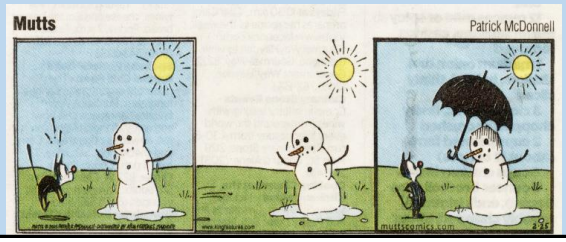
Design for Future Climates

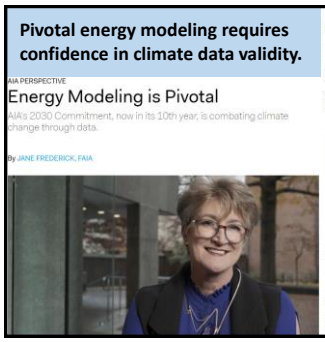
1

Part 1
Climate Data and Analysis



2

Pivotal energy modeling requires confidence in climate data validity.


AIA PERSPECTIVE

Energy Modeling is Pivotal

AIA's 2030 Commitment, now in its 10th year, is combating climate change through data.

By JANE FREDERICK, FAIA

National Geographic, Oct 5, 2021

ENVIRONMENT | PLANET POSSIBLE

How climate models got so accurate they earned a Nobel Prize

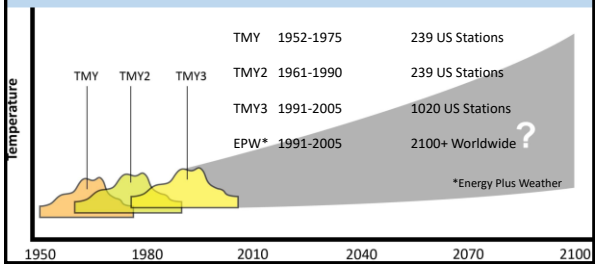
Climate predictions were treated with heavy skepticism just 30 years ago, but they've become our main window into how global warming works.


Nobel Prize for Physics winners Syukuro Manabe, Klaus Hasselmann, and Giorgio Parisi

ILLUSTRATION BY NIKLAS ELMEHED, NOBEL PRIZE OUTREACH

3

Typical Meteorological Year (TMY) Files



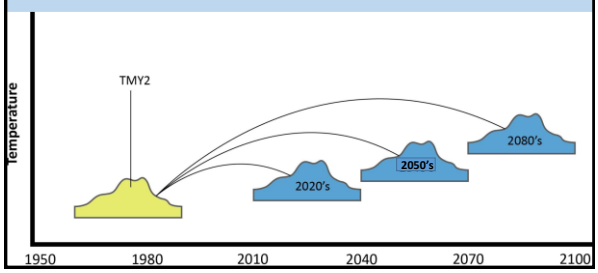
4

A decade ago, Arup climate expert Jacob Hacker and academic colleagues at the University of Southampton pioneered morphing *(a mathematical method to superimpose changes predicted by climate modelers on observed weather data),* **using an IPCC climate model to produce future data sets for U.K. weather station sites in 2020, 2050, and 2080.**

The Chartered Institution of Building Services Engineers (CIBSE), has distributed the morphed data sets and encouraged their use in U.K. projects.

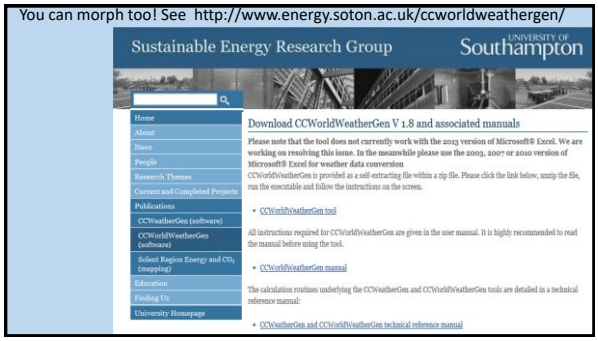
5

Morphing Results:



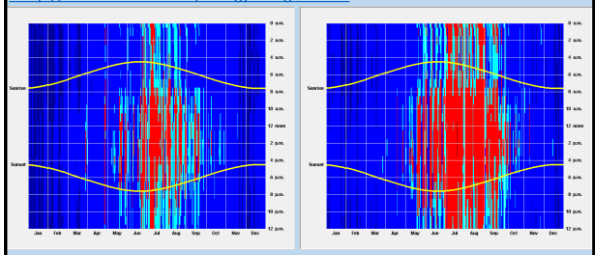
6

You can morph too! See http://www.energy.soton.ac.uk/ccworldweathergen/



7

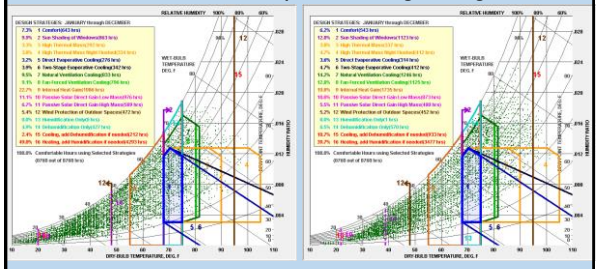
Use Climate Consultant to view and analyze the morphed data.
<http://www.aud.ucla.edu/energy-design-tools>.



Boston 1991-2005 vs. Boston 2080

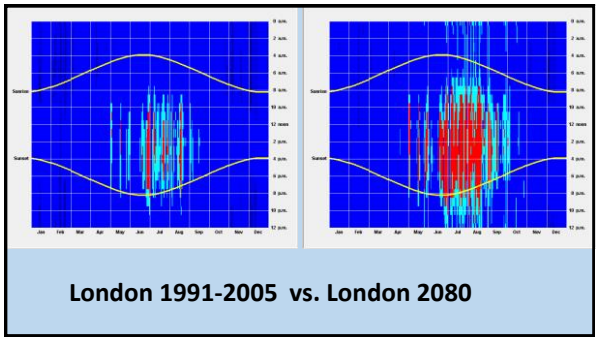
8

Climate Consultant identifies and prioritizes design strategies.



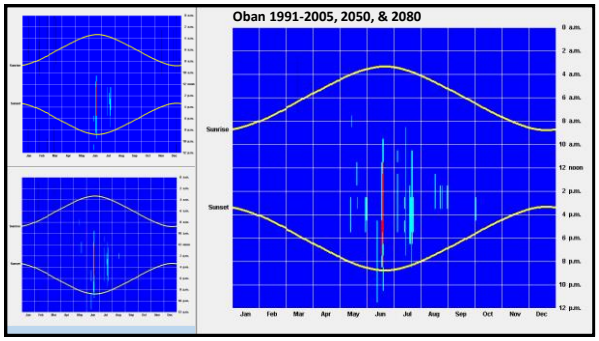
Boston 1991-2005 vs. Boston 2080

9



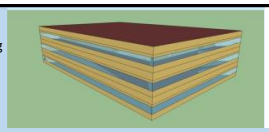
London 1991-2005 vs. London 2080

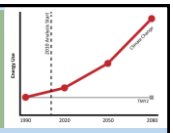
10



11

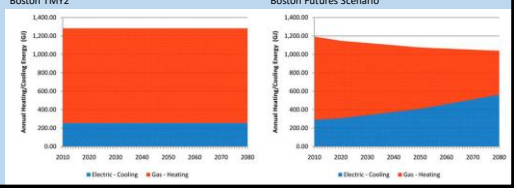
Seth Holmes modeled a typical office block using TMY2 data then 2020, 2050, and 2080 data to show performance difference over time.





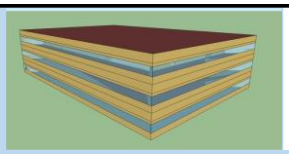
Boston TMY2

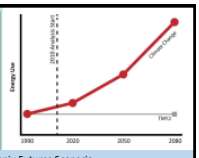
Boston Futures Scenario



12

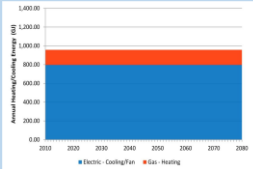
Same building in Phoenix with a different future….



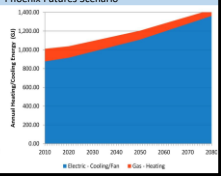


Seth is happy he lives in Boston, not Phoenix!

Phoenix TMY2



Phoenix Futures Scenario



13

Other Efforts

An ASHRAE tool: expected to be released later in 2015 (can't find it), this tool targets weather data's geographic limits. ASHRAE publishes standard design-year data sets for use in energy modeling. These represent natural variation in temperature, sunshine, and other meteorological conditions observed at weather stations.

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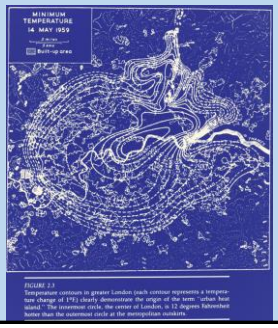
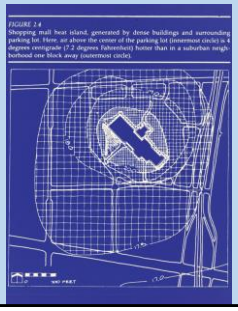
Dru Crawley, building-performance director for design software vendor Bentley Systems and chair of ASHRAE's technical committee for climatic data, says urban heat island effects elevate downtown temperatures 2 to 9 °F (1.5 to 5°C). As a result, says Crawley, a data set from the closest weather station (most are at airports) just a few miles away may "mean absolutely nothing when you get to a particular building site."



15

His committee's solution: rewrite history. They commissioned a tool from Guelph, Ontario-based Novus Environmental to generate weather data for virtually any 6-square-mile block of territory in the continental U.S. The software uses a weather model, informed by topography and land-use data and calibrated by historic observations, to capture each block's local microclimate.



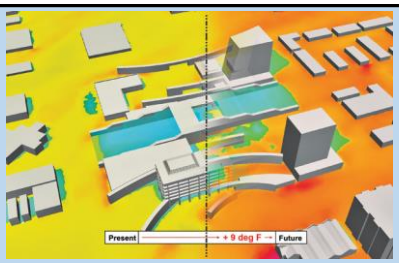
16

WeatherSHIFT by Arup http://www.weathershift.com/

Another thrust of technology development targets historical data sets' inevitably backward vision—a growing liability in an era of global climate change. International engineering firm Arup collaborated with climate-data startup Argos Analytics to develop WeatherSHIFT, which Arup uses internally to predict future design-year data sets.

Arup's Hacker and Cole Roberts, a San Francisco–based Arup principal, say WeatherSHIFT offers better morphing algorithms, relies on the latest climate models, can morph data sets from sites worldwide, and shows designers a broad range of climate-adjusted weather under different carbon-emissions scenarios. Roberts says North American designers and clients are a step behind the U.K.'s, but he sees interest growing.

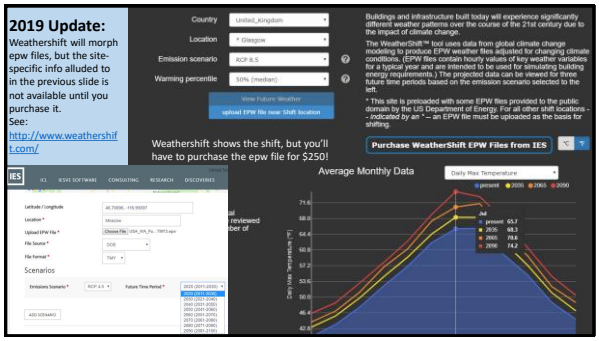
17



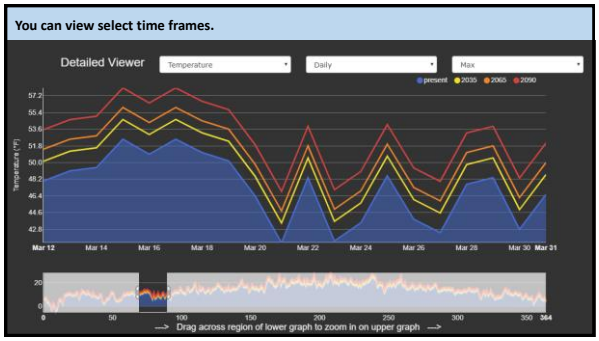
Arup's WeatherSHIFT results for a proposed development in Mesa, Arizona, show an increase in average temperatures by up to 9 degrees Fahrenheit by the end of the century, resulting in a tenfold increase in heat stress.

Source: *Architectural Record*, March 2015

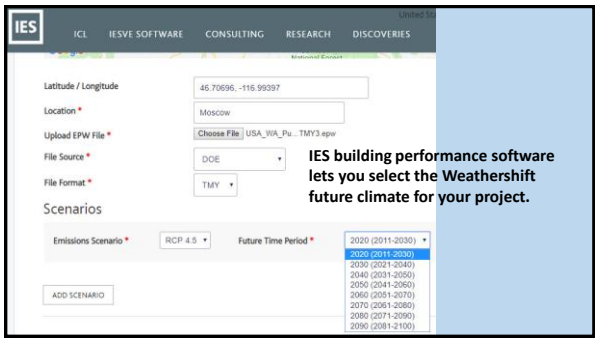
18


2019 Update:
Weathershift will morph epw files, but the site-specific info alluded to in the previous slide is not available until you purchase it.
See: http://www.weathershift.com/
Country
Location
Emission scenario
Warming percentile
Buildings and infrastructure built today will experience significantly different weather patterns over the course of the 21st century due to the impact of climate change.
The WeatherShift™ tool uses data from global climate change modeling to produce EPW weather files adjusted for changing climate conditions. (EPW files contain hourly values of key weather variables for a typical year and are intended to be used for simulating building energy requirements.) The projected data can be viewed for three future time periods based on the emission scenario selected to the left.
* This site is preloaded with some EPW files provided to the public domain by the US Department of Energy. For all other shift locations - - indicated by an * – an EPW file must be uploaded as the basis for shifting.
Weathershift shows the shift, but you'll have to purchase the epw file for $250!
Purchase WeatherShift EPW Files from IES
Average Monthly Data
Scenarios

19


You can view select time frames.
Detailed Viewer
Temperature
Daily
Max
present
2035
2065
2090
Drag across region of lower graph to zoom in on upper graph

20


IES
ICL
IESVE SOFTWARE
CONSULTING
RESEARCH
DISCOVERIES
Latitude / Longitude
46.70696, -116.99397
Location *
Moscow
Upload EPW File *
Choose File
USA_WA_Pu...TMY3.epw
File Source *
DOE
File Format *
TMY
Scenarios
Emissions Scenario *
RCP 4.5
Future Time Period *
2020 (2011-2030)
2030 (2021-2040)
2040 (2031-2050)
2050 (2041-2060)
2060 (2051-2070)
2070 (2061-2080)
2080 (2071-2090)
2090 (2081-2100)
ADD SCENARIO
IES building performance software lets you select the Weathershift future climate for your project.

21

The Prometheus tool

An innovation from U.K. academics, meanwhile, is offering designers both climate perspective and the site-specificity expected from ASHRAE's software. The Prometheus tool created by Matthew Eames, a research fellow at the University of Exeter's Centre for Energy and the Environment, relies on an artificial weather generator to synthesize both historic and future weather data sets for every location in the U.K.

Just 11 weather stations in the UK! And 5 in Ireland.

22

Centre for Energy and the Environment

PROMETHEUS Downloads

The PROMETHEUS project has resulted in the release of a number of future weather files which can be used to test how future-proof buildings are against predicted climate change. The files were created using the UKCP09 weather generator, and are available for download for free from this website, subject to terms and conditions. The weather files are currently available for 45 locations as indicated by the map on the right, each for 3 time periods and 2 emissions scenarios. Weather files for other locations may be created if required: please contact the Centre for further details.

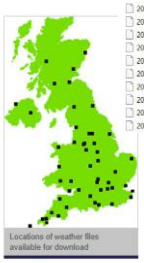
The files are in the Energy Plus format (.epw) which can be imported into most building thermal simulation software packages including IES. The files can also be opened in Excel as a comma separated variable file. More details can be found in the Read Me file (downloadable PDF).

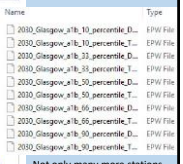
The full methodology has been peer-reviewed and is published in BSER&T and you can also download a pre print version (PDF file). When referencing the weather files in publications and reports please reference as:

M. Eames, T. Kershaw and D. Coley *Building Serv. Eng. Res. Technol.*, 32 127-142 (2011)

Downloading the future weather files

In order to download the future weather files you must first read and agree to our terms and conditions.





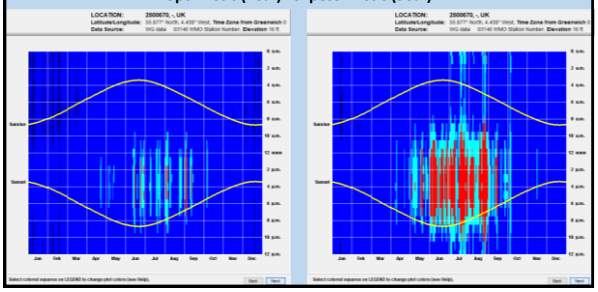
Not only many more stations but 5 levels of certainty from optimistic (10%) to pessimistic (90%).

And they're free!
http://emps.exeter.ac.uk/engineering/research/cee/research/prometheus/downloads/index.php

23

Glasgow 2080

optimistic (10%) vs. pessimistic (90%)



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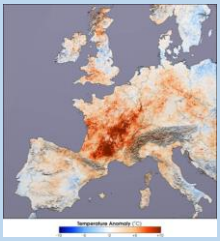

European temperature extremes, Summer, 2003

Eames says U.K. architects and engineers using future-weather data sets are already gaining broad insights about what climate change means for their designs—especially the present and growing threat of overheating in certain structures. The European heat wave of 2003 (with ~35,000 dead) was considered a 1-in-1,000-year event, says Eames, but the design data sets show that such temperatures could be typical summer conditions by the 2040s.

25

Often viewed as more resilient since they eschew mechanical systems, naturally ventilated buildings are also the most closely designed for the historical climate, explains Arup's Cole Roberts. "As climate shifts even a few degrees, those buildings will suffer more."

Is BedZED fit for 2080?

26

Problem: All these methods only provide typical weather files w/o extreme conditions. All the methods provide enough information to study the long-term impacts of climate change on average, but underrepresent the consequences of extreme events.

- Typical weather data sets can only predict long-term variations of climate.
- Extreme weather files are needed to assess short-term variations such as heatwaves and forest fires.
- Extreme weather files are needed for a robust design in building and urban scales.
- Using only typical data underestimates peak load calculations considerably.

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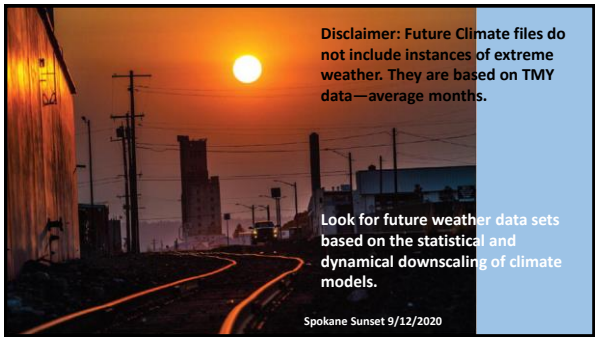

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Part 2
Building Energy Use

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ZNE Building Energy Supply Options

Table 1. ZEB Renewable Energy Supply Option Hierarchy

Option Number	ZEB Supply-Side Options	Examples
0	Reduce site energy use through low-energy building technologies	Daylighting, high-efficiency HVAC equipment, natural ventilation, evaporative cooling, etc.
	On-Site Supply Options	
1	Use renewable energy sources available within the building's footprint	PV, solar hot water, and wind located on the building.
2	Use renewable energy sources available at the site	PV, solar hot water, low-impact hydro, and wind located on-site, but not on the building.
	Off-Site Supply Options	
3	Use renewable energy sources available off site to generate energy on site	Biomass, wood pellets, ethanol, or biodiesel that can be imported from off site, or waste streams from on-site processes that can be used on-site to generate electricity and heat.
4	Purchase off-site renewable energy sources	Utility-based wind, PV, emissions credits, or other "green" purchasing options. Hydroelectric is sometimes considered.

30

Design Process Priorities

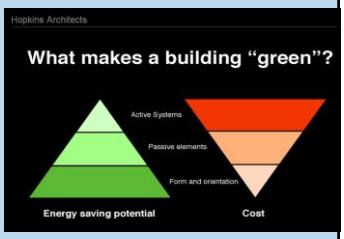
Reduce loads
- External loads … envelope
- Internal loads … process

Meet reduced loads via passive solutions
- Daylighting
- Passive heating
- Passive cooling

Supply remaining loads with no/low-carbon renewables
- PV
- Solar thermal
- Wind
- Other

Commission the building and do ongoing commissioning or POE

Passive and Low-Energy Buildings Can Leverage Carbon



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EUI (Energy Use Intensity)

Typical values: Below are some average EUIs for three building types in the US. (These are meant to give a rough idea of EUI ranges; actual values can vary widely based upon location & specific space uses.)

	Source EUI (power plant's energy consumption)	**Site EUI** (building energy consumption)	**2030 Challenge target** (80% reduction, site EUI)
Office	**148** kBTU/ft2/yr 467 kWh/m2/yr	**67** kBTU/ft2/yr 211 kWh/m2/yr	**13** kBTU/ft2/yr 42 kWh/m2/yr
K-12 Education	**141** kBTU/ft2/yr 445 kWh/m2/yr	**58** kBTU/ft2/yr 183 kWh/m2/yr	**12** kBTU/ft2/yr 36 kWh/m2/yr
Single-family residence	**68** kBTU/ft2/yr 215 kWh/m2/yr	**46** kBTU/ft2/yr 145 kWh/m2/yr	**09** kBTU/ft2/yr 29 kWh/m2/yr

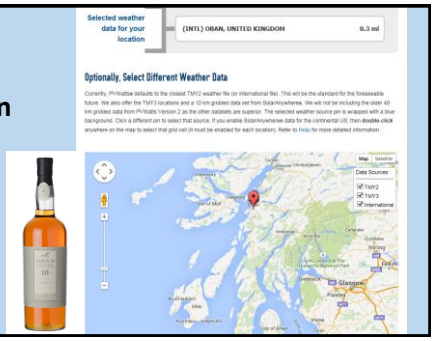
32

We'll use PVWatts to establish an energy budget for the building/site.

33

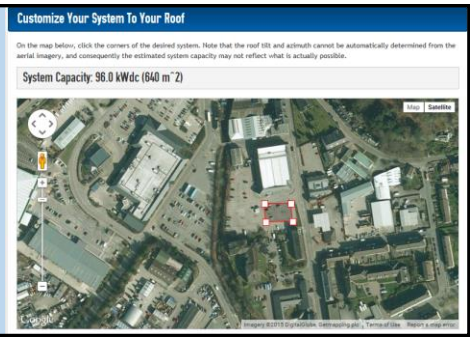
Select a location anywhere in the world.

Let's try Oban!



34

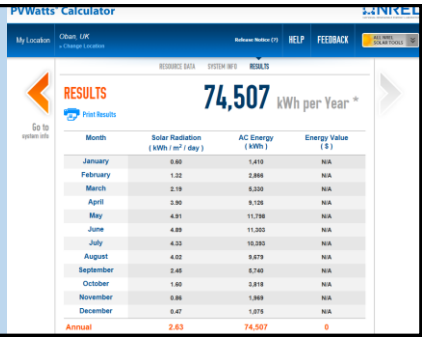
Zoom in on your site.



35

Monthly and annual energy generation is calculated.

You can then calculate your target EUI.
(Divide annual production by building floor area.)



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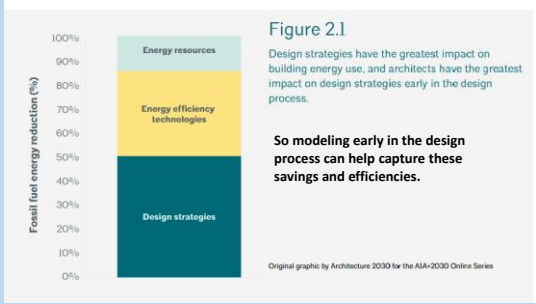
Part 3
Building Performance Modeling

All models are wrong, but some are useful.

We'll use SBEED, and Sefaira or Covetool.

37

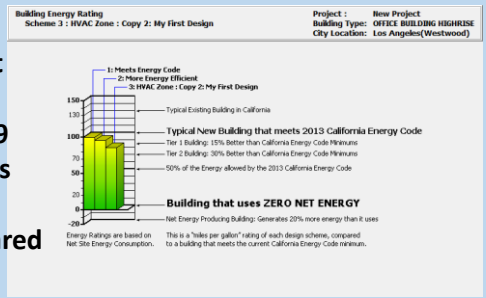


So modeling early in the design process can help capture these savings and efficiencies.

38

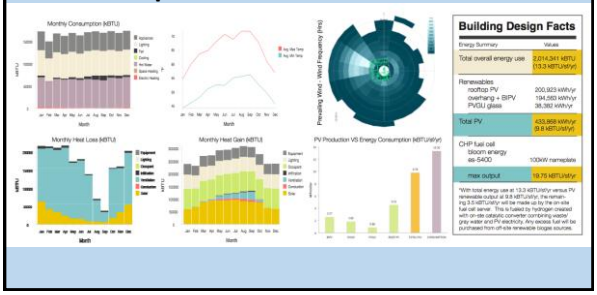
SBEED output

Up to 9 designs can be compared



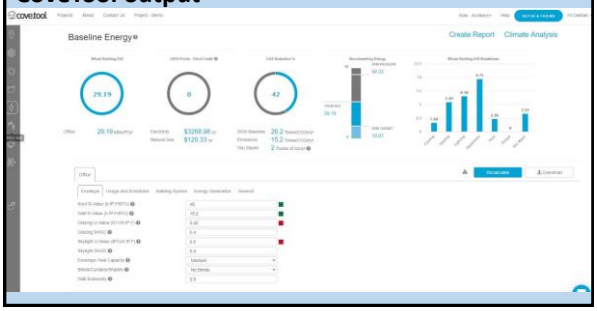
39

Sefaira output (you'll get a new version)



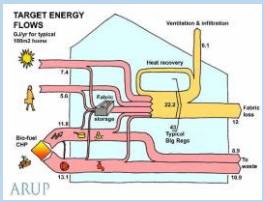
40

CoveTool output



41

Arup's Cole Roberts's hope is that anticipating future weather will become "a default for how work is being done on every project globally." He proposes one way to entice clients to buy in: convincing LEED and other green building-rating systems to award points for testing designs against predicted weather. He is also looking for partners to help make WeatherSHIFT available beyond Arup (it is!).



42

Musée d'Orsay

Forecast data sets enable designers to think ahead. For example, they can oversize mechanical rooms to accommodate a future need for more equipment. "You don't build your building to cope with 2080 now. It's about making sure your building can adapt," says UExeter's Matthew Eames.

43

Designed for ZERO?

Guggenheim Museum, NYC
F.L. Wright

44