF THEM?
I MEAN, IT WOULD BE A BIT STUPID TO CUT THEM ALL DOWN - THEY WOULDN'T BE ABLE TO MAKE BOATS TO GO FISHING OR TRAVEL BACK TO THE ISLANDS THEY CAME FROM...


WELL, IT WENT LIKE THIS: EACH GENERATION THERE WERE FEWER AND FEWER TREES, UNTIL PEOPLE HARDLY NOTICED THE LAST FEW SHRUBS.
EACH GENERATION GREW UP ASSUMING THINGS WOULD ALWAYS BE THE WAY THEY WERE AT THAT MOMENT.
THIS IS CALLED THE SHIFTING BASELINE.
THIS PLACE IS LIKE THE WORLD IN MINIATURE. YOUR LIVES ARE SIMPLY TOO SHORT. YOU HUMANS DON'T HAVE TIME IN YOUR PIDDLING LITTLE EXISTENCES TO NOTICE HOW YOU ARE CHANGING THINGS AROUND YOU.
?
THINK OF WHEN YOU WERE A CHILD AND WENT TO SEE YOUR GRANNY. I BET SHE SAID:
MY, HAVEN'T YOU GROWN?
YOUR PARENTS WOULDN'T SAY THAT BECAUSE YOU GREW A LITTLE EVERY DAY SO THEY DIDN'T SEE IT. IT WAS ONLY THE FACT THAT YOUR GRANNY HADN'T SEEN YOU FOR SIX MONTHS THAT SHE WAS ABLE TO RECOGNISE THE DIFFERENCE.
THE EFFECTS OF CLIMATE CHANGE ARE LIKE THIS - SPREAD OVER CENTURIES SO THE AVERAGE HUMAN WILL ASSUME THAT THINGS ARE ALWAYS THE WAY THEY HAVE BEEN, EVEN IN AN ENVIRONMENT THAT IS COLLAPSING.
UH, I THINK I'D BETTER LEAVE. SINCE THEY RUINED THE ECOSYSTEM, THERE IS NOTHING LEFT TO EAT EXCEPT.... EACH OTHER.
ROASTED ALIEN WOULD MAKE A NICE CHANGE.

LOW CARBON DREAM

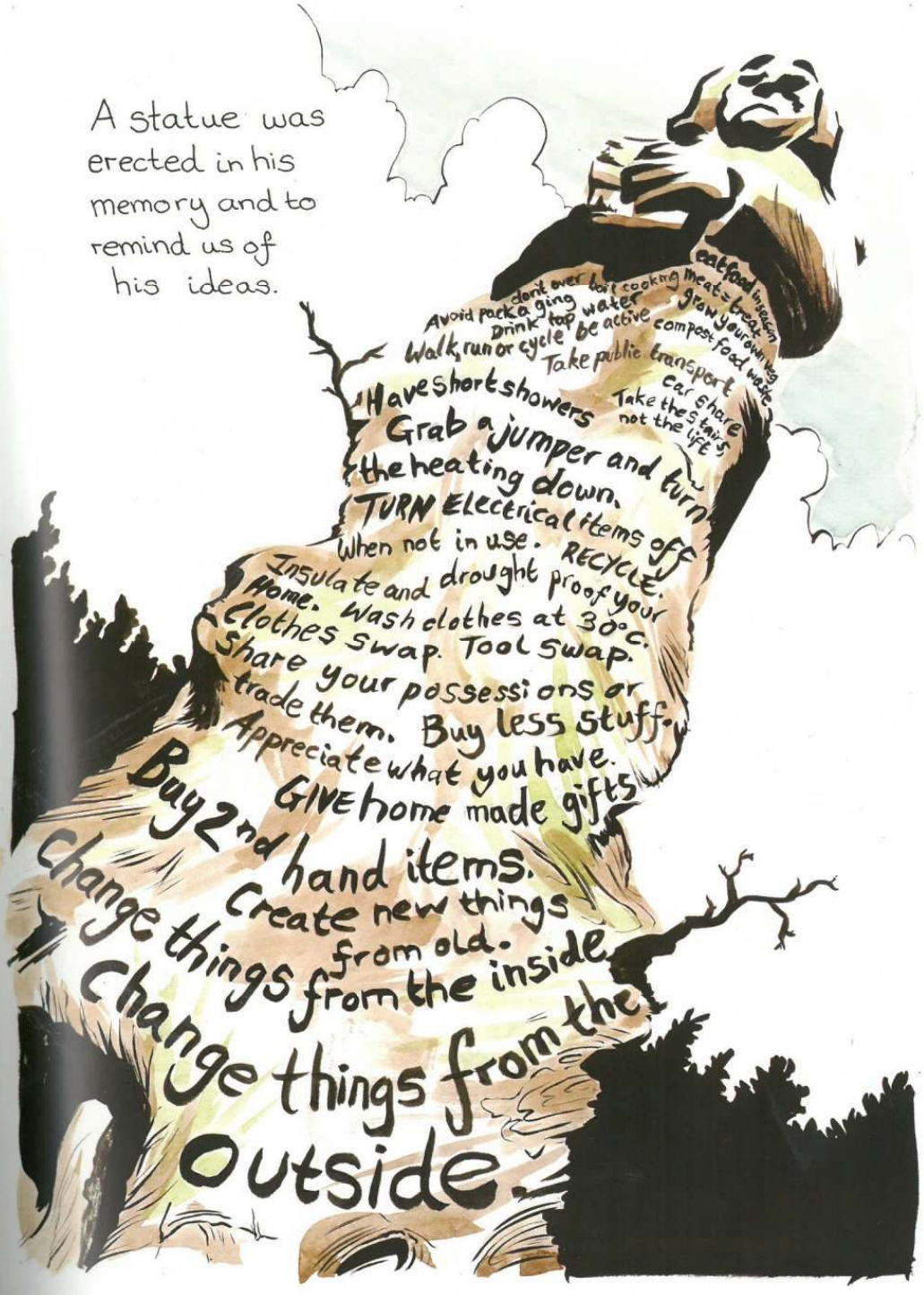



Professor Wem told us that as a boy, he witnessed the destruction of the Amazon Rainforest.
from that day on, he dedicated his life to low carbon technology.


In 2063, he took the last Brazil to UK flight to argue his ideas at a carbon energy conference.
but the floods cancelled everything


Professor Wem was a believer. He always said, never give up, change comes from within. If we utilise our knowledge and skills, we can change our world outside.


But his time with us was short. The heatwave of 2071 took many lives including Professor Wem's.


A statue was erected in his memory and to remind us of his ideas.
Avoid packaging
don't over boil
cooking meat = treat
eat food in season
Drink tap water
grow your own veg
Walk, run or cycle
be active
compost food waste
Take public transport
car share
Take the stairs not the lift
Have short showers
Grab a jumper and turn the heating down.
TURN Electrical items off when not in use. RECYCLE.
Insulate and drought proof your home. Wash clothes at 30°c.
Clothes swap. Tool swap.
Share your possessions or trade them. Buy less stuff.
Appreciate what you have.
GIVE home made gifts
Buy 2nd hand items.
Create new things from old.
Change things from the inside
Change things from the outside.

We put people in charge of our new island depending on their skills and experience.

Some were put to the task of creating the floating allotments out on the lagoon.

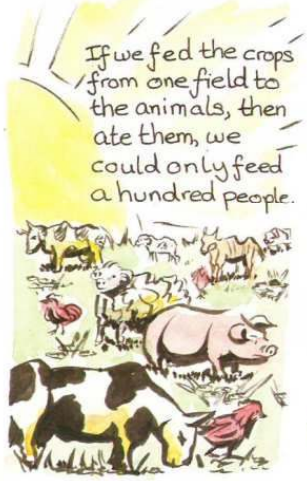
The summers, as you know are blisteringly hot. So the floating allotments could grow crops all year round.

We fertilised with biochar as it allowed us to grow crops on fertile land for generations to come.

And by growing seaweed around the island allotments, we could provide food and bioenergy for us all.

And, as you all know the micro-algae that also grows underneath the allotments still provides us with bio diesel today.

We all became vegetarian when we realised that with limited crop space we have...



Plus, we would save precious water otherwise wasted on water for livestock.

The scarcity of water in the summer has been a problem for decades.

But in winter, floods ate away at our new coastline.

So the geography team planted the reed beds to act as a flood defence.

Plus, the excess reeds make a great building material.

They provide a saltmarsh environment for wildlife...

...and can be harvested for biomass energy.

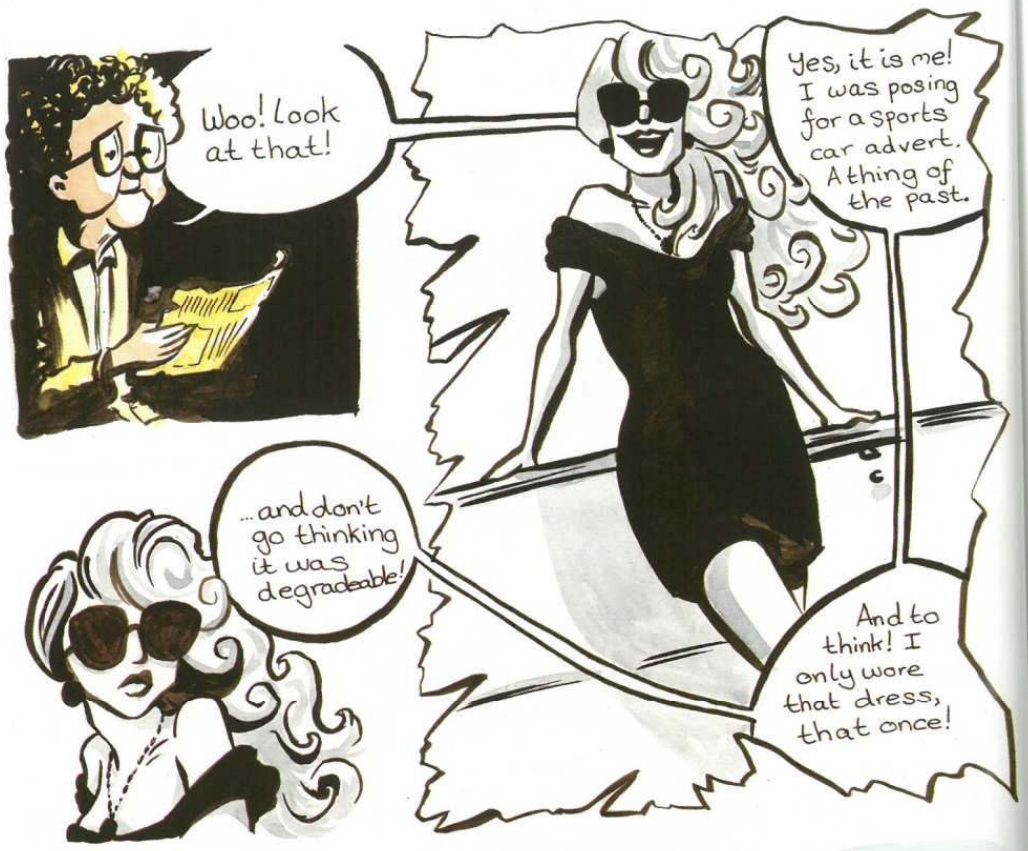
The reeds also inspired the renewable energy scientists

They created great forests of swaying wind reed hairs.

As they swayed...

...they generated energy.

Something I still enjoy watching from my window.


Woo! Look at that!
Yes, it is me! I was posing for a sports car advert. A thing of the past.
...and don't go thinking it was degradeable!
And to think! I only wore that dress, that once!


Of course, these days it is designed to protect us from the sun.


And to be edible after we are finished wearing them.


To bury one's clothes now, is to release the life awaiting within.


What better place to plant your clothes than on the roof of your house.
We made existing buildings more efficient and insulated.
There is a lot less water now than when I was a small girl.
The plants absorb and treat water.
Harvesting rainwater for us.

The engineers collected all the sources of water and waste to preserve every last drop.

To think! When I was young we flushed away our buisness with water!

We use composting toilets. With a waste retrival system we can fertilise our farms with unwanted waste.

We developed a balance where water for drinking is free.

But water for other purposes is expensive.

Around 2089 people went in search across the new oceans.

And returned with stories of survivors.

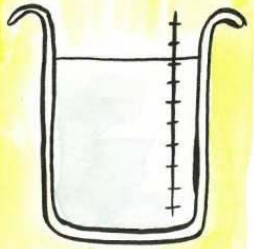
And a new map of the United Kingdom.

Thus the monorail was built to connect the many islands.

But how to power it?

We were to use wind and solar power...

... and to liquify air and store it for use when needed.



The monorail runs on liquid air using a dearman engine.

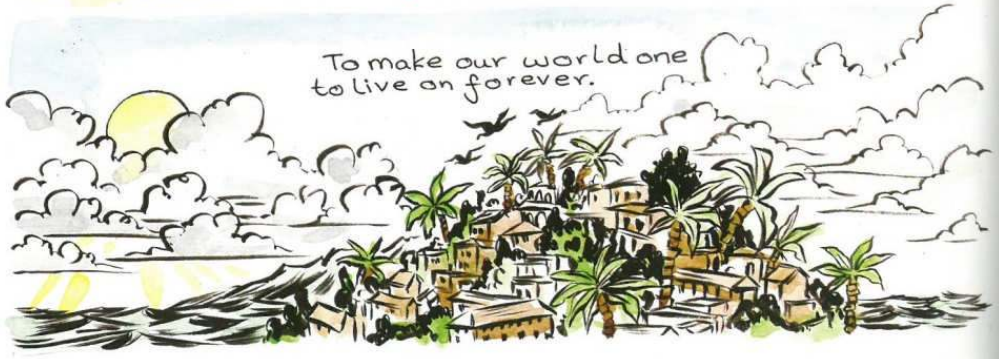

Electricity
water in
As a way to store energy as a backup we created a pumped hydro station.
Transformer
Generator
When we're producing more energy than we were using, we pump water up a tunnel to the lake at the top of the hill.
When we need energy we let all the water run back down turning huge turbines to produce electricity.
In a way, the sucess of our community has been the storage of energy.
To respond to something like a powercut


We have left behind our carbon intensive eating and drinking lifestyles.
SUPERMARKET


Happy Chicks
The old transport.

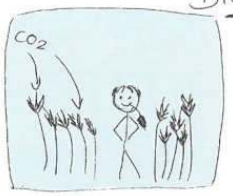

The intensive heat, water and waste strain our domestic lives put on the environment.


All of time
20th Century

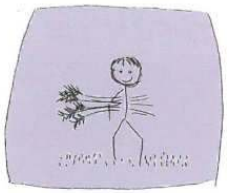


Biochar

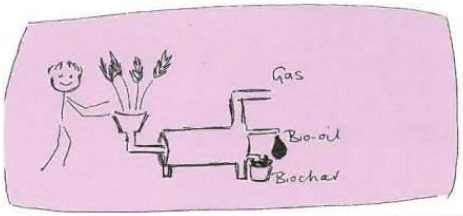
FARMER JOVI IS HAPPY -- HE HAS DISCOVERED BIOCHAR. HE IS GROWING CROPS WHICH ARE ABSORBING CARBON DIOXIDE THROUGH PHOTOSYNTHESIS.



HE HARVESTS THE CROPS, WHICH HAVE STORED THE CARBON DIOXIDE AS CARBON.

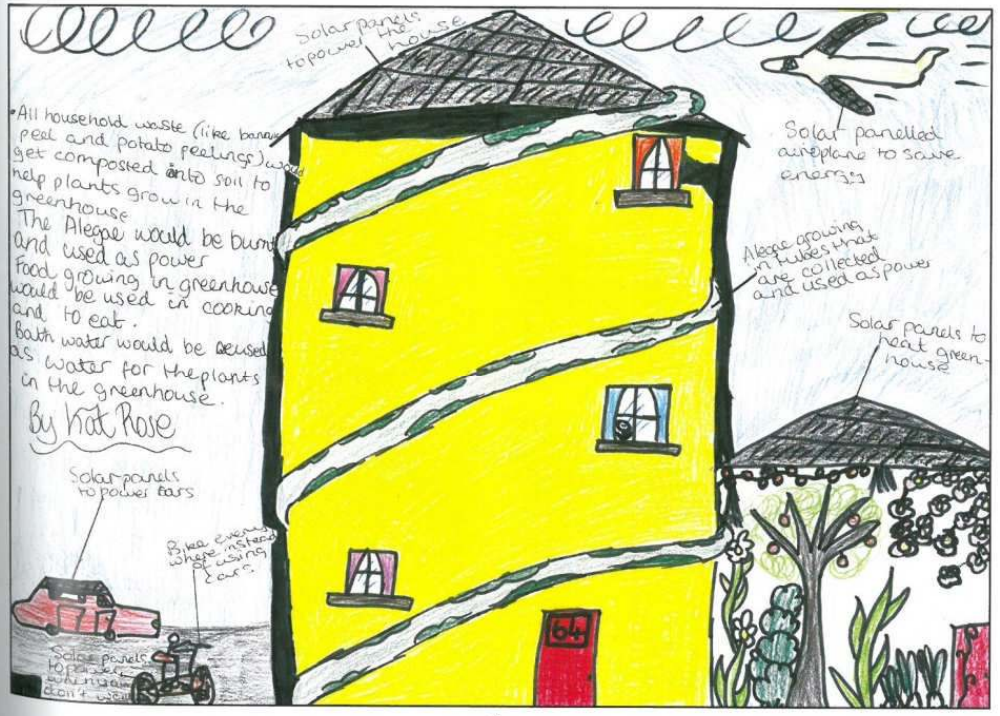


HIS FAB NEW PYROLYSER TURNS THE WASTE FROM HIS CROPS INTO BIOCHAR AND OIL AND GAS!



THE SOLID CARBON BIOCHAR IS PUT INTO HIS FIELDS. THE CARBON IS STORED IN THE SOIL INSTEAD OF GOING BACK INTO THE ATMOSPHERE.

THE BIOCHAR CAN HELP TO GROW MORE CROPS NEXT TIME, SO MORE CARBON DIOXIDE IS REMOVED FROM THE ATMOSPHERE. FARMER JOVI IS HAPPY!



LOW CARBON UTOPIA: NORTHERN UK 2113 A.D. -- EARLY FEBRUARY

LATE WINTER IS THE BEST TIME OF YEAR, AS OTHERWISE IT IS TOO HOT TO BE OUTSIDE. THE HOUSES ALL HAVE 'GREEN ROOFS' WHICH HELP TO KEEP THEM COOL DURING THE BLISTERINGLY HOT SUMMER MONTHS. THE GREEN ROOFS ARE ALSO GARDENS FULL OF FRUIT CROPS LIKE BERRIES AND GRAPES.

COLOURFULLY DECORATED WIND STALKS AND SOLAR PANELS PROVIDE ENERGY, ALONG WITH A COMBINED HEAT AND POWER PLANT (CHP) FED BY WOOD FROM THE NEARBY PLANTATION OF CROP-TREES. GIANT SHADE TREES ARE ALSO PLANTED TO SURROUND THE HOUSES AND COOL THEM. SOME HOUSES ARE ON STILTS, BOTH TO KEEP THEM SAFE DURING FLOODS, BUT ALSO THIS ALLOWS AIR TO CIRCULATED AROUND THEM AND COOL THEM DOWN.

WATER BUTTS COLLECT PRECIOUS RAINWATER.

THE CHILDREN WEAR CLOTHES THAT ARE ENDLESSLY PATCHED-TOGETHER AND RECYCLED. IN THE DISTANCE, A FAMILY ARE RETURNING FROM THE WOODS WITH A LOAD OF COPPICE-WOOD FOR BUILDING FENCES. ON THE HORIZON, THE ECO-TRAIN EXPRESS (RUNNING ON LIQUID AIR USING A DEARMAN ENGINE) IS PASSING BY ACROSS THE LAGOON ON ITS WAY TO NEARBY ISLANDS.

EVERYONE LIVES CLOSE TOGETHER AND ALL HELP EACH OTHER, ESPECIALLY DURING THE HARSH SUMMER MONTHS WHEN THE VERY YOUNG AND VERY OLD ARE MOST AT RISK FROM THE HEAT.

IN THIS ADDITIONAL VIEW, YOU CAN SEE THE MAIN VILLAGE LIVING QUARTERS -- A SINGLE BUILDING MADE OF MULTIPLE MODULES, POWERED BY A CHP PLANT. YOU CAN ALSO SEE THE STORE WHERE EVERYONE TRADES THEIR FRUIT AND VEG.

THE GREAT FLOOD: DOGGERLAND, 6,213 B.C.

AS THE ICE AGE ENDED, WATER PREVIOUSLY LOCKED IN THE ICE SHEETS FLOODED THE WORLD. SEA LEVELS ROSE 160 METRES.

...IT WAS TERRIBLE!

THE WAVES JUST CAME IN AND DROWNED T' WHOLE CRANNOG*!

*CRANNOG = A TOWN BUILT ON STILTS OVER A LAKE OR THE SEA

WE GRABBED EVERYTHING WE COULD AND RAN LIKE THE CLAPPERS.

FROM NOW ON, BERT, WE'RE GOING TO LIVE ON TOP OF A HILL.

A NICE DRY LIMESTONE OUTCROP SOMEWHERE IN THE YORKSHIRE DALES WILL DO NICELY.

...AND AS FAR AWAY AS POSSIBLE FROM THAT AWFUL ***WOLF SKULL TRIBE*** THAT KICKED US OFF OUR OLD TERRITORY IN THE FIRST PLACE!

YES DEAREST. THANK GOODNESS WE'LL NEVER HAVE TO GO THROUGH THAT AGAIN...

DYSTOPIA

All water is toxic

Clouds and Rain all the time

Illnesses coming from dead bodies

Dead

All trees cut down and not replaced

Smashed

Rats every where

Factories taking over everywhere

No-one using public transport everyone using cars that are polluting

Depressed

Flooding

ILL

DIRTY

Everything overpriced

£11:99 for bread

Smashed windows

Everyone depressed and smoking and drinking

No-one walking along pavements

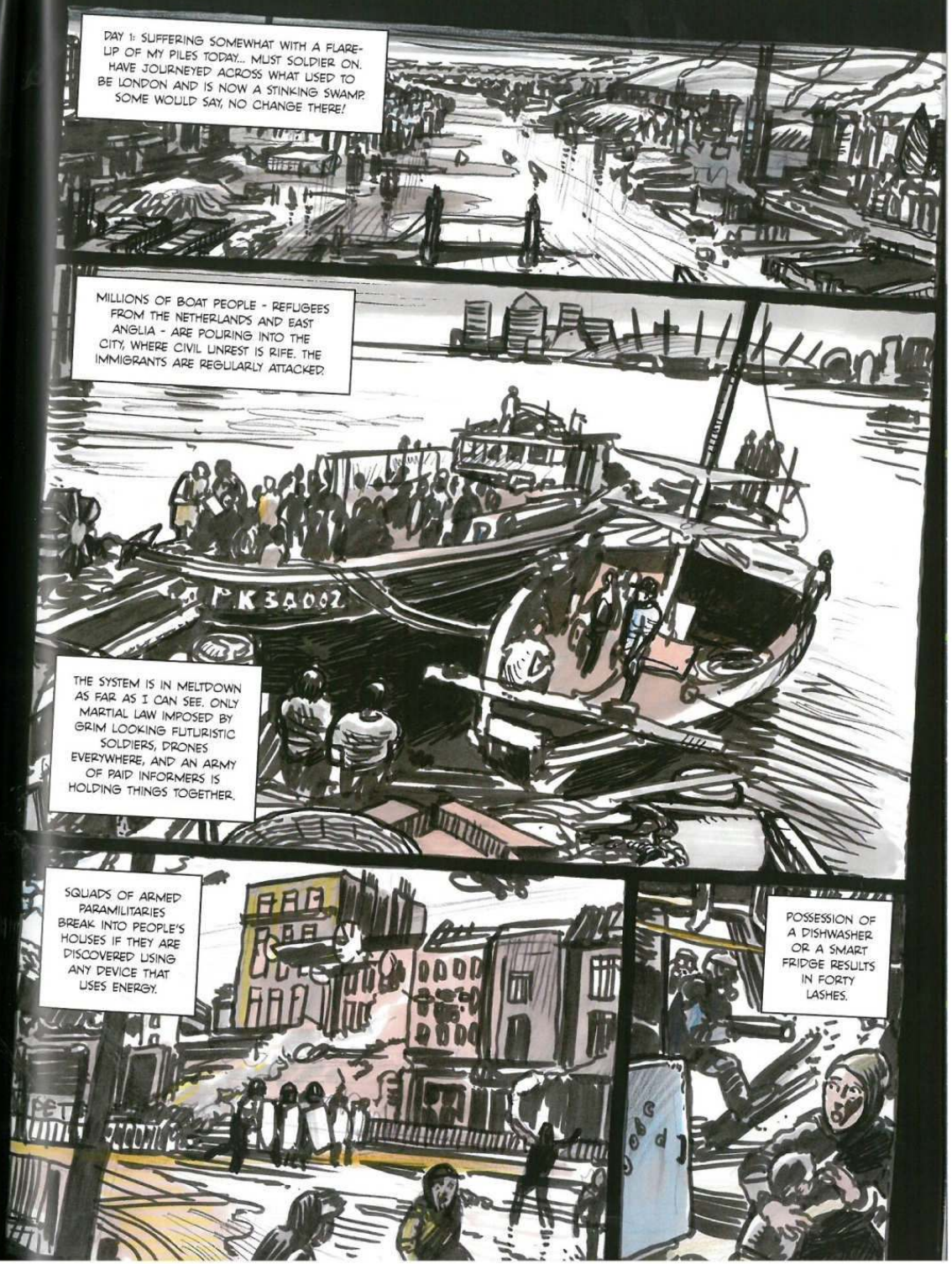
Litter Bins Tipped over

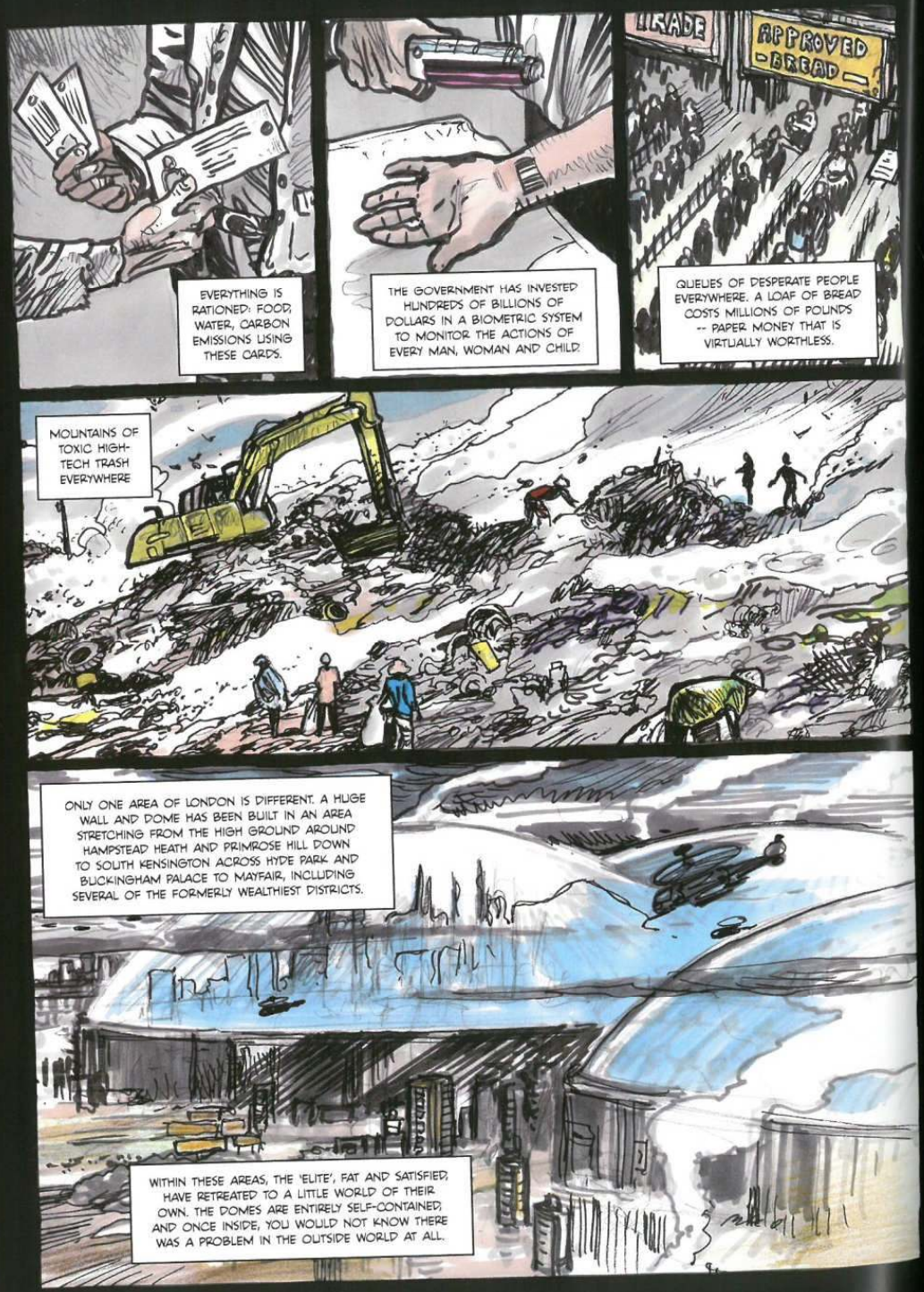
Litter

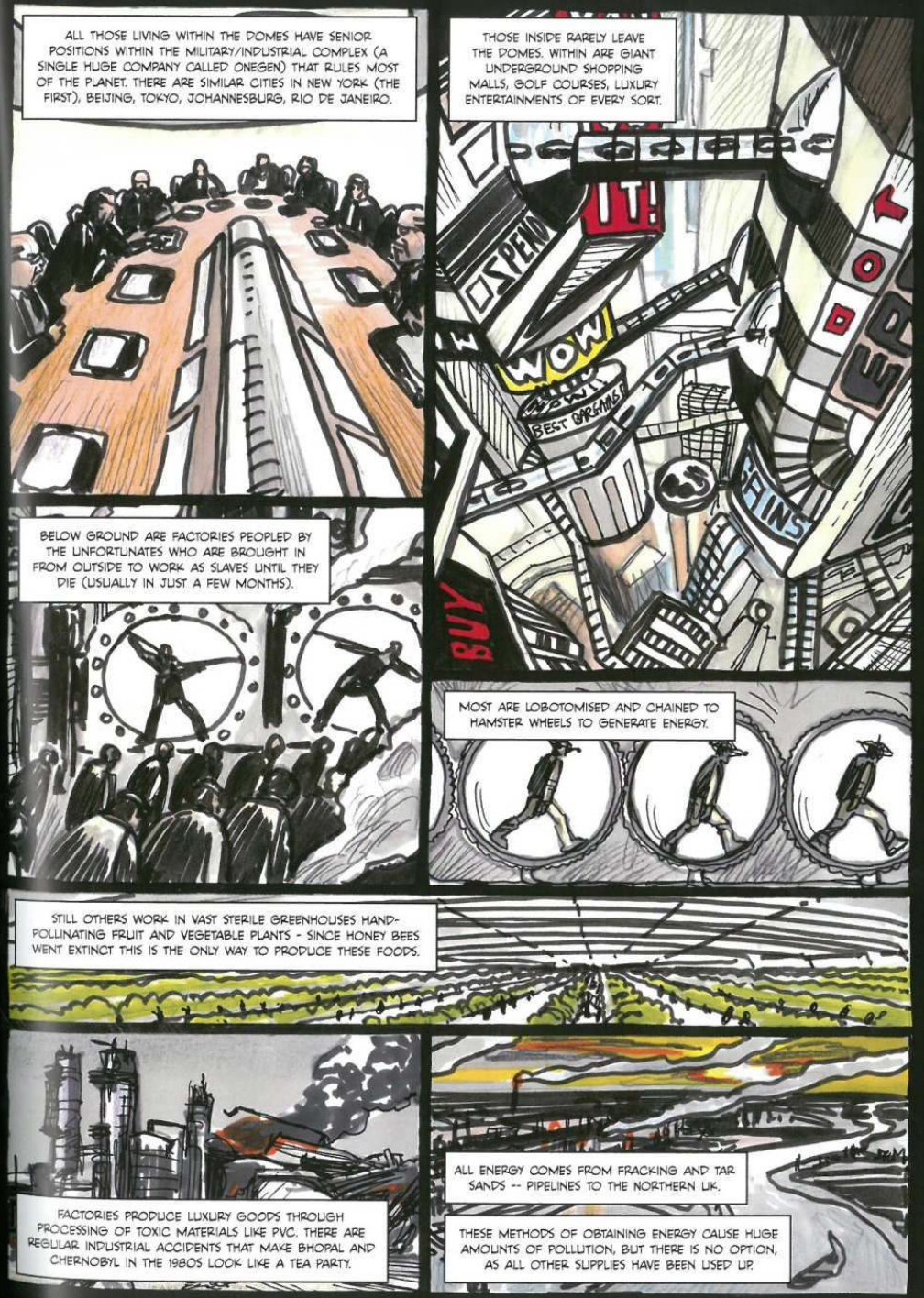

BANGLADESH - 2020.
TREADING WATER
STORY: ALON YOUNG
ART: ALEX DAWSON
A LITTLE "PITTER-PATTER" AIN'T GONNA GET IN MY WAY.
GETTING HEAVIER.
PRRR
THEN AGAIN...
SOMEWHERE YOU NEED TO BE, NUH?
IT'S SOTI. SHE NEEDS TO GET HERE SOON.
WHAT'S THE HURRY?
NORMALLY? WE MEET FOR LUNCH AND TALK ABOUT NOTHING MUCH.
BUT TODAY IS DIFFERENT.
YOU'RE GETTING MARRIED?!
YES! BUT THIS RAIN...
BE GLAD WE'RE NOT ON THE COAST!
I HEARD THE EMBANKMENTS IN CHITTAGONG...
THE BAY IS FLOODED.
ALL THE RESERVOIRS HAVE BEEN SPOILED WITH BRINE.
AND WE HAVEN'T EVEN HAD A CYCLONE YET. LAST YEAR...
...MY SISTER WAS NEARLY BLOWN AWAY!
WILL YOU COME TOMORROW?
WHERE?
TO JUMU'AH... TO PRAY.
HERE COMES MY MONSOON BRIDE!
PEOPLE... WE IGNORE THE SIGNS.
THE SIGNS CAN WAIT. TODAY, I'M GETTING MARRIED!


BANGLADESH, 2050
BUT EVERYTHING'S UNDER WATER NOW...
WATER IS WATER. HE'LL GET BY, SOTI.
I DON'T WANT HIM HERE.
THERE'S ONLY A METRE BETWEEN US AND THE SEA, NUH.
THEN WHAT... SEND HIM TO YOUR SISTER, IN THE NORTH?
BY THE MOUNTAIN? WHERE THE PEAK MELTS?
COUGH!
JUST AS BAD THERE AS IT IS HERE.
THEN THE OTHER WAY... KHULNA WAY.
AND GET SHOT AT BY OUR "NEIGHBOURS"? NO, THANK YOU.
THEN --
DON'T EVEN SAY "DHAKA"! ALL THE MUGGINGS, THE KILLINGS.
THEN IT'S SETTLED. HE GOES TO HARLEM.
MAYBE.
BETTER THAN PEDALLING A CAB UPSTREAM.
MAYBE, YES.
COUGH!
NOT MANY YOUNG ONES HERE ANYWAY...
HE'LL THANK US.
WHAT IF HE PREFERS IT OVER THERE?
THIS WASN'T WHAT I HAD IN MIND.
WE'LL ROLL WITH THE PUNCHES.


DYSTOPIA: WELCOME TO JUDD CITY - 2045AD
SO, PROFESSOR... KWERBLOIDE....ROAGAAL. CLEARLY A FAKE IDENTITY. YOU WERE CAUGHT ATTEMPTING TO SNEAK INTO JUDD CITY WITH INTENT TO FRATERNISE WITH SUBBERS.
WHAT?
SUBBERS.OUR FACTORY WORKERS. THEY ARE SUB-HUMAN, HENCE SUBBERS.
WELL, I'LL HAVE YOU KNOW I'M AN INTERGALACTIC AUDITOR FROM-
WE DO NOT CARE WHO YOU ARE.
WE CARE ABOUT THE FACT THAT YOU ARE IN JUDD CITY WITHOUT AN IMPLANT ID, AND WE HAVE REASON TO BELIEVE YOU ARE AN ILLEGAL ALIEN-
YES, I AM AN ALIEN!
WE HAVE REASON TO BELIEVE YOU ARE HERE ILLEGALLY, CARRYING INCRIMINATING PAPERS AND BLACKLISTED BOOKS.
FURTHERMORE, WE BELIEVE YOU ARE AFFILIATED TO ANTI-CONSUMERIST TERRORIST ORGANISATIONS AND PRO-RENEWABLE ENERGY SUBVERSIVES.
HERE, AND I QUOTE:
THAT'S MY PRIVATE DIARY!
DEAR DIARY...
DIARY


DAY 1: SUFFERING SOMEWHAT WITH A FLARE-UP OF MY PILES TODAY... MUST SOLDIER ON. HAVE JOURNEYED ACROSS WHAT USED TO BE LONDON AND IS NOW A STINKING SWAMP. SOME WOULD SAY, NO CHANGE THERE!
MILLIONS OF BOAT PEOPLE - REFUGEES FROM THE NETHERLANDS AND EAST ANGLIA - ARE POURING INTO THE CITY, WHERE CIVIL UNREST IS RIFE. THE IMMIGRANTS ARE REGULARLY ATTACKED.
THE SYSTEM IS IN MELTDOWN AS FAR AS I CAN SEE. ONLY MARTIAL LAW IMPOSED BY GRIM LOOKING FUTURISTIC SOLDIERS, DRONES EVERYWHERE, AND AN ARMY OF PAID INFORMERS IS HOLDING THINGS TOGETHER.
SQUADS OF ARMED PARAMILITARIES BREAK INTO PEOPLE'S HOUSES IF THEY ARE DISCOVERED USING ANY DEVICE THAT USES ENERGY.
POSSESSION OF A DISHWASHER OR A SMART FRIDGE RESULTS IN FORTY LASHES.

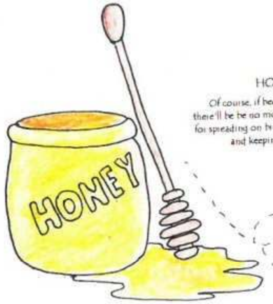

EVERYTHING IS RATIONED: FOOD, WATER, CARBON EMISSIONS USING THESE CARDS.
THE GOVERNMENT HAS INVESTED HUNDREDS OF BILLIONS OF DOLLARS IN A BIOMETRIC SYSTEM TO MONITOR THE ACTIONS OF EVERY MAN, WOMAN AND CHILD.
QUEUES OF DESPERATE PEOPLE EVERYWHERE. A LOAF OF BREAD COSTS MILLIONS OF POUNDS -- PAPER MONEY THAT IS VIRTUALLY WORTHLESS.
TRADE
APPROVED BREAD
MOUNTAINS OF TOXIC HIGH-TECH TRASH EVERYWHERE
ONLY ONE AREA OF LONDON IS DIFFERENT. A HUGE WALL AND DOME HAS BEEN BUILT IN AN AREA STRETCHING FROM THE HIGH GROUND AROUND HAMPSTEAD HEATH AND PRIMROSE HILL DOWN TO SOUTH KENSINGTON ACROSS HYDE PARK AND BUCKINGHAM PALACE TO MAYFAIR, INCLUDING SEVERAL OF THE FORMERLY WEALTHIEST DISTRICTS.
WITHIN THESE AREAS, THE 'ELITE', FAT AND SATISFIED, HAVE RETREATED TO A LITTLE WORLD OF THEIR OWN. THE DOMES ARE ENTIRELY SELF-CONTAINED, AND ONCE INSIDE, YOU WOULD NOT KNOW THERE WAS A PROBLEM IN THE OUTSIDE WORLD AT ALL.


ALL THOSE LIVING WITHIN THE DOMES HAVE SENIOR POSITIONS WITHIN THE MILITARY/INDUSTRIAL COMPLEX (A SINGLE HUGE COMPANY CALLED ONEGEN) THAT RULES MOST OF THE PLANET. THERE ARE SIMILAR CITIES IN NEW YORK (THE FIRST), BEIJING, TOKYO, JOHANNESBURG, RIO DE JANEIRO.
THOSE INSIDE RARELY LEAVE THE DOMES. WITHIN ARE GIANT UNDERGROUND SHOPPING MALLS, GOLF COURSES, LUXURY ENTERTAINMENTS OF EVERY SORT.
WOW
BUY
BELOW GROUND ARE FACTORIES PEOPLED BY THE UNFORTUNATES WHO ARE BROUGHT IN FROM OUTSIDE TO WORK AS SLAVES UNTIL THEY DIE (USUALLY IN JUST A FEW MONTHS).
MOST ARE LOBOTOMISED AND CHAINED TO HAMSTER WHEELS TO GENERATE ENERGY.
STILL OTHERS WORK IN VAST STERILE GREENHOUSES HAND-POLLINATING FRUIT AND VEGETABLE PLANTS - SINCE HONEY BEES WENT EXTINCT THIS IS THE ONLY WAY TO PRODUCE THESE FOODS.
FACTORIES PRODUCE LUXURY GOODS THROUGH PROCESSING OF TOXIC MATERIALS LIKE PVC. THERE ARE REGULAR INDUSTRIAL ACCIDENTS THAT MAKE BHOPAL AND CHERNOBYL IN THE 1980S LOOK LIKE A TEA PARTY.
ALL ENERGY COMES FROM FRACKING AND TAR SANDS -- PIPELINES TO THE NORTHERN UK.
THESE METHODS OF OBTAINING ENERGY CAUSE HUGE AMOUNTS OF POLLUTION, BUT THERE IS NO OPTION, AS ALL OTHER SUPPLIES HAVE BEEN USED UP.


FRACKING IS WHERE CHEMICALS ARE PUMPED INTO ROCK LAYERS UNDERGROUND TO FORCE OUT THE OIL AND GAS.
THE CHEMICALS LEACH UP INTO WATER SUPPLIES -- SOME CITIZENS CAN SET FIRE TO THEIR TAP WATER!
OIL IS EXTRACTED FROM STICKY DEPOSITS IN 'TAR SANDS'. FOR MILES, THE LANDSCAPE IS OBLITERATED, AND ALL LIFE WIPED OUT.
IT GOES ON...
DIARY
GIANT SPORTS UTILITY VEHICLES ARE A STATUS SYMBOL. EVERY FAMILY HAS TO HAVE AT LEAST FOUR OR FIVE, AND THE MODELS HAVE TO BE UPDATED EVERY YEAR...
ALONG WITH EVEN MORE INTENSIVELY GAS-GUZZLING PERSONAL "TOY" HOVER CARS...
...AND EVEN HOVER HOUSES!.
THE AMOUNT OF FUEL YOU CONSUME HAS ALSO BECOME A STATUS SYMBOL AS SUPPLIES ARE SO SCARCE.THERE ARE NO PEDESTRIAN AREAS -- EVERYONE DRIVES.
ANOTHER STATUS SYMBOL ARE CLONED EXTINCT ANIMALS. EACH ONE IS THE RESULT OF THE INVESTMENT OF HUNDREDS OF MILLIONS OF DOLLARS AND ARMIES OF SCIENTISTS. NO FAMILY SHOULD BE SEEN WITHOUT ITS PET THYLACINE OR DODO. AMUR LEOPARDS ARE FOR THE ELITE OF THE ELITE.
THE IRONY IS THAT NONE OF THESE ANIMALS HAVE ANYWHERE TO LIVE -- THEIR HABITATS NO LONGER EXIST. WHAT IF THE MONEY AND EFFORT SPENT HAD INSTEAD GONE TO PRESERVE THE HABITAT AND THOSE SPECIES BEFORE THEY WERE GONE?
AND SO IT GOES ON. MORE AND MORE SUBVERSIVE, ANTI-CONSUMERIST NONSENSE.
WHAT HAVE YOU TO SAY IN YOUR DEFENCE?
YOU'VE ALL BEEN BRAINWASHED! ALL THAT MIND-NUMBING TV HAS ADDLED YOUR BRAINS.
TV ENTERTAINS US WHEN WE'RE BORED. WITHOUT IT THE KIDS WOULD RIOT, SHOPLIFT AND VANDALISE AS THEY DO OUTSIDE.
BUT TV JUST PERPETUATES YOUR CONSUMER SOCIETY, AND KEEPS YOU IN A BUBBLE WHILE THE PLANET CRUMBLES AROUND YOU! WHY DON'T YOU AT LEAST TRY TO USE RENEWABLE ENERGY SOURCES?
EVERYONE KNOWS WIND FARMS CAUSE DISEASE.
THAT'S NUTS!
OUR WHOLE ECONOMY DEPENDS ON FOSSIL FUELS! OUR PENSIONS, PEOPLE'S JOBS... WITHOUT THEM, SOCIETY WOULD COLLAPSE!
IT'S GOING TO COLLAPSE REGARDLESS! CLIMATE CHANGE IS UNSTOPPABLE!
CLIMATE CHANGE. PLEASE EXPLAIN YOUR RIDICULOUS BELIEF SYSTEM TO US. REMEMBER, EVERY STATEMENT COULD BE THE DIFFERENCE BETWEEN US SETTING YOU FREE TO WORK IN THE FACTORIES, OR LIFE OUTSIDE. IT'S YOUR CHOICE.
I DON'T HAVE A RIDICULOUS BELIEF SYSTEM. ALREADY IN THE TEENS, BEFORE THEY WERE ROUNDED UP AND IMPRISONED; 1000 CLIMATE SCIENTISTS TO ONE WERE RECORDED AS SUPPORTING IT.
THE ONLY PROBLEM WAS THEY FAILED TO PREDICT HOW BAD IT WOULD GET, AND HOW FAST! THE RUNAWAY MELTING OF THE GREENLAND ICE SHEET HAS ALREADY RAISED SEA LEVELS 5M ABOVE THOSE IN THE YEAR 2000.
WE HAVE CONDUCTED OUR OWN STUDY. WE PUT DUCKS IN THE SEA AND MEASURED HOW FAR UP THEIR BACKS THE WATER WENT.
NO OBSERVABLE CHANGE! WHAT DO YOU SAY TO THAT?
water only halfway up ducks back
OK, LOCK HIM UP.
YOU'RE MAD!
SHUTTING YOURSELVES OFF FROM THE WORLD AS IT FALLS APART!
YOU'LL ONLY EARN THE RIGHT TO BE THE LAST TO STARVE!

Extinction of the Honey Bee

by Anya Walker



HONEY

Of course, if bees become extinct there'll be be no more DELICIOUS honey for spreading on bread, flavouring foods and keeping us healthy.

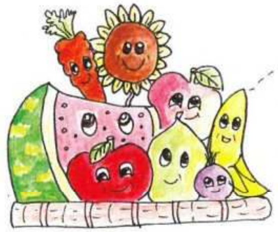
COTTON

The list of crops that won't grow without bees is a long one, a very important one is Cotton, without which we would be totally reliant on synthetic fibres made from OIL !!!

Albert Einstein is reputed to have said that mankind would become extinct four years after honeybees disappear from the face of the earth.

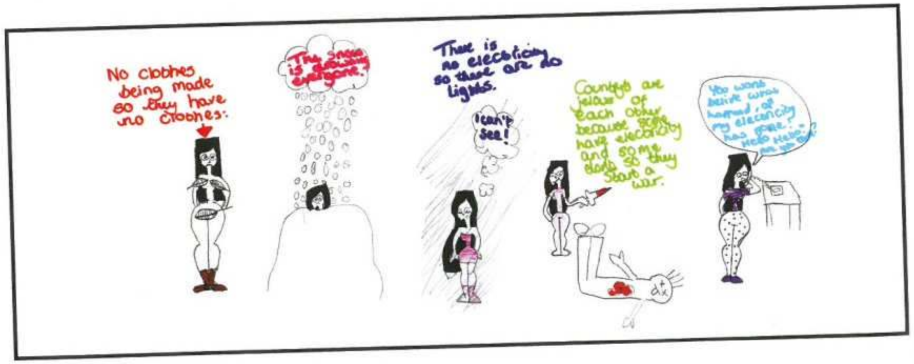
MEDICINES

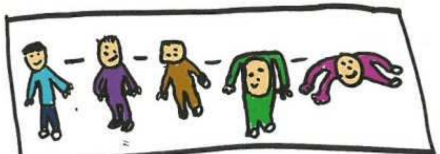
Many medicines are plant-based: Morphine- the basis of most pain-killers is extracted from opium poppies. If bees become extinct we could lose lots of our vital medicines.



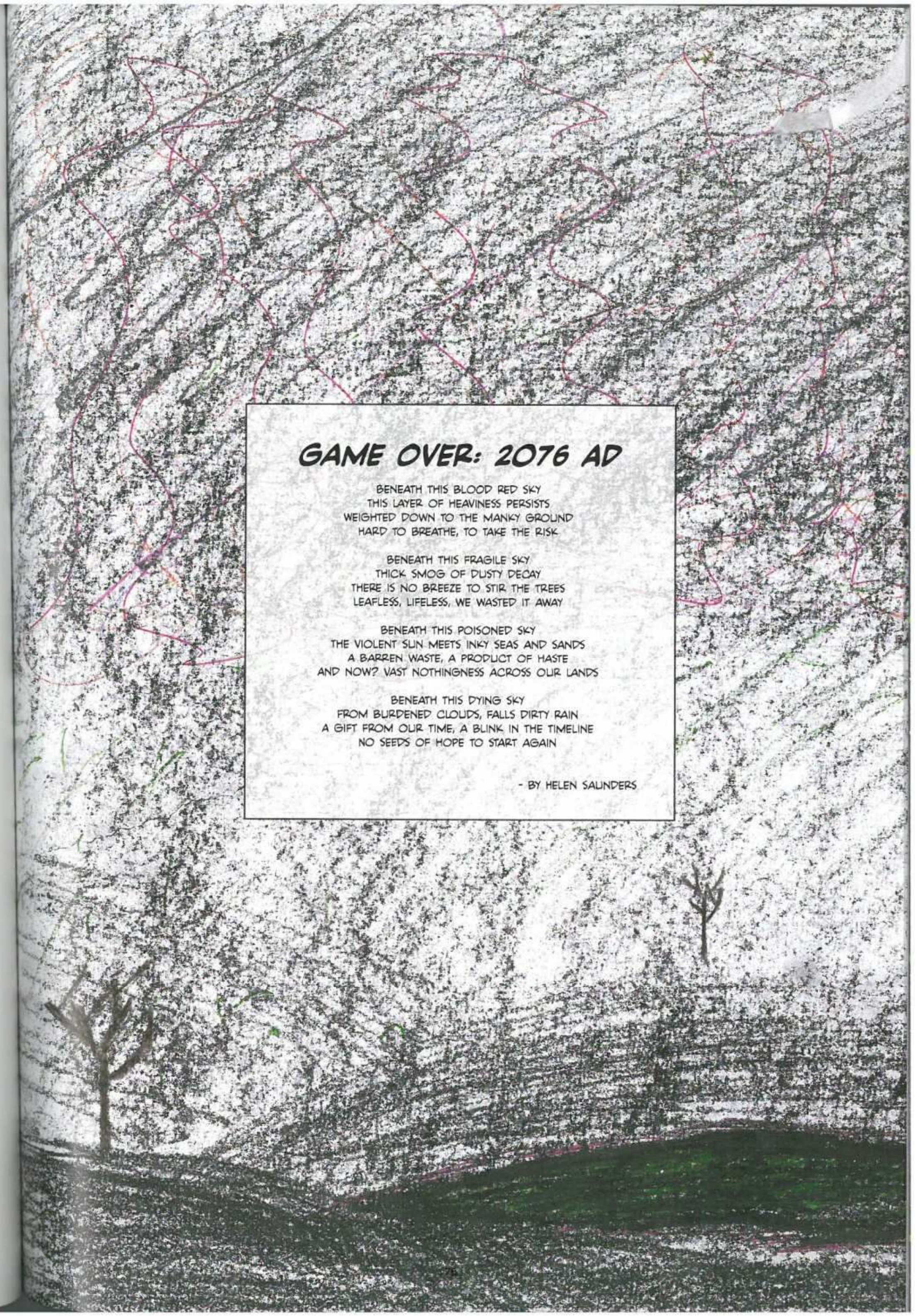
FLOWERS, FRUIT & VEGETABLES

One third of all food we eat relies on bees for its production. Without bees crop yields would fall dramatically as they help pollinate around 70% of all the world's crops.





JUDD CITY:
POLLUTION AND RADIATION ON THE OUTSIDE, CAUSING MUTATIONS TO OCCUR.



GAME OVER: 2076 AD

BENEATH THIS BLOOD RED SKY
THIS LAYER OF HEAVINESS PERSISTS
WEIGHTED DOWN TO THE MANKY GROUND
HARD TO BREATHE, TO TAKE THE RISK

BENEATH THIS FRAGILE SKY
THICK SMOG OF DUSTY DECAY
THERE IS NO BREEZE TO STIR THE TREES
LEAFLESS, LIFELESS, WE WASTED IT AWAY

BENEATH THIS POISONED SKY
THE VIOLENT SUN MEETS INKY SEAS AND SANDS
A BARREN WASTE, A PRODUCT OF HASTE
AND NOW? VAST NOTHINGNESS ACROSS OUR LANDS

BENEATH THIS DYING SKY
FROM BURDENED CLOUDS, FALLS DIRTY RAIN
A GIFT FROM OUR TIME, A BLINK IN THE TIMELINE
NO SEEDS OF HOPE TO START AGAIN

- BY HELEN SAUNDERS

EPILOGUE

UNFORTUNATELY FOR YOU, EARTHLINGS, I'M AFRAID TO SAY THAT I AM A BIT OF A FRAUD.

THERE IS NO INTERGALACTIC TASKFORCE THAT IS GOING TO SORT OUT YOUR PROBLEMS FOR YOU.

I AM JUST A CHARACTER DESIGNED BY A 10 YEAR OLD GIRL CALLED LUCY FROM LEEDS, WEST YORKSHIRE, UK.

MY UNIQUE CRAFT, THE ***BILLENIUM EGG***, REQUIRED THE ENERGY AND RESOURCES OF SEVERAL IMAGINARY STAR SYSTEMS TO CONSTRUCT, AND THEREFORE WAS ENTIRELY UNSUSTAINABLE ITSELF.

I'LL LEAVE YOU WITH A FINAL VISION OF A TRULY SUSTAINABLE SOCIETY OF THE FAR FUTURE, FROM A TIME LONG AFTER YOUR CURRENT CIVILISATION HAS COLLAPSED.

REMEMBER, IF YOU CONTINUE ON YOUR PRESENT COURSE, THE CRASH IS INEVITABLE.

ONLY ***YOU*** CAN STOP IT.

THE BEST THING I HAVE TO TELL YOU IS THAT IT ***IS*** IN YOUR POWER TO DO THIS.

LOOK AT THE COMMON ELEMENTS OF THE POSITIVE SCENARIOS IN THIS BOOK AND LEARN FROM THEM.

GOODBYEEE....

?

EVERYTHING IS CONNECTED: FUTURE HUNTER-GATHERERS

SOUTHERN GREENLAND, 2253 A.D.

JAY-RO, IT IS YOUR TURN TO SPEAK. COME HERE AND HOLD GRANDMA TIK.

I AM JAY-RO. I AM HUMAN, WHICH COMES FROM THE SAME ROOT AS HUMUS, THE DECAYING EARTH ON THE FOREST FLOOR.

WE ARE THE SAME AS THE EARTH, THE DIRT. WE ARE THE EARTH PEOPLE. "*THE EARTH AND MYSELF ARE OF ONE MIND. THE MEASURE OF THE LAND AND THE MEASURE OF OUR BODIES ARE THE SAME...*"*

*JOSEPH (NEZ PERCE 1830-1904)

SO, CHILD, TELL US ABOUT THE OLD FOLKS, AND WHAT YOU HAVE LEARNED OF THE TEACHINGS OF WEM.

OLD PROFESSOR, I HAVE STUDIED THE OLD FOLKS AND THEIR SILLY VYE-SAY-SHUN.

YOU MEAN 'CIVIL-IS-ATION'.

SORRY SIR. YES. IT WAS A PLACE WHERE MILLIONS OF PEOPLE ALL LIVED TOGETHER IN GIANT METAL BOXES IN THE SKY, CALLED 'CITIES'.

AND WHAT WAS WRONG WITH THIS?

WELL, WEM TEACHES US THAT SOMETHING SUCH AS CIVIL-IS-ATION CAN NEVER BE SUSTAINABLE. THOSE GIANT METAL BOXES REQUIRED THAT THE INHABITANTS TAKE EVERYTHING THEY NEEDED OR WANTED FROM SOMEWHERE ELSE.

AND BECAUSE THEY DIDN'T LIVE CLOSE TO THE LAND, LIKE US, THE OLD FOLKS FORGOT THAT THEY WERE PART OF NATURE, AND IN FACT THEY WENT TO WAR AGAINST IT AND USED IT ALL UP -- AFTER ALL, THERE WERE MILLIONS OF THEM. THEY WERE VERY CLEVER AT FINDING NEW WAYS TO MAINTAIN THEIR CITIES.


AND WHAT ARE THE WORDS OF WEM ON THIS?
"HUMANS ARE A PART OF NATURE AND THEIR WAR AGAINST NATURE IS INEVITABLY A WAR AGAINST THEMSELVES"*
*RACHEL CARSON
GOOD. GO ON.
THEY HAD A THING CALLED AN 'EEK-O-MONNY'
AN ECONOMY.
YES, SORRY SIR. THIS WAS WHERE THEY ALL BOUGHT STUFF, MORE AND MORE OF IT EVERY YEAR, TO KEEP THE EEK --O- NOMY GOING. SOME OF THEM HAD WHOLE CITIES TO THEMSELVES! THE THING IS, ALL THIS STUFF HAD TO BE MADE OUT OF THINGS THEY FOUND IN THE GROUND, OR FROM ANIMALS, OR FROM TREES.
IT WILL CHANGE YOUR LIFE!
THEY DESTROYED THE LAND IN ORDER TO MAKE MORE STUFF, AND POLLUTED THE AIR, THE WATER AND THE SOIL OF THE ENTIRE PLANET.
THAT IS WHY IT GOT SO HOT AND THE GREAT FLOOD HAPPENED.
AND HOW ARE WE DIFFERENT?
WE COULD NEVER SET OURSELVES APART LIKE THAT. WEM HAS TAUGHT US THAT EVERY ANIMAL AND PLANT IS A BROTHER AND A SISTER TO US, TIES OF KINSHIP THAT STRETCH BACK, AND BACK INTO THE MISTS OF DEEP TIME, TO GRANDMA TIK AND BEYOND. WE ARE ALL OF US ONE FAMILY.
WHILE WE HUMBLY ACCEPT THE SACRIFICE OF THEIR BODIES TO PRESERVE OUR OWN, WE PAY HOMAGE TO THEIR SPIRITS IN PRESCRIBED PRAYERS AND OFFERINGS, AND TAKE RESPONSIBILITY FOR THE CONTINUATION OF THEIR TRIBE.AND WE PLEDGE OUR OWN BODIES TO THEM WHEN WE DIE.

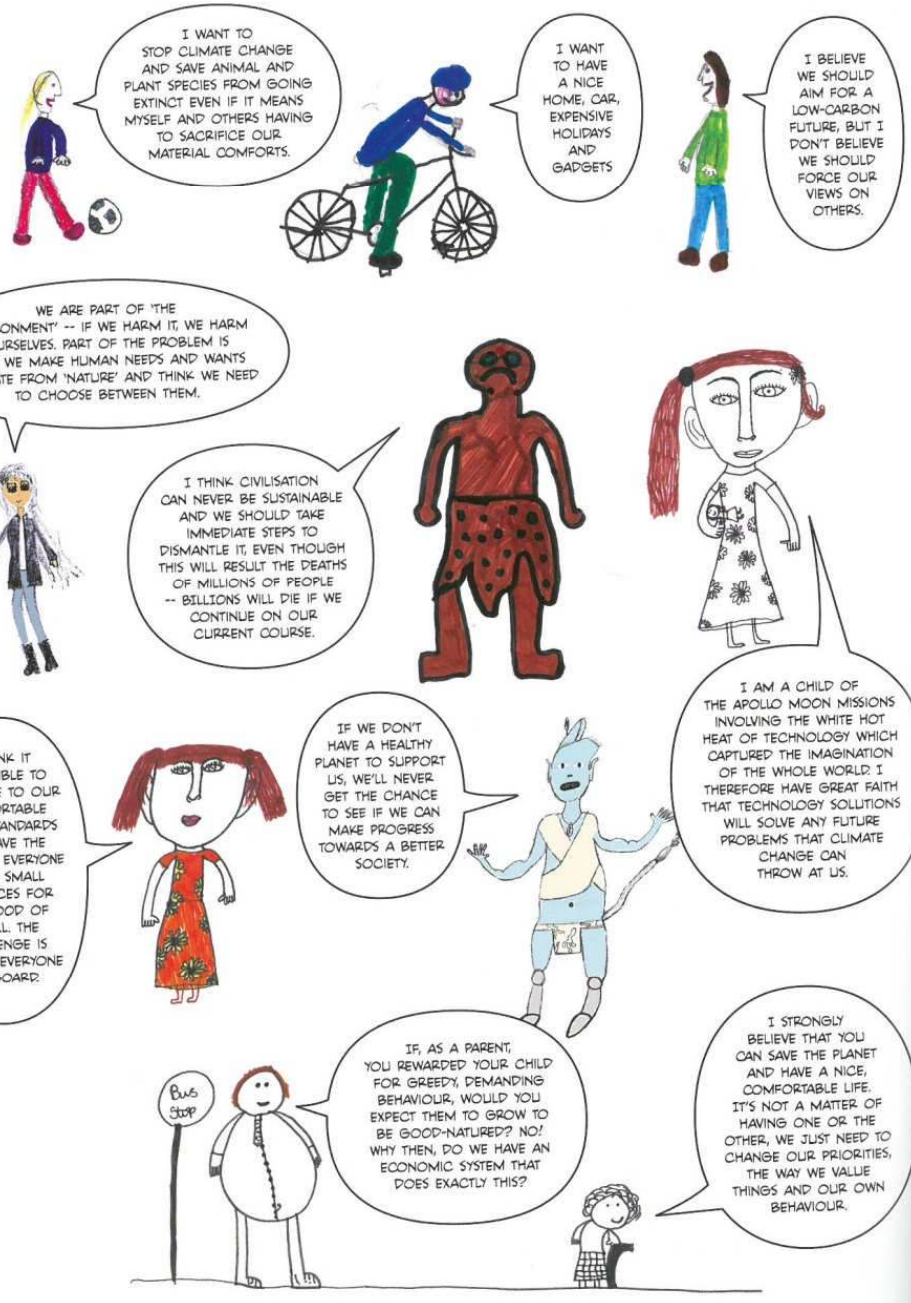

INDEED. CARRY ON. HOW WERE THE OLD FOLKS ABLE TO SURVIVE? IF WE DESTROYED OUR LAND LIKE THEY DID, WE WOULD STARVE...
WELL, SIR, THEY HAD TECH-LOGENY-
TECHNOLOGY.
YESSIR. WELL, THEY HAD IT, SO IT MEANT THEY COULD DESTROY EVERYTHING, EVEN THE PEOPLE, WHO LIVED IN ONE AREA, BUT THEN JUST MOVE ON TO THE NEXT AREA. IN THIS WAY, MOVING FROM ONE THING TO ANOTHER, THEY DESTROYED MOST OF THE PLANET. THEY CALLED EVERYTHING 'RESOURCES', WHICH MEANS, SOMETHING YOU CAN USE UP.
THEY EVEN CALLED OTHER PEOPLE 'HUMAN RESOURCES'!! IMAGINE THAT!
THEY FORGOT ABOUT WHY WE HAVE STORY PLACES LIKE THIS.
AND WHAT ARE STORY PLACES?
SOME PEOPLE REALISED THAT YOU CANNOT CONSTANTLY TAKE WITHOUT GIVING BACK.
THEY UNDERSTOOD THAT THERE IS NO SURPLUS IN NATURE: THAT WHEN YOU KILL A PLANT OR ANIMAL TO EAT IT, THAT YOU ARE TAKING THIS OTHER'S LIFE, AND ALSO THAT THIS MEANS SOMEONE ELSE CAN'T EAT THAT PLANT OR ANIMAL.
THEY UNDERSTOOD THAT ALL BEINGS NEED TO EAT, AND THAT ALL BEINGS NEED PLACES TO LIVE. THEY UNDERSTOOD THAT IN ORDER TO SURVIVE IN THE LONG TERM, YOU NEED TO MAKE SURE THAT THE LAND IS HEALTHIER BECAUSE YOU ARE THERE.
SO THE PEOPLE WOULD HAVE TO COME TOGETHER TO RECOGNIZE THEIR COMMON INTEREST IN THE LAND BEING HEALTHY, AND TO RECOGNIZE THAT HARMING THE LAND WOULD HARM ALL OF THEIR CHILDREN, AND THEIR CHILDREN'S CHILDREN.

"WE SHALL NOT CEASE FROM EXPLORATION,
AND THE END OF ALL OUR EXPLORING
WILL BE TO ARRIVE WHERE WE STARTED
*AND KNOW THE PLACE FOR THE FIRST TIME."**

*T.S. ELIOT -- FOUR QUARTETS

A LOW CARBON FUTURE: WHAT ARE YOUR OPINIONS?

VISIT HTTP://WWW.ENGINEERING.LEEDS.AC.UK/DTC-LOW-CARBON-TECHNOLOGIES TO TELL US YOURS*
*ALL THE STATEMENTS ON THIS PAGE ARE BY REAL PEOPLE



LOW CARBON FUTURE

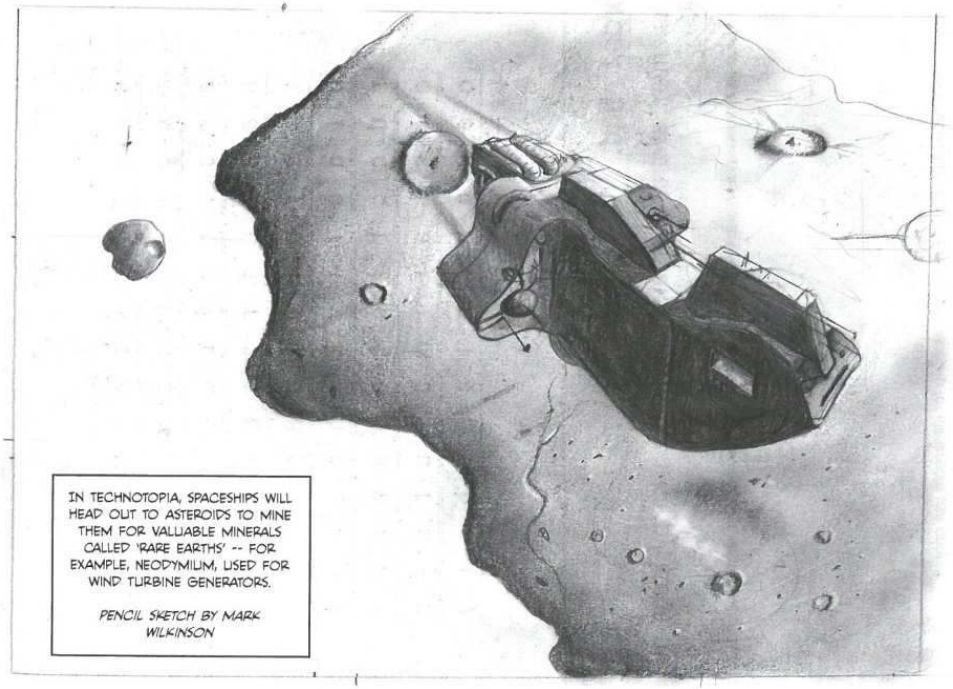
GALLERY

THIS PROJECT WAS LED BY PROF PAUL WILLIAMS AND JAMES MCKAY AT THE UNIVERSITY OF LEEDS DOCTORAL TRAINING CENTRE FOR LOW CARBON TECHNOLOGIES. JAMES MCKAY IS A COMICS ARTIST AT THE SAME TIME AS BEING MANAGER OF THE CENTRE. JAMES DEVISED THE PROJECT IN ORDER TO USE THE GRAPHIC NOVEL FORMAT AS A VEHICLE TO TRAIN ENGINEERING RESEARCHERS IN THE SKILLS AND TECHNIQUES NEEDED TO RAISE AWARENESS OF THEIR WORK WITH SCHOOL CHILDREN AND THE WIDER PUBLIC.

FIRSTLY, THE ENGINEERING PHD RESEARCHERS HELD DOZENS OF WORKSHOPS WITH OVER 350 SCHOOL CHILDREN TO INTRODUCE THEM TO THE CONCEPTS OF CLIMATE CHANGE AND ENERGY USE. THE SCHOOL CHILDREN WERE THEN ASKED TO PRODUCE PROJECT ART WORK AND WERE GIVEN FEEDBACK BY THE ENGINEERS. SOME CHILDREN'S WORK WAS USED STRAIGHT AWAY; FOR OTHERS, ARTISTS AND WRITERS WERE ENGAGED TO TAKE THE IDEAS, EDIT THEM INTO A CERTAIN NUMBER OF SCENARIOS AND THEN ILLUSTRATE A MORE COMPLETE STORY. ALL OF THE CONCEPTS AND VIEWS EXPRESSED IN THE BOOK WERE DEVISED BY THE SCHOOL CHILDREN AND ENGINEERS WITHIN THE PROJECT WORKSHOPS. NOT ALL OF THE WORK COULD BE USED, AS MANY OF THE CHILDREN AT DIFFERENT SCHOOLS PRODUCED VERY SIMILAR PICTURES (FOR EXAMPLE, LOTS OF PENGUINS ON MELTING ICEBERGS!).

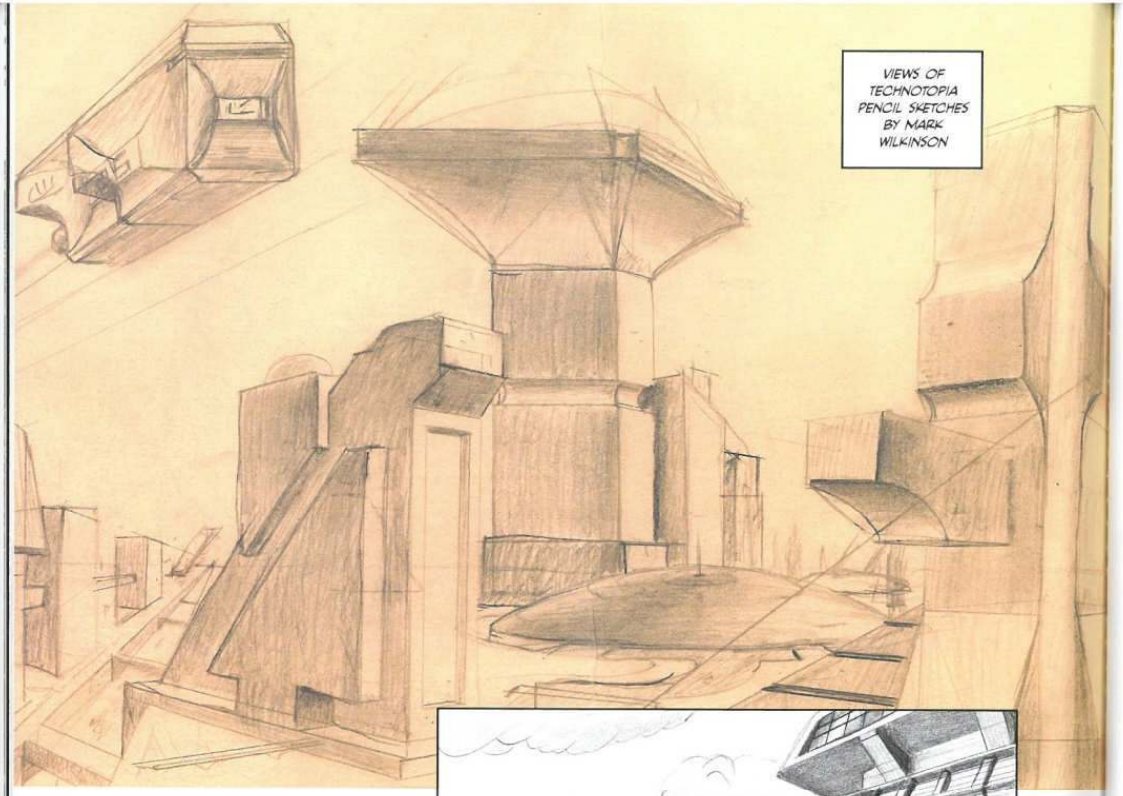
THE MAIN AIM WAS TO GET ENGINEERING RESEARCHERS, ARTISTS, SCHOOL CHILDREN AND WRITERS TO WORK IN A TEAM TOGETHER ON AN EQUAL FOOTING. WHEN THINKING ABOUT THE FUTURE, IT BECAME OBVIOUS THAT 10-YEAR OLD SCHOOL CHILDREN WERE JUST AS CAPABLE OF EXPLORING COMPLEX ISSUES AS THE EXPERIENCED SPECIALISTS, AND THEIR ARTWORK WAS OFTEN BETTER THAN ADULTS THREE TIMES THEIR AGE!

ARTWORK WHICH COULDN'T BE FITTED INTO THE MAIN STORIES CAN BE SEEN OVER THE FOLLOWING PAGES.

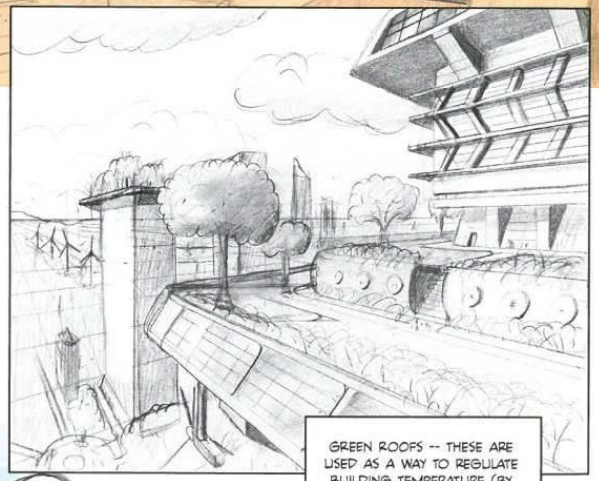


IN TECHNOTOPIA, SPACESHIPS WILL HEAD OUT TO ASTEROIDS TO MINE THEM FOR VALUABLE MINERALS CALLED 'RARE EARTHS' -- FOR EXAMPLE, NEODYMIUM, USED FOR WIND TURBINE GENERATORS.

PENCIL SKETCH BY MARK WILKINSON

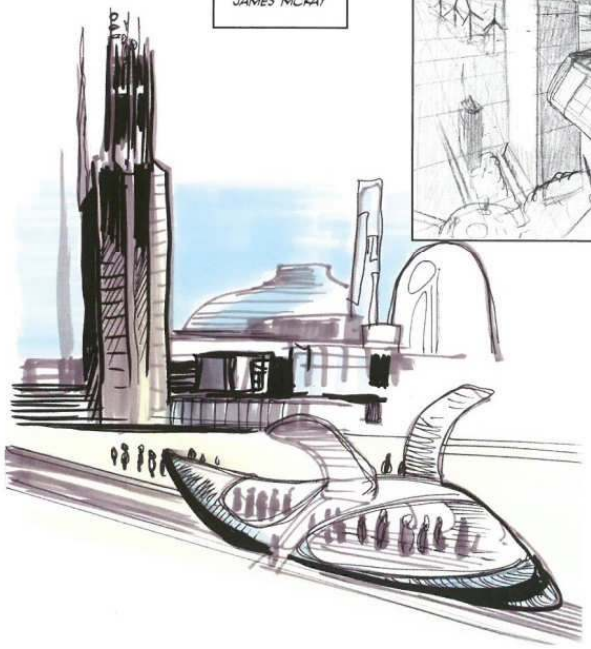


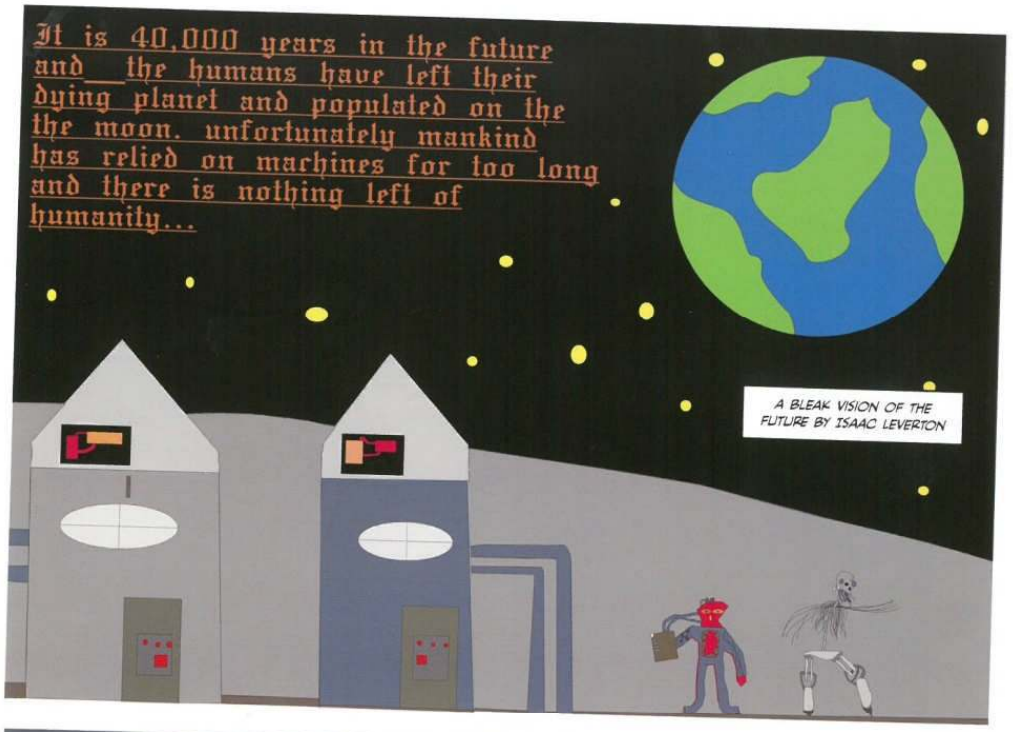
VIEWS OF TECHNOTOPIA PENCIL SKETCHES BY MARK WILKINSON



GREEN ROOFS -- THESE ARE USED AS A WAY TO REGULATE BUILDING TEMPERATURE (BY PROVIDING INSULATION), FOR WATER CAPTURE, AND TO PROVIDE AN URBAN HABITAT FOR WILDLIFE INCLUDING POLLINATING INSECTS: FRUIT AND CEREAL CROPS ARE GROWN IN HUGE VERTICAL GARDENS.

CITY POD SKETCH BY JAMES MCKAY

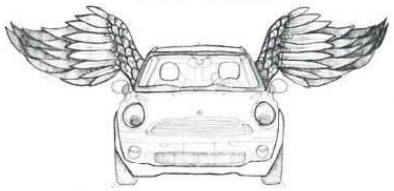




A BLEAK VISION OF THE FUTURE BY ISAAC LEVERTON

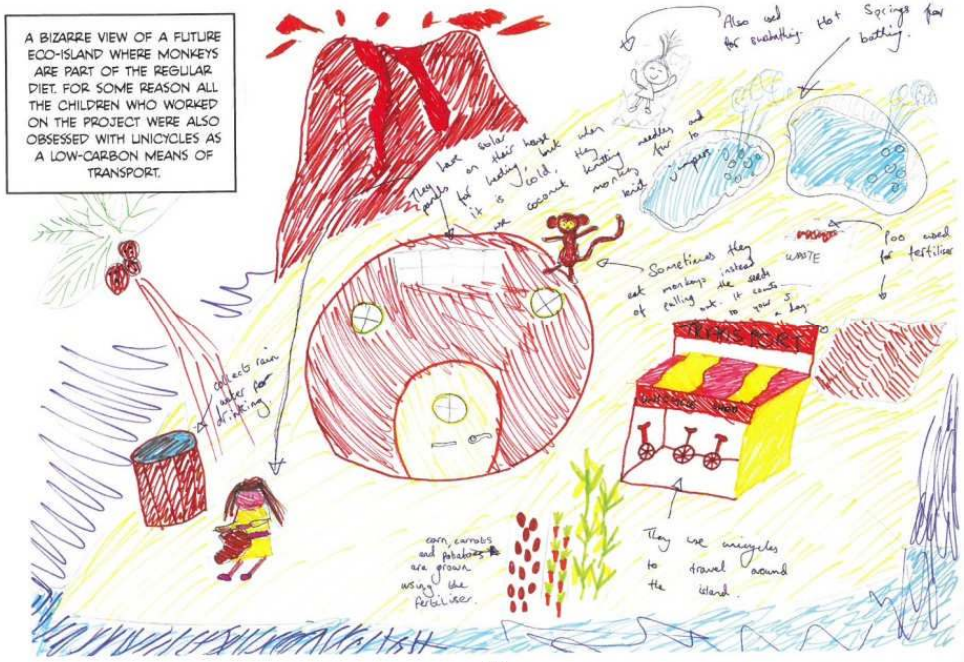
PENGUIN FAMILY ISSUES AS A RESULT OF CLIMATE CHANGE. AT LEAST JANE STILL HAS HER COCO-POPS NEARBY -- BY CHARLEY GRIFFITHS

WINGED CAR BY KIM DIAMOND

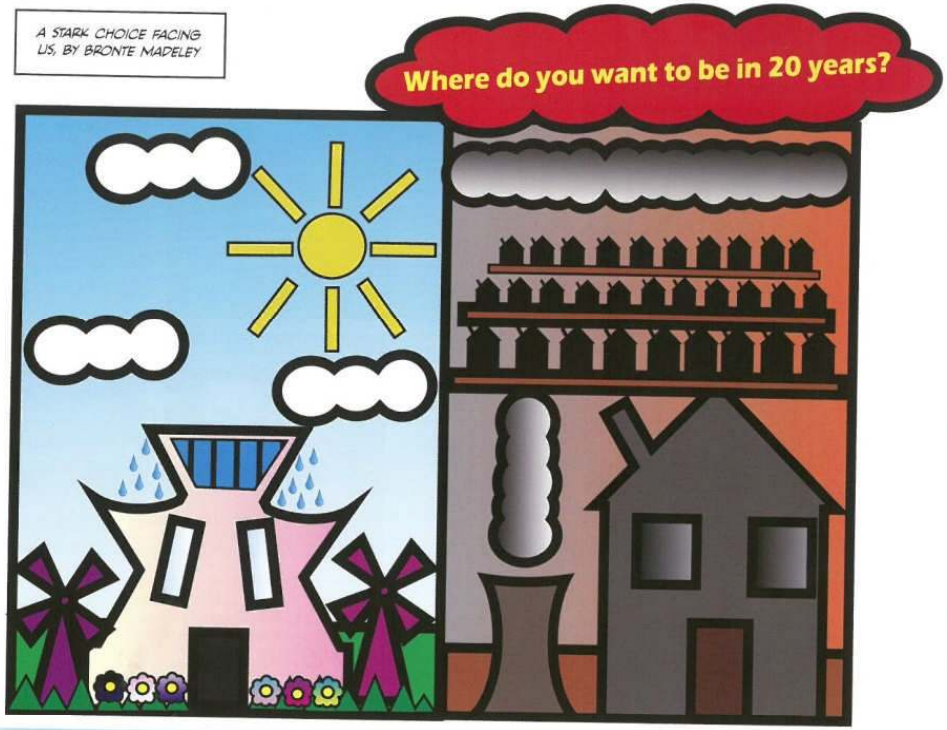


FUTURE-TECH DESERT NOMAD BY MITCHELL GREGORY -- THE NOMADS FIGHT WANDERING BANDS OF CANNIBALS AFTER CIVILISATION HAS COLLAPSED.

A BIZARRE VIEW OF A FUTURE ECO-ISLAND WHERE MONKEYS ARE PART OF THE REGULAR DIET. FOR SOME REASON ALL THE CHILDREN WHO WORKED ON THE PROJECT WERE ALSO OBSESSED WITH UNICYCLES AS A LOW-CARBON MEANS OF TRANSPORT.

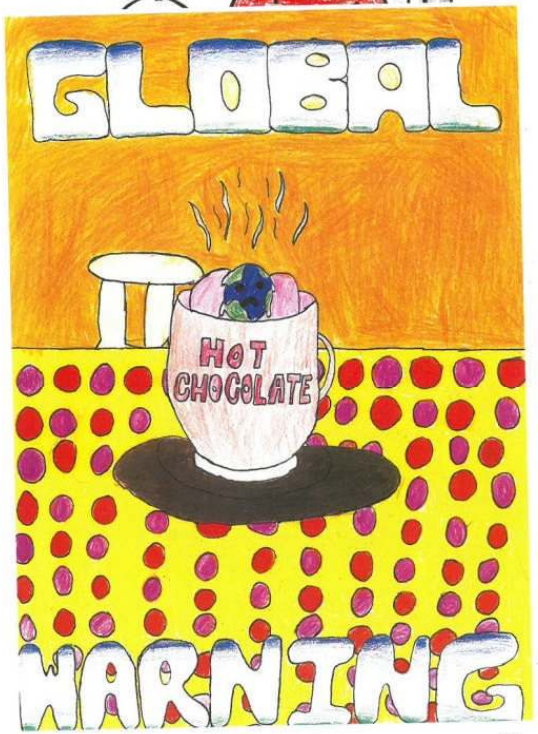


A STARK CHOICE FACING US. BY BRONTE MADELEY



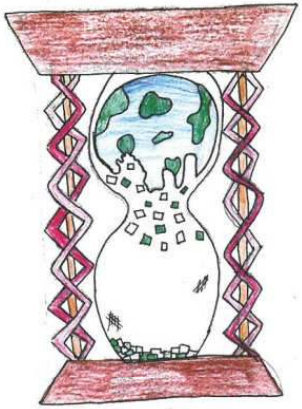
SNORKEL HOUSE, BY REBECCA WOOD. A RESPONSE TO RISING SEA LEVELS. LIVESTOCK ARE OF COURSE KEPT IN STOCKYARDS RAISED ABOVE THE WATER ON STILTS.

THIS SUMS UP OUR ECONOMIC AND ENVIRONMENTAL PROBLEMS NICELY -- COMIC BY ZAHRA MASSEY



SIMPLE -- BY ARRAN BULL

CLIMATE WARNING POSTERS BY SOPHIE DERRICK AND CARA MOULTON -- DOZENS OF INVENTIVE PICTURES OF THE EARTH BEING MELTED IN DIVERSE AND BIZARRE WAYS WERE SUBMITTED, BUT UNFORTUNATELY WE COULD ONLY INCLUDE A COUPLE: OUR FAVOURITE BEING THE ONE WHERE THE EARTH IS DROWNED IN HOT CHOCOLATE.



A VIEW OF A LOW-CARBON FUTURE SOCIETY WHERE PEOPLE LIVE IN TREEHOUSES CONNECTED BY ZIP WIRES. THEY ARE STILL RELIANT ON QUITE ADVANCED WIND TECHNOLOGY. BY HELEN SAUNDERS

MEET THE TEAM

THIS PROJECT WAS BUILT AROUND THE EXPERTISE OF THE ENGINEERS OF THE DOCTORAL TRAINING CENTRE IN LOW CARBON TECHNOLOGIES AT THE UNIVERSITY OF LEEDS, AS WELL AS OTHER RESEARCHERS CONNECTED TO THE CENTRE. THE CENTRE IS FUNDED TO LOOK INTO ALL ASPECTS OF A LOW CARBON FUTURE, FROM THINGS LIKE WIND ENERGY AND SOLAR ENERGY, TO HOW TRANSPORT POLLUTION IS AFFECTED BY DRIVER BEHAVIOUR, ECO-BUILDINGS, THE LIFE-CYCLE OF PRODUCTS, WASTE, AND ECONOMICS AND POLICY. THE RESEARCHERS CONTRIBUTED THEIR IDEAS, ARTWORK, AND CONCEPTS FOR THE FUTURE, AND ALSO WORKED WITH THE SCHOOLCHILDREN DURING THE PROJECT SESSIONS TO PRODUCE THE BOOK.

CENTRE DIRECTOR: PROFESSOR PAUL WILLIAMS

PROFESSOR PAUL WILLIAMS WHO LED THIS PROJECT IS DIRECTOR OF THE CENTRE. HE IS A PROFESSOR OF ENVIRONMENTAL ENGINEERING INTERESTED IN ENERGY, FUELS AND MATERIALS RECOVERY FROM WASTE, FOR EXAMPLE, OBTAINING HIGH-VALUE PRODUCTS FROM CAR TYRES THAT HAVE BEEN THROWN AWAY. HE HAS WON SEVERAL AWARDS INCLUDING THE 2012 DISTINGUISHED GUEST LECTURER MEDAL OF THE ENVIRONMENTAL CHEMISTRY GROUP OF THE ROYAL SOCIETY OF CHEMISTRY.

CLIMATE SCIENCE -- NICHOLA AUSTEN; ZARASHPE KAPADIA

SMALL PARTICLES IN THE ATMOSPHERE CAN HAVE A BIG EFFECT ON OUR CLIMATE. THEY ARE PRODUCED BY FACTORIES, CARS AND EVEN VOLCANOES AND PLANTS AND TRAVEL UP INTO THE ATMOSPHERE WHERE THEY REACT WITH OTHER PARTICLES AND GASES TO MAKE CLOUDS AND RAIN. SOME PARTICLES CAN BE HARMFUL TO THE ENVIRONMENT AND TO HUMANS, BUT SOME ARE USEFUL IN HELPING TO COUNTERACT CLIMATE CHANGE AND WARMING FROM GREENHOUSE GASES. NICHOLA'S RESEARCH AIMS TO SEE HOW MUCH THESE PARTICLES ARE ABLE TO HELP TO "COOL" THE PLANET THROUGH COMPUTER MODELLING.

ZARASHPE IS ALSO USING COMPUTER MODELLING TO INVESTIGATE HOW THE FUTURE USE OF DIFFERENT FUELS IN AEROPLANES MIGHT AFFECT THE ATMOSPHERE.

SOLAR ENERGY -- DAVID JACQUES; PHILIPPA HARDY; ROSS JARRETT; JOSH COTTOM; JAMIE BRIGHT

THE SUN'S ENERGY IS CLEAN, RENEWABLE AND FREE. SOLAR PANELS CONVERT SUNLIGHT DIRECTLY INTO ELECTRICITY, HOWEVER, CURRENT SOLAR CELLS ARE EXPENSIVE COMPARED TO FOSSIL FUELS AND THEIR EFFICIENCY IS LIMITED DUE TO THE MATERIALS USED.

PHILIPPA'S RESEARCH LOOKS AT MAKING A NEW SORT OF SOLAR CELL THAT USES NANOCRYSTALS (SUPER TINY CRYSTALS). ALL OF THE MATERIALS AND TECHNIQUES THAT SHE USES ARE LOW COST AND THE NANOCRYSTALS HAVE SPECIAL PROPERTIES WHICH CAN HELP TO INCREASE THE EFFICIENCY OF THE SOLAR CELL.

DAVID'S RESEARCH IS ALSO IN TRYING TO WORK OUT HOW TO USE NANOTECHNOLOGY SO THAT SOLAR PANELS CAN TURN AS MUCH SUNLIGHT INTO ELECTRICITY AS POSSIBLE.

ROSS'S RESEARCH IS ON SILVER NANOWIRES. THESE ARE LIKE NORMAL WIRES, EXCEPT A THOUSAND TIMES SMALLER THAN THE WIDTH OF A HAIR. THEY ARE USED TO MAKE A MESH TO PUT ON TOP OF SOLAR CELLS. THE MESH ALLOWS LIGHT TO PASS THROUGH IT AND ALSO COLLECTS ELECTRICITY PRODUCED BY THE SOLAR CELL.

JOSH'S RESEARCH IS ON CREATING SOLAR PANELS WITH EXTREMELY SMALL NANOPARTICLES ON THE SURFACE. WHEN THE PARTICLES ARE VERY SMALL THEY START INTERACTING WITH LIGHT IN STRANGE WAYS SUCH AS FOLDING IT INTO CONCENTRATED LAYERS NEAR THE SOLAR PANEL SURFACE. THIS CONCENTRATION OF LIGHT CAN IMPROVE HOW MUCH LIGHT IS ABSORBED BY THE SOLAR PANEL AND THEREFORE IMPROVE HOW MUCH POWER IT PRODUCES.

JAMIE LOOKS AT THE DIFFERENT WAYS OF ASSESSING THE POTENTIAL FOR GENERATING SOLAR ENERGY IN THE UK. HE'S TRYING TO WORK OUT HOW THE TECHNOLOGY WILL ADVANCE IN THE FUTURE. HE WANTS TO CONSIDER THE MANY POLITICAL, SOCIAL, TECHNOLOGICAL, AND ENVIRONMENTAL IMPLICATIONS OF DEVELOPING THE WAY THAT WE GENERATE SOLAR ENERGY.

CHRIS'S RESEARCH IS INVESTIGATING WHETHER CLIMATE CHANGE IS LIKELY TO HAVE ANY EFFECTS ON SOLAR ENERGY. PUTTING HUGE SOLAR FARMS IN DESERTS TO CREATE A LOT OF ENERGY HAS BEEN TALKED ABOUT FOR A LONG TIME AND HE'S TRYING TO WORK OUT IF THESE BIG SOLAR FARMS COULD CHANGE THE WEATHER THEMSELVES.

WIND ENERGY -- JAMES GOODING; DAVID ALLEN; SHEMAIAH WEEKES; JOEL MILLWARD-HOPKINS

THE UK IS THE WINDIEST COUNTRY IN EUROPE AND SO WE HAVE A GREAT CHANCE TO DEVELOP THIS RENEWABLE ENERGY SOURCE. WIND ENERGY CAN BE GENERATED ON MANY DIFFERENT SCALES, FROM LARGE WIND FARMS OUT AT SEA TO SMALL, INDIVIDUAL TURBINES AT PEOPLE'S HOMES AND BUSINESSES. WE WILL NEED TO USE AS MANY TYPES OF WIND ENERGY AS POSSIBLE AS WE WORK TOWARDS A LOW-CARBON ENERGY FUTURE IN THE UK.

JAMES IS RESEARCHING THE GENERATION OF ELECTRICITY AT PEOPLE'S HOUSES FROM SMALL WIND TURBINES. HE'S TRYING TO WORK OUT HOW WE CAN IMPROVE THE ACCURACY OF DOING THIS FOR EVERY TYPE OF HOUSE ACROSS THE UK.

DAVID'S RESEARCH IS IN WIND POWER ON LAND AND HE IS LOOKING AT HOW YOU CAN WORK OUT HOW MUCH WIND THERE IS IN THE WHOLE UK. BY DOING THIS, HE HOPES TO SEE AN INCREASE IN THE NUMBER OF SMALL TURBINES USED IN THE UK.

SHEMAIAH AND JOEL'S RESEARCH INVOLVES TRYING TO PREDICT HOW MUCH ENERGY WE CAN GET FROM THE WIND IN DIFFERENT PLACES AS THIS IS A MAJOR CHALLENGE TO SCIENTISTS AND ENGINEERS. THEIR GROUP'S IDEA IS TO USE MATHEMATICS AND AN UNDERSTANDING OF WEATHER TO IMPROVE THE WAY WE CALCULATE HOW MUCH WIND ENERGY WE CAN GENERATE.

NUCLEAR ENERGY -- HELEN FREEMAN; JAIYANA BUX

NUCLEAR ENERGY IS IMPORTANT FOR OUR FUTURE BECAUSE IT CAN CREATE A LOT OF ENERGY WITH A LOW CARBON FOOTPRINT. IT IS VERY IMPORTANT THAT WE FIND WAYS OF MAKING NUCLEAR ENERGY SAFELY AND WAYS OF DEALING WITH THE WASTE PRODUCTS RESPONSIBLY.

HELEN'S RESEARCH LOOKS INTO PREDICTING THE BEHAVIOUR OF THE MATERIALS USED INSIDE NUCLEAR POWER PLANTS. THE RADIATION AND HIGH TEMPERATURES INSIDE A NUCLEAR REACTOR CAN DAMAGE MATERIALS, SO UNDERSTANDING THE BEHAVIOUR OF THEM IS ESSENTIAL FOR SAFETY AND ECONOMIC SUCCESS.

JAIYANA'S RESEARCH IS ABOUT HELPING THE UK NUCLEAR INDUSTRY WITH THE CLEAN-UP OF SOME OF ITS NUCLEAR WASTE. WHEN THE NUCLEAR ENERGY BUSINESS STARTED IN THE 20TH CENTURY, PEOPLE WERE SO FOCUSSED ON CREATING ENERGY THAT THEY DIDN'T WORRY ABOUT DEALING WITH THE WASTE THEY WERE CREATING. NOW, ALTHOUGH THE WASTE NEEDING CLEAN-UP ISN'T A LOT (COMPARED WITH OTHER INDUSTRIES), IT IS TOXIC AND CHALLENGING TO DEAL WITH.

WHOLE SYSTEMS AND CARBON CAPTURE AND STORAGE -- TOM LYNCH; THOM BEST; RAY EDMUNDS; RICI MARSHALL; LLOYD DAVIES

CARBON CAPTURE AND STORAGE (CCS) IS A METHOD OF CAPTURING CARBON DIOXIDE CREATED FROM BURNING A FOSSIL FUEL IN A POWER STATION AND TRANSPORTING IT TO A STORAGE SITE DEEP UNDERGROUND FOR THOUSANDS OF YEARS, IN ORDER TO STOP THE EFFECTS OF FOSSIL FUEL USE ON THE ATMOSPHERE. THE GAS IS SQUASHED UNDER PRESSURE UNTIL THE CARBON DIOXIDE BECOMES A LIQUID SO IT CAN BE TRANSPORTED IN A PIPE.

TOM LYNCH IS USING COMPUTER MODELS TO UNDERSTAND HOW MUCH SPACE THERE IS UNDERGROUND TO STORE CARBON DIOXIDE SAFELY WITHOUT IT LEAKING BACK TO THE SURFACE.

THOM BEST LOOKS AT HOW GAS CAN BE BURNT DIFFERENTLY IN POWER STATIONS TO MAKE THE WHOLE PROCESS MORE EFFICIENT SO THAT THE ELECTRICITY PRODUCED IS AS CHEAP AS POSSIBLE.

RAY'S RESEARCH IS ON FINDING AN APPROACH TO MANAGING THE ENERGY SYSTEM AS A WHOLE RATHER THAN FOCUSING ON ONE TECHNOLOGY. HE'S TRYING TO WORK OUT HOW TO OPTIMIZE PRODUCTION FROM LOW CARBON TECHNOLOGIES AND THIS INCLUDES RESEARCH INTO OFFSHORE AND WIND ON LAND; HYDROPOWER, CCS, SMART GRIDS AND ENERGY STORAGE (FINDING

BETTER WAYS TO STORE ENERGY FROM TIMES WHEN WE DON'T NEED IT FOR TIMES WHEN WE DO NEED IT).

LLOYD IS TRYING TO WORK OUT HOW STORING ELECTRICITY AND CHANGING WHEN IT IS USED CAN HELP US MAKE SURE THE AMOUNT OF ELECTRICITY WE PRODUCE MATCHES HOW MUCH WE ARE CONSUMING. THIS IS IMPORTANT BECAUSE ELECTRICAL 'SUPPLY' AND 'DEMAND' MUST ALWAYS BE THE SAME. IF THERE ISN'T BALANCE WE CAN HAVE BLACKOUTS WHERE OUR LIGHTS AND APPLIANCES STOP WORKING.

IN RICI MARSHALL'S WORK, SHE NOT ONLY LOOKS AT THE ENERGY WE USE AND HOW WE USE IT, BUT ALSO WHY WE USE IT. NO-ONE ACTUALLY WANTS ELECTRICITY OR OIL OR GAS -- THEY'RE A BIT DANGEROUS IF YOU'RE NOT VERY CAREFUL - SO SHE WANTS TO KNOW WHY WE ARE SO OBSESSED WITH THE STUFF. SHE'S LOOKING INSTEAD AT WHAT COULD BE CALLED 'ENERGY SERVICES'; THE ACTUAL SERVICES WE GET FROM THE ENERGY -- COMFORTABLE HOMES, LIGHTING, COOKED FOOD, CLEAN HOUSES, ENTERTAINMENT AND RELAXATION.

IN THE HOME AND ON THE MOVE -- JANNIK GIESEKAM; RUTH BUSH; JO ROBINSON; HANNAH JAMES; CLARE LINTON; GILLIAN HARRISON; JON ACOMB; ANDY DIXON; HOLLY EDWARDS; DAVID WYATT;GEMMA BRADY; MORGAN TATCHELL-EVANS

WARM AND COMFORTABLE HOMES ARE REALLY IMPORTANT FOR KEEPING US HAPPY AND HEALTHY. IN ORDER TO MAKE OUR BUILDINGS AND INFRASTRUCTURE, LIKE SCHOOLS, HOMES AND HOSPITALS, THE CONSTRUCTION INDUSTRY CONSUMES AROUND 6 TONNES OF MATERIALS EVERY YEAR ON BEHALF OF EACH PERSON IN THE UK. THAT'S ABOUT THE SAME WEIGHT AS TWO ADULT ELEPHANTS PER PERSON (EXCEPT THESE ELEPHANTS WOULD BE MADE OF MATERIALS LIKE STEEL, CONCRETE AND ALUMINIUM). MAKING THESE MATERIALS USES LARGE AMOUNTS OF ENERGY AND PRODUCES A LOT OF GREENHOUSE GASES. FORTUNATELY, THERE ARE MANY OPTIONS FOR REDUCING THE USE OF THESE MATERIALS IN CONSTRUCTION. THESE INCLUDE: USING ALTERNATIVE NATURAL MATERIALS; INCREASING RECYCLING AND RE-USE OF MATERIALS; USING WASTES TO MAKE COMMON PRODUCTS; AND EXTENDING THE LIVES OF OUR CURRENT BUILDINGS.

JANNIK WANTS TO FIND OUT HOW MUCH OF A DIFFERENCE THESE SOLUTIONS COULD MAKE IN THE UK. TO DO THIS, HE WANTS TO UNDERSTAND WHAT IMPACTS THESE NEW PRACTICES MAY HAVE, WHAT PREVENTS THEIR USE AND WHAT COULD ENCOURAGE THEIR USE.

RUTH'S RESEARCH IS ABOUT HOW WE CAN HEAT OUR HOMES WITHOUT EMITTING GREENHOUSE GASES. THINGS LIKE PUTTING INSULATION BLANKETS ROUND THE WALLS AND ROOFS OF OUR HOMES, OR CHANGING FROM USING GAS HEATING TO USING SUPER-EFFICIENT ELECTRIC HEAT PUMPS. THE HARDEST THING WILL BE TO USE LESS ENERGY ALTOGETHER. SHE'S TRYING TO WORK OUT WHAT HELP PEOPLE WILL NEED TO MAKE IT HAPPEN BUT SHE ALSO WANT TO MAKE SURE ANY CHANGES ARE FAIR. AT THE MOMENT A LOT OF PEOPLE CAN'T AFFORD TO HEAT THEIR HOMES PROPERLY AND SHE THINKS WE CAN CHANGE THIS IN THE FUTURE.

JO IS TRYING TO FIND OUT HOW TO DECIDE WHAT MATERIALS AND DESIGN TO USE TO CREATE A BUILDING WHICH WORKS WELL NO MATTER WHO USES IT.

HANNAH'S RESEARCH IS ON MICROGENERATION; HOW PEOPLE CAN GENERATE ELECTRICITY AND HEAT IN THEIR OWN HOME USING ENERGY FROM THE SUN, THE WIND AND EVEN FROM UNDERGROUND. HER DREAM IS FOR EVERYONE TO BE ABLE TO GENERATE THEIR OWN ELECTRICITY FOR FREE FROM THE NATURAL RESOURCES AROUND US.

CLARE'S RESEARCH IS IN HOW PEOPLE TRAVEL IN CITIES AND HOW WE CAN REDUCE EMISSIONS FROM TRANSPORT TO STOP CLIMATE CHANGE. SHE'S EXPLORING HOW NEW TECHNOLOGY IN COMPUTERS AND SMART PHONES MIGHT HELP PEOPLE TO CHANGE THE WAY THEY TRAVEL SO THAT IT IS BETTER FOR THE ENVIRONMENT. WE COULD DO THIS BY PROVIDING INFORMATION THAT MAKES WALKING, CYCLING OR TAKING THE BUS EASIER.

IN THE FUTURE, A LARGE NUMBER OF CARS WILL NEED TO BE SWAPPED FOR LOW CARBON VEHICLES (LCVS) THAT USE ALTERNATIVE FUELS AND TECHNOLOGIES TO THOSE WE USE NOW. THIS WILL BE DIFFICULT AS WE ARE USED TO OUR CURRENT VEHICLES AND THESE NEW TECHNOLOGIES WILL OPERATE DIFFERENTLY AND COST MORE. GILLIAN IS TRYING TO WORK OUT HOW THESE TECHNOLOGIES AND POLICIES COULD RESULT IN ISSUES OF INEQUALITY AND SOME PEOPLE THINKING THAT THE PROCESS IS UNFAIR.

JON'S RESEARCH IS ON RECYCLING WASTE PLASTICS, MAINLY ON TURNING THEM INTO VALUABLE OR USEFUL MATERIALS. AT THE MOMENT HE IS WORKING ON TURNING WASTE PLASTIC INTO CARBON NANOTUBES WHICH ARE A REALLY EXCITING MATERIAL. THEY ARE WORTH OVER 20 TIMES MORE THAN GOLD AND IN THE FUTURE THEY COULD BE USED TO MAKE TOUCH SCREEN DEVICES LIKE MOBILE PHONES, HIGH STRENGTH MATERIALS LIKE BULLET PROOF VESTS AND MAYBE EVEN AN ELEVATOR THAT TAKES THINGS INTO SPACE!

ANDY'S RESEARCH IS FOCUSSED ON MAKING BETTER, LESS EXPENSIVE FUEL CELLS THAT CAN BE USED FOR ANYTHING THAT CAN RUN ON ELECTRICITY, FROM PHONES, TO CARS, TO BUILDINGS. FUEL CELLS RUN ON HYDROGEN AND AIR AND PRODUCE ONLY WATER. A SINGLE FUEL CELL IS ONLY CAPABLE OF GENERATING ABOUT 1V OF ELECTRICITY BUT AS YOU CAN 'STACK' FUEL CELLS, YOU CAN DESIGN STACKS TO GENERATE AS MUCH, OR AS LITTLE, ELECTRICITY AS YOU NEED. WHILE ALL THIS SOUNDS A LITTLE FUTURISTIC IT'S WORTH REMEMBERING THAT FUEL CELLS PUT A MAN ON THE MOON!

HOLLY IS TRYING TO WORK OUT HOW TO REDUCE GREENHOUSE GAS EMISSIONS FROM AEROPLANES. TO DO THIS SHE'S LOOKING AT MAKING BETTER USE OF COCKPIT TECHNOLOGIES, WHICH WILL ENABLE PILOTS TO FLY MORE EFFICIENTLY.

DAVID'S RESEARCH INVESTIGATES THE POLLUTION GENERATED BY ROAD VEHICLES. THE TRANSPORT SECTOR IS RESPONSIBLE FOR ABOUT 20% OF THE UK'S GREENHOUSE GAS EMISSIONS, SO REDUCING THE EMISSION FROM CARS, TRUCKS AND BUSES WILL BE A VERY IMPORTANT ELEMENT IN THE UK'S EFFORTS TO TACKLE CLIMATE CHANGE.

EVERYTHING THAT YOU READ, VIEW, PLAY AND SHARE ON THE INTERNET USES ENERGY. ALL OF THESE THINGS THAT YOU ACCESS ON THE INTERNET ARE HOUSED ON COMPUTER SERVERS. DATA CENTRES ARE ROOMS FULL OF COMPUTERS WHICH STORE AND PROCESS INFORMATION SUCH AS VIDEOS ON YOUTUBE OR PAYMENTS MADE OVER THE INTERNET. THE COMPUTERS ARE VERY POWERFUL, AND USE LOTS OF ELECTRICITY, WHICH CREATES HEAT. THEY NEED TO BE COOLED TO STOP THE COMPUTERS FROM OVERHEATING, WHICH WOULD DAMAGE THEM. THIS COOLING ALSO USES LOTS OF ELECTRICITY AND MEANS THAT DATA CENTRES ARE EXTREMELY POWER HUNGRY. GEMMA AND MORGAN FOCUS ON HOW TO REDUCE THEIR ENERGY USE SO THEY DON'T CONTRIBUTE TO THE WORLD'S RISING LEVELS OF GREENHOUSE GAS EMISSIONS.

BIOMASS -- SAM PICKARD; BEN DOOLEY; PAULA MCNAMEE; LAURA CAMPBELL

THE 'BIO' MEANS THAT THE SOURCE HAS COME FROM PLANTS. WHEN PLANTS GROW, THEY TAKE IN CARBON DIOXIDEFROM THE ATMOSPHERE. WHEN THEY DIE, THEY DECOMPOSE AND THE CARBON DIOXIDE IS RETURNED TO THE ATMOSPHERE, SO IN THEORY THE TWO PROCESSES CANCEL EACH OTHER OUT. THIS IS BETTER THAN USING FOSSIL FUELS BECAUSE THESE HAVE ACCUMULATED CARBON FROM THE EARTH OVER MILLIONS OF YEARS AND BURNING THIS CARBON INCREASES THE OVERALL AMOUNT OF CARBON DIOXIDE IN OUR ATMOSPHERE.

EDDY'S RESEARCH IS LOOKING AT HOW WE CAN BURN WOOD IN A SUSTAINABLE WAY TO HEAT OUR HOMES, WITHOUT CAUSING TOO MUCH AIR POLLUTION IN OUR TOWNS AND CITIES. (SOME SCIENTISTS EVEN THINK THAT BURNING TOO MUCH WOOD COULD CHANGE HOW CLOUDS FORM!)

SAM IS TRYING TO WORK OUT HOW WE COULD USE BIOMASS LIKE WOOD AND CROPS TO REPLACE COAL IN OUR POWER STATIONS AND HOW TO CAPTURE THE EMISSIONS BEFORE THEY POLLUTE THE ATMOSPHERE.

BEN IS LOOKING AT HOW BIOMASS ACTUALLY BURNS AND HOW WE CAN MAKE THIS PROCESS MORE EFFICIENT MEANING WE GET THE MOST ENERGY FROM THE FUEL THAT IS POSSIBLE.
TO MAKE BIOCHAR, WASTE BIOMASS IS COLLECTED BEFORE IT CAN DECOMPOSE, MADE INTO CHARCOAL THEN PUT INTO SOIL WHERE IT SHOULD STAY FOR A LONG TIME. MUCH OF THE CARBON DIOXIDE REMOVED AND STORED BY THE PLANT IS NOW STORED AS CARBON IN THE BIOCHAR. JAYNE CHOSE TO RESEARCH BIOCHAR AND OTHER WAYS TO TAKE CARBON DIOXIDE OUT OF THE ATMOSPHERE AFTER STUDYING ISSUES OF CLIMATE CHANGE AND SUSTAINABILITY.

PAULA'S RESEARCH IS IN TORREFACTION OF BIOMASS. THIS INVOLVES THE HEATING OF BIOMASS TO A TEMPERATURE OF 300ΠC IN THE ABSENCE OF AIR TO REMOVE MOISTURE, AND SOME GASES AND IN ORDER TO PREPARE THE BIOMASS TO BE MORE SUITABLE FOR THE GENERATION OF ENERGY.

LAURA'S RESEARCH IS LOOKING AT HARMFUL

EMISSIONS FROM TRANSPORT SUCH AS TINY PARTICLES OF SOOT AS THESE ARE VERY DANGEROUS FOR HUMAN HEALTH AND ESPECIALLY CHILDREN, CAUSING BREATHING PROBLEMS AND ASTHMA. SHE'S TRYING TO WORK OUT HOW BIOFUELS CAN HELP REDUCE THESE EMISSIONS AND SHE'S ALSO INTERESTED IN WASTE COOKING OIL THAT CAN BE USED TO POWER VEHICLES INSTEAD OF GOING TO THE DUMP.

ALGAE --HARRIET FLETCHER; RAMZI CHERAD; PHILIPPA USHER; HELEN SAUNDERS

BIOMASS RESOURCES ALSO INCLUDE BIOMASS FROM THE SEA (SEAWEED) AND THESE ARE BEING INVESTIGATED BECAUSE THEY DON'T COMPETE WITH FOOD PRODUCTION ON LAND. BIOENERGY WILL HAVE AN INCREASINGLY IMPORTANT ROLE TO PLAY IN THE FUTURE, BUT THE SAME TIME, GLOBAL DEMAND FOR FOOD AND WATER IS INCREASING, AND SO ENERGY PRODUCTION TECHNOLOGIES MUST LIMIT COMPETITION.

HARRIET, PHILIPPA'S AND RAMZI'S RESEARCH IS ON USING SEAWEED TO MAKE FUEL TO PUT IN YOUR CAR. THIS IS DONE BY A PROCESS CALLED FERMENTATION, WHERE LIVING YEAST USES THE SUGARS IN THE PLANT TO MAKE ALCOHOL, THE SAME WAY AS BEER IS MADE. HARRIET IS TRYING TO WORK OUT THE BEST WAY TO DO THIS BY USING A MICROWAVE. USING SEAWEED TO MAKE FUEL IS A GOOD IDEA, BECAUSE IT IS RENEWABLE AND WON'T RUN OUT IN THE FUTURE AS WE CAN GROW MORE.

HELEN SAUNDERS IS INTERESTED IN THE COMBUSTION PROPERTIES OF FUELS MADE FROM ALGAE.

THE GRAPHIC NOVEL ARTISTS

ALON YOUNG IS A COMIC BOOK WRITER, AND ALEX DAWSON IS A COMICS ARTIST, BOTH BASED IN LEEDS, AND CURRENTLY COLLABORATING ON A COMIC BOOK SERIES ENTITLED *'THE TIES THAT BIND'*(WWW.TIESBLOG.TUMBLR.COM). THIS IS THEIR FIRST COLLABORATION WHICH THEY INTEND TO PUBLISH IN 2014.

CORBAN WILKIN IS A COMICS ARTIST AND ILLUSTRATOR. IN 2012 HE WON THE PRESTIGIOUS *CAPE/COMICA* GRAPHIC SHORT STORY PRIZE FOR HIS FOUR-PAGE COMIC *'BUT I CAN'T.'* HIS COMICS HAVE APPEARED IN VARIOUS PUBLICATIONS INCLUDING OFF LIFE AND LIVE MAGAZINE. HE'S ALSO WORKED IN ILLUSTRATING FOR MAGAZINES AND BOOKS, ANIMATING FOR VIDEO GAMES, AND STORYBOARDING FOR FILMS. HE'S WRITTEN AND DRAWN SOME GRAPHIC NOVELS TOO, INCLUDING *'BREAKER'S END'* WHICH DEBUTED AT THE 2013 LATITUDE FESTIVAL AND WAS LISTED FOR THE MYRIAD FIRST GRAPHIC NOVEL PRIZE. *WWW.CORBANWILKIN.COM*

JAMES MCKAY IS A COMICS ARTIST AND ILLUSTRATOR, CURRENTLY WORKING FOR 2000AD MAGAZINE ON THE SCI-FI SERIES *'FLESH'*, WRITTEN BY PAT MILLS. JAMES HAS ALSO PUBLISHED THE GRAPHIC NOVEL SERIES *"CITY OF SECRETS"* IN FRANCE, AND HAS ILLUSTRATED BOOKS, DONE CONCEPT WORK FOR TV PROGRAMMES AND COMPUTER GAMES, AND ILLUSTRATED SCIENTIFIC PAPERS (ESPECIALLY ON DINOSAURS AND PREHISTORIC LIFE). HE WAS SHORTLISTED FOR THE 2009 *ARTS FOUNDATION AWARD* FOR BEST NEW UK GRAPHIC NOVEL ARTIST. *WWW.JAMESMCKAY.INFO*

MARK WILKINSON, THE COVER ARTIST, WAS ALWAYS TOLD OFF IN SCHOOL FOR NOT PAYING ATTENTION IN CLASS. HE STARTED WORK IN THE ELECTRONICS FIELD BUT IT WASN'T LONG BEFORE HIS INNER ARTISTIC MUSES CAME CALLING. BY CHANCE HE CAME ACROSS A BOOK ABOUT SCI-FI AND FANTASY ART, AND WAS SO INSPIRED BY THIS HE BEGAN TO PRODUCE FANTASTIC PIECES OF WORK DEPICTING ALIEN WORLDS AND FUTURE TECHNOLOGIES.

BENJAMIN DICKSON IS A COMICS WRITER/ARTIST AND REGULAR COLLABORATOR WITH JAMES MCKAY. HIS OWN COMICS INCLUDE THE NON-FICTION GRAPHIC NOVEL *'FIGHT THE POWER! A VISUAL HISTORY OF PROTEST AMONG THE ENGLISH-SPEAKING PEOPLES'* (CO-WRITTEN WITH SEAN MICHAEL WILSON, ILLUSTRATED BY VARIOUS), *'SLUMDROID'* (WITH TONY SULERI), AND *'SANTA CLAUS VS THE NAZIS'* (WITH GAVIN MITCHELL) AMONG OTHERS. *WWW.BENDICKSON.CO.UK*

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GLOSSARY
(FOR FURTHER DETAILS ON SOME TYPES OF ENERGY, SEE 'MEET THE TEAM')

ATOM
AN ATOM IS THE SMALLEST PART OF A CHEMICAL SYSTEM, MAKING UP EVERYTHING THAT EXISTS. ALMOST ALL OF AN ATOM IS EMPTY SPACE. AT THE CENTRE IS A TINY POSITIVE NUCLEUS COMPOSED OF PROTONS AND NEUTRONS, AND THE REST OF THE ATOM CONTAINS ONLY ELECTRON SHELLS.

BIODIVERSITY
BIODIVERSITY IS THE VARIETY OF ALL LIVING THINGS, INCLUDING PLANTS, ANIMALS, MICROORGANISMS AND HOW THEY RELATE TO ONE ANOTHER. MAINTAINING BIODIVERSITY ENSURES CLEAN AIR, WATER AND FERTILE SOILS AND IS THE FOUNDATION OF THE HEALTHY, FUNCTIONING ECOSYSTEMS UPON WHICH ALL LIFE DEPENDS.

BIOMASS
BIOMASS IS ORGANIC MATERIAL MADE FROM PLANTS AND ANIMALS. BIOMASS CONTAINS STORED ENERGY FROM THE SUN. PLANTS ABSORB THE SUN'S ENERGY IN A PROCESS CALLED PHOTOSYNTHESIS. THE CHEMICAL ENERGY IN PLANTS IS PASSED ON TO ANIMALS AND PEOPLE THAT EAT THEM. BIOMASS IS A RENEWABLE ENERGY SOURCE BECAUSE WE CAN KEEP GROWING MORE TREES AND CROPS. SOME EXAMPLES OF BIOMASS FUELS ARE WOOD, MANURE AND SEAWEED.

CARBON CAPTURE AND STORAGE
THE GREENHOUSE GAS EMISSIONS FROM A POWER PLANT OR FACTORY CAN BE CAPTURED SO THAT THEY ARE NOT RELEASED INTO THE ATMOSPHERE. THE CAPTURED GAS CAN BE SENT THROUGH A PIPELINE TO UNDERGROUND ROCK FORMATIONS WHERE IT CAN BE STORED SAFELY AND PERMANENTLY (IN THEORY ANYWAY).

CIVILISATION
A SOCIETY WITH COMPLEX LEGAL, POLITICAL AND RELIGIOUS ORGANIZATIONS AND DIVISION OF LABOUR. ALL CIVILISATIONS ARE IN FACT UNSUSTAINABLE BECAUSE THEY REQUIRE THE IMPORTATION OF RAW MATERIALS.

COAL
A FOSSIL FUEL FORMED FROM LAND PLANTS WHICH ARE BURIED AND TRANSFORMED OVER MILLIONS OF YEARS BY HEAT AND PRESSURE.

DYSTOPIA
THIS IS THE OPPOSITE OF UTOPIA, AN UNSUSTAINABLE SOCIETY WHERE NOTHING WORKS AND THE MAJORITY OF PEOPLE LEAD MISERABLE LIVES. WITHIN A DYSTOPIA, IT'S POSSIBLE THAT A FEW PEOPLE (THE WEALTHIEST) MAY HAVE A VERY PLEASANT LIFE (FOR A SHORT TIME) BY USING EVERYTHING FOR THEMSELVES, WHILE OTHERS MISS OUT.

ECONOMY
THIS COMES FROM THE GREEK WORDS 'OIKOS' (HOME) AND 'NOMOS' (MANAGEMENT) THAT IS, MANAGING THE AFFAIRS OF YOUR HOME. THE BUYING AND SELLING OF PRODUCTS AND SERVICES MAKE UP AN ECONOMY.

ECOSYSTEM
ALSO DERIVES FROM 'OIKOS' -- OUR 'HOME' SYSTEM. THE PLANTS AND ANIMALS THAT ARE FOUND IN A PARTICULAR LOCATION ARE REFERRED TO AS AN ECOSYSTEM. THESE PLANTS AND ANIMALS DEPEND ON EACH OTHER TO SURVIVE. DISRUPTIONS TO AN ECOSYSTEM CAN BE DISASTROUS TO ALL ORGANISMS WITHIN THE ECOSYSTEM.EVERY LIVING ORGANISM, INCLUDING HUMAN BEINGS, NEEDS AN ECOSYSTEM TO EXIST. IT IS OBVIOUS THAT AN 'ECONOMY' MUST BE PART OF AN 'ECOSYSTEM', BUT THIS IS NOT THE CASE AT PRESENT WHERE THE ECONOMY IS INSTEAD DESTROYING ECOSYSTEMS.

ENERGY
ENERGY IS DEFINED AS THE ABILITY TO DO WORK. IT IS WHAT MOVES CARS ALONG THE ROAD AND MAKES AEROPLANES FLY. ENERGY IS NEEDED FOR OUR BODIES SO THAT WE CAN GROW AND MOVE ABOUT AND ALSO FOR PLANTS SO THEY CAN MAKE FLOWERS AND FRUIT. ENERGY DEMAND IS THE AMOUNT OF ENERGY NEEDED TO DO THINGS. LOWERING GLOBAL ENERGY DEMAND MAY BE VITAL TO THE PREVENTION OF FURTHER CLIMATE CHANGE.

ENERGY STORAGE
ENERGY STORAGE IS WHERE WE STORE ENERGY TO PERFORM USEFUL OPERATIONS AT A LATER TIME. A WIND-UP CLOCK STORES POTENTIAL ENERGY (IN THIS CASE MECHANICAL, IN THE SPRING TENSION). A BATTERY STORES CHEMICAL ENERGY TO OPERATE A MOBILE PHONE. FOSSIL FUELS SUCH AS COAL AND GAS STORE ANCIENT ENERGY DERIVED FROM SUNLIGHT BY ORGANISMS THAT LATER DIED, BECAME BURIED AND OVER TIME WERE THEN CONVERTED INTO THESE FUELS.

FRACKING
HYDRAULIC FRACTURING, OR FRACKING, IS A TECHNIQUE DESIGNED TO RECOVER GAS AND OIL FROM SHALE ROCK. FRACKING IS THE PROCESS OF DRILLING DOWN INTO THE EARTH BEFORE A HIGH-PRESSURE WATER MIXTURE IS DIRECTED AT THE ROCK TO RELEASE THE GAS INSIDE.

FUEL CELLS
CELLS THAT PRODUCE ELECTRICITY BY OXIDATION OF FUEL (HYDROGEN AND OXYGEN OR ZINC AND AIR); FOR USE IN ELECTRIC CARS AND SMALLER GADGETS E.G. MOBILE PHONES.

GEOENGINEERING
GEOENGINEERING CONTROVERSIALLY AIMS TO TACKLE CLIMATE CHANGE BY REMOVING GREENHOUSE GASES FROM THE AIR OR LIMITING THE SUNLIGHT REACHING THE PLANET.

GREEN ROOF
A GREEN ROOF IS A ROOF OF A BUILDING WHICH IS PARTIALLY OR COMPLETELY COVERED WITH PLANTS. THIS ACTS TO REGULATE THE BUILDING'S TEMPERATURE, AIR QUALITY, AND ALSO PROVIDE A HABITAT FOR SOME PLANTS AND ANIMALS.

HYDROGEN ENERGY
HYDROGEN CAN BE USED AS AN ALTERNATIVE FUEL TO POWER VEHICLES, OR DEVICES LIKE MOBILE PHONES. HYDROGEN FUEL CELLS (BATTERIES) MAKE ELECTRICITY. THEY ARE VERY EFFICIENT, BUT EXPENSIVE TO BUILD. WHEN HYDROGEN IS USED FOR FUEL IN A CAR, WATER COMES OUT OF THE EXHAUST PIPE INSTEAD OF HARMFUL CHEMICALS.

MACROALGAE
SEAWEEDS ARE ALSO KNOWN AS MACROALGAE. THEY ARE DIVIDED INTO THREE GROUPS BASED ON THEIR COLOUR--- GREEN, BROWN AND RED. SEAWEEDS APPEAR SIMILAR TO LAND PLANTS; HOWEVER, THEY LACK COMPLEX STRUCTURES LIKE FLOWERS, ROOTS, STEMS AND LEAVES.

MASLOW'S HIERARCHY OF NEEDS
MASLOW'S HIERARCHY OF NEEDS IS A THEORY IN PSYCHOLOGY PROPOSED BY ABRAHAM MASLOW. HE TRIED TO PRIORITISE HUMAN NEEDS AND HIS THEORY IS THAT AS OUR BASIC NEEDS (E.G. FOOD AND WATER) ARE MET, WE DESIRE HIGHER NEEDS.

MICROALGAE
THERE ARE SEVERAL GROUPS SIMILAR TO PLANTS BUT NOT ACTUALLY TRUE PLANTS THAT WE CALL MICROALGAE. JUST LIKE SEAWEED, MICROALGAE LACK TRUE LEAVES, ROOTS, FLOWERS, AND OTHER STRUCTURES.

NUCLEAR FISSION
SOME ATOMS ARE UNSTABLE AND SPLIT APART - TERMED NUCLEAR FISSION. THE ENERGY RELEASED IN MOST NUCLEAR REACTIONS IS MUCH LARGER THAN THAT FOR CHEMICAL REACTIONS.

NUCLEAR FUSION
THIS IS A PROCESS IN WHICH TWO NUCLEI JOIN TO FORM A LARGER NUCLEUS, THEREBY GIVING OFF ENERGY. NUCLEAR FUSION IS THE ENERGY SOURCE WHICH CAUSES STARS TO "SHINE".

OIL
A FOSSIL FUEL FORMED FROM MARINE MICRO-ORGANISMS LIKE BACTERIA AND PHYTOPLANKTON WHICH FALL TO THE SEABED AND FORM A LIQUID TRAPPED IN LAYERS OF ROCK.

PHYTOPLANKTON
PHYTOPLANKTON ARE MICROSCOPIC PLANT LIFE THAT FLOATS FREELY IN SURFACE WATERS AND PHOTOSYNTHESISE LIKE LAND PLANTS, CAPTURING HUGE AMOUNTS OF CARBON DIOXIDE FROM THE ATMOSPHERE AND PROVIDING A LOT OF OUR OXYGEN.

PUMPED STORAGE POWER STATION
HERE, WATER IS STORED BEHIND A DAM. WHEN THE WATER IS RELEASED, IT RUNS DOWN PIPES TO TURN A TURBINE. THE TURBINE IS CONNECTED TO A GENERATOR TO PRODUCE ELECTRICITY. THE WATER IS THEN PUMPED BACK INTO THE RESERVOIR WHEN THERE ARE PERIODS OF LOW POWER DEMAND;FOR EXAMPLE WHEN THERE IS EXCESS ENERGY BEING PRODUCED BY OTHER POWER STATIONS.

REBOUND EFFECT
THE 'REBOUND EFFECT' IS THE TERM USED TO DESCRIBE THE EFFECT THAT CHEAPER ENERGY, DUE TO INCREASED EFFICIENCY, HAS ON US. THE SAVING IN TERMS OF ENERGY (AND EMISSIONS) IS CANCELLED OUT BY THE CONSUMER USING THE PRODUCT MORE BECAUSE IT IS NOW CHEAPER TO OPERATE.

RESOURCE
A PERSON, ASSET, MATERIAL, OR MONEY WHICH CAN BE USED TO ACCOMPLISH A GOAL. WHEN PARTS OF THE WORLD E.G. WATER, SOIL, FISH STOCKS, PLANTS AND ANIMALS ARE REGARDED AS A RESOURCE, IT USUALLY MEANS THEY WILL BE DESTROYED OR NOT LOOKED AFTER.

SHALE
SHALE IS A TYPE OF ROCK FORMED FROM TINY PARTICLES OF MINERALS AND DEAD PLANTS AND ANIMALS THAT LIVED MILLIONS OF YEARS AGO. OVER TIME, THEY BECAME COMPRESSED AND THEN HARDENED INTO THIS TYPE OF ROCK.

SHIFTING BASELINE
THIS IS A PROBLEM REGARDING PEOPLE'S VIEW OF THE NATURAL WORLD: A HUMAN LIFESPAN IS TOO SHORT FOR PEOPLE TO SEE THAT WHAT THEY THINK OF AS 'NORMAL' IS ACTUALLY A HUGE CHANGE FROM WHAT EXISTED BEFORE.

SMART CITY
A SMART CITY IS WHERE SYSTEMS ARE VERY EFFICIENT BECAUSE EVERYTHING IS CONNECTED THROUGH BEHAVIOUR CHANGES AND ADVANCED COMPUTING.

SOLAR ENERGY
SOLAR ENERGY IS THE SUN'S RAYS (SOLAR RADIATION) THAT REACH THE EARTH. THIS ENERGY CAN BE CONVERTED INTO OTHER FORMS OF ENERGY, SUCH AS HEAT AND ELECTRICITY.

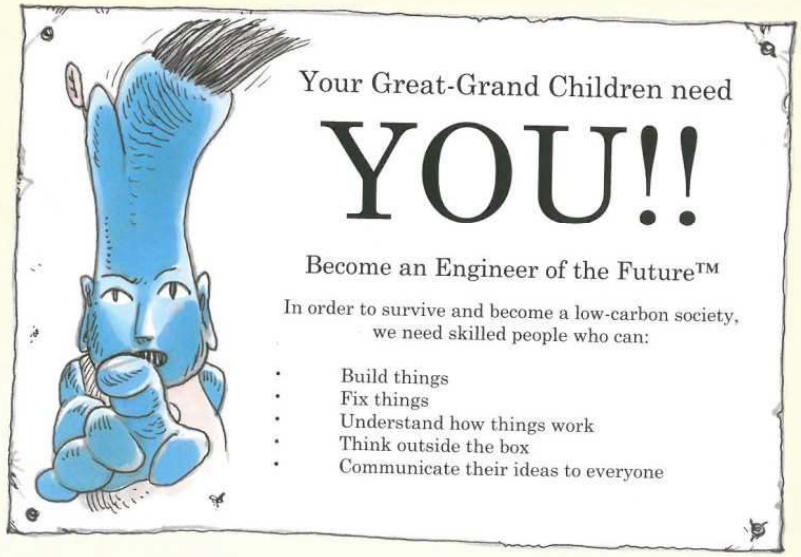
SUSTAINABILITY
SUSTAINABILITY MAY BE BAD OR GOOD -- FOR EXAMPLE AN EVIL DICTATOR MAY FIND A WAY TO SUSTAIN HIS RULE, ENSURING THAT EVERYONE ELSE IS MISERABLE. SUSTAINABILITY IS USUALLY MEANT IN A POSITIVE WAY AND MEANS TO ACT IN A WAY THAT DOESN'T REGARD THE PLANET AS A RESOURCE TO BE USED UP. ASK YOURSELF THE QUESTION: IF WE ALL CARRY ON DOING WHAT WE'RE DOING NOW, FOREVER, WILL THAT WORK? ACTING SUSTAINABLY MEANS ENSURING THAT WE WILL LEAVE A HABITABLE PLANET TO FUTURE GENERATIONS. SOMEONE WHO PLANTS A TREE IS ACTING IN A SUSTAINABLE WAY, AS IT MEANS THEY BELIEVE IN THE FUTURE 100 OR 1000 YEARS FROM NOW.

TAR SANDS
TAR SANDS, ALSO REFERRED TO AS OIL SAND OR BITUMINOUS SAND, ARE A COMBINATION OF CLAY, SAND, WATER, AND BITUMEN. TAR SANDS ARE MINED FOR THE OIL RICH BITUMEN WHICH IS REFINED INTO OIL.

TIDAL ENERGY
THE MOON'S PULL ON THE EARTH RESULTS IN TIDES; IE. RISES AND FALLS IN WATER LEVEL. THESE FLUCTUATIONS MEAN WATER IS MOVING, AND MOVING WATER MEANS KINETIC ENERGY. THERE ARE SEVERAL WAYS TO TURN THIS TIDAL ENERGY INTO ELECTRICITY, INCLUDING TIDAL FENCES, TIDAL BARRAGES (LIKE DAMS) AND TIDAL TURBINES. EACH USES THE MOVEMENT OF THE TIDES TO SPIN TURBINES, OR ELECTROMECHANICAL GENERATORS.

UTOPIA
THIS IS A SOCIETY THAT IS IN PERFECT BALANCE AND HARMONY, WHERE EVERYONE'S NEEDS ARE MET. FOR THE PURPOSES OF THIS BOOK, A UTOPIA WOULD BE A SUSTAINABLE SOCIETY WHERE HUMANS ARE LIVING IN HARMONY WITH THEIR SURROUNDING ECOSYSTEM.

WIND ENERGY
LIKE OLD FASHIONED WINDMILLS, TODAY'S WIND TURBINES USE BLADES TO COLLECT THE WIND'S ENERGY. THE WIND FLOWS OVER THE BLADES CREATING LIFT, JUST LIKE AEROPLANE WINGS, WHICH CAUSES THEM TO TURN. THE BLADES ARE CONNECTED TO A DRIVE SHAFT THAT TURNS AN ELECTRIC GENERATOR TO PRODUCE ELECTRICITY.



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FURTHER READING

SUSTAINABLE ENERGY WITHOUT THE HOT AIR, *DAVID J. C. MACKAY, UIT CAMBRIDGE, 2009.*

ENDGAME, *DERRICK JENSEN,SEVEN STORIES PRESS, 2006.*

COLLAPSE, *JARED M. DIAMOND, VIKING PRESS ,2005.*

THE FUTURE EATERS: AN ECOLOGICAL HISTORY OF THE AUSTRALASIAN LANDS AND PEOPLE, *TIM FLANNERY, GROVE PRESS, 1994.*

THE WEATHER MAKERS: THE HISTORY AND FUTURE IMPACT OF CLIMATE CHANGE, *TIM FLANNERY, TEXT PUBLISHING COMPANY, 2008.*

REINVENTING FIRE: BOLD BUSINESS SOLUTIONS FOR THE NEW ENERGY ERA, *AMORY B. LOVINSAND THE ROCKY MOUNTAIN INSTITUTE, CHELSEA GREEN, 2011*

HOW BAD ARE BANANAS?: THE CARBON FOOTPRINT OF EVERYTHING, *MIKE BERNERS-LEE, PROFILE BOOKS, 2010*

THE STORY OF STUFF: HOW OUR OBSESSION WITH STUFF IS TRASHING THE PLANET, OUR COMMUNITIES, AND OUR HEALTH - AND A VISION FOR CHANGE, *ANNIE LEONARD, FREE PRESS, 2010*

CRADLE TO CRADLE: REMAKING THE WAY WE MAKE THINGS, *MICHAEL BRAUNGART AND WILLIAM MCDONOUGH, VINTAGE, 2009.*

YOU, TOMORROW, *IAN PEARSON, WWW. FUTURIZON.COM, 2011.*

THE SHAPE OF THINGS TO COME, *H G WELLS, HUTCHINSON (UK) MACMILLAN (USA), 1933*

ENOUGH IS ENOUGH: BUILDING A SUSTAINABLE ECONOMY IN A WORLD OF FINITE RESOURCES, *DAN O'NEILL AND ROB DIETZ, ROUTLEDGE, 2013*

THE END OF GROWTH, *RICHARD HEINBERG, CLAIRVIEW, 2011*

1984, *GEORGE ORWELL, SECKER AND WARBURG, LONDON, 1949*

SCIENCE TALES, *DARRYL CUNNINGHAM, MYRIAD EDITIONS, 2012*

THE SONG OF THE DODO: ISLAND BIOGEOGRAPHY IN AN AGE OF EXTINCTION, *DAVID QUAMMEN, SCRIBNER, 1997.)*

CLIMATE WARS, *GWYNNE DYER, RANDOM HOUSE CANADA 2008*

THE HITCHHIKERS GUIDE TO THE GALAXY, *DOUGLAS ADAMS, PAN BOOKS, 1979*

DINOSAURS AND ALL THAT RUBBISH, *MICHAEL FOREMAN, PUFFIN, 1993*