Saginaw Valley State University: New Directions in Agri-Energy Research

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C. J. Strosacker Professor and Chair of Engineering

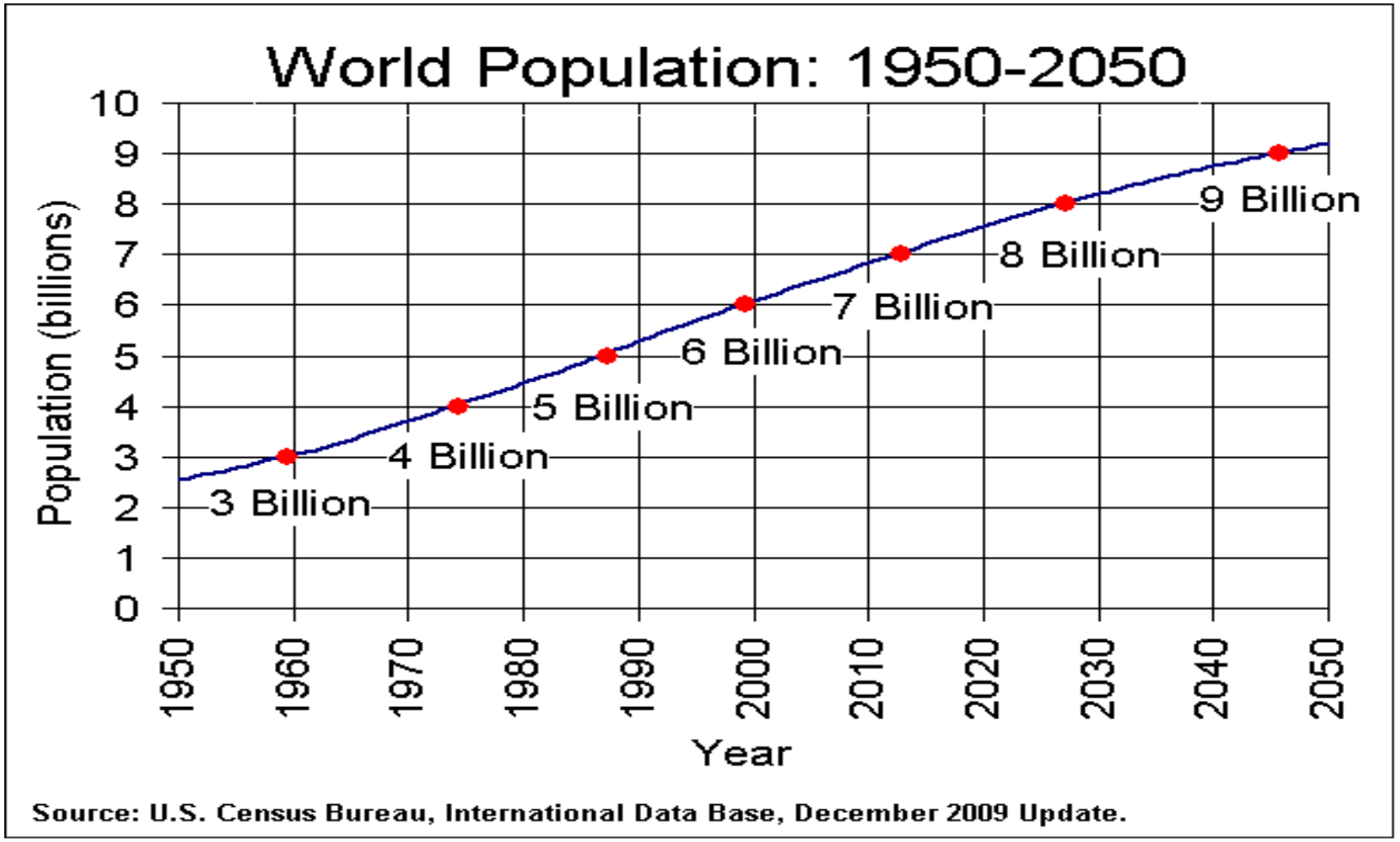
Sustainable intensification:

Growing more food with the same land area, less environmental impacts, less fossil fuel.

C. Godfray et al., "Food Security: The Challenge of Feeding 9 Billion People," Science, Feb 12, 2010, p. 812-18

Are you a science or engineering major?

Watch for jobs in food & energy industries.



mechanical engineering
THE MAGAZINE OF ASME
An engineering community

World energy demand should double by 2030.

➡ **Before this happens, expect the following:**

Major expansion / repair of transmission grid

Significant renovation and new construction of power plants

Many retiring baby-boomers in the power industry

Reference: J. Thornton, "Positions of Power," Mechanical Engineering 132 (1) 42-45 (2010).

Sustainable Intensification: producing more food & energy with less fossil resources

Biodigester in Laholm, Sweden.

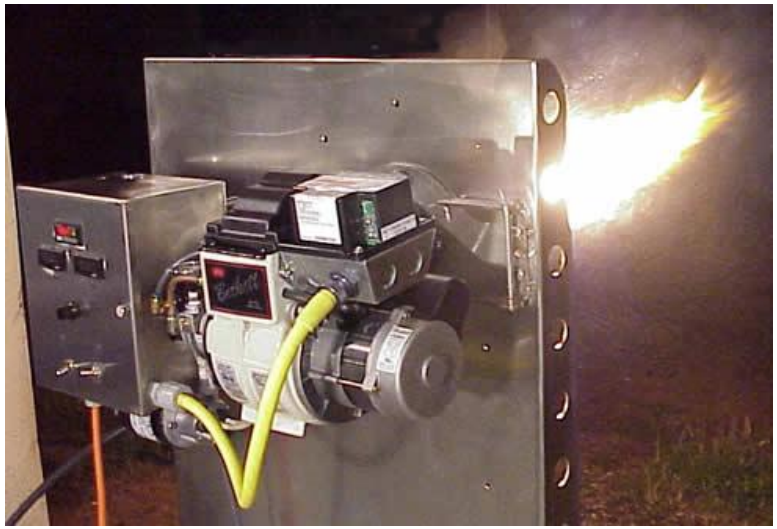
Biogas-fueled train in Sweden.

Soy Biodiesel

U.S. production approaching 2 billion gallons per year*

- often limited by 2 main byproducts:
- **800 million bushels meal**
- **200 million gallons glycerin**

Our contribution → better uses for the above byproducts



Glycerin as heating fuel

Wood-like biodegradable materials

* "U.S. biodiesel production capacity", National Soybean Board Fact Sheet, June 7, 2007.

Boiler measures fuel efficiency and emissions

glycerin tank

fuel oil tank

air inlet

1:1 glycerin : fuel oil
~$1.48 / 100,000 Btu

100% fuel oil:
~$2.14 / 100,000 Btu

Besides burning a cheap by-product, there's an environmental benefit

	Part per billion in exhaust	
	Fuel oil	Fuel oil/glycerin
Formaldehyde	2356	1782
Acetaldehyde	424	349
Acrolein	340	292
Acetone	0	0
Propionaldehyde	0	0
Butyraldehyde	403	0
Benzaldehyde	0	0

Collaborators: David Karpovich (SVSU Chemistry), Lanny Robbins (Larco Technologies, Gantec), Bill Kurz (OmniTech International), Randy Telesz (MDEQ)

Funding: Michigan Soybean Promotion Committee, National Science Foundation

Installation of radiant floor heating in a Vermont greenhouse. Waste vegetable oil fuels the furnace.

Source: www.petesgreens.com

Wood-like, biodegradable materials from plant biomass.

- **Distiller's grain is a by-product of ethanol processing.**
- **Sold as animal feed, it's made at a rate of 1 pound distiller's grain per pound of ethanol.**

Acknowledgements

- Michigan Corn Marketing Program
- U.S. Department of Labor
- Michigan Department of Agriculture
- US Department of Agriculture
- Michigan Initiative for Innovation and Entrepreneurship

Generic process crosslinks just about any polysaccharide to just about any protein.

- Distiller's grain
- Sugar beet pulp
- Spent coffee grounds
- Grass, leaves
- Corncobs
- Wood
- Paper waste
- Food waste

- Distiller's grain
- Beans
- Oilseed meal
- Spent coffee grounds
- Slaughterhouse residues
- Whey

Generic process crosslinks just about any polysaccharide to just about any protein…

… rendering them moldable with ordinary plastic manufacturing equipment.

Color patterns vary with raw materials selected.

Potential Applications

- **Disposable packaging**
- **Temporary landscape structures**
- **Disposable concrete forms**
- **Biodegradable plant pots**
- **Fillers in engineered plastics**
- **Non-toxic sporting clays** ⟶
- **Jewelry**
- **Furniture**

Eco-checkers anyone?

FISH AND WORMS

DEVELOPING FOOD PRODUCTION SYSTEMS IN POPULATION CENTERS

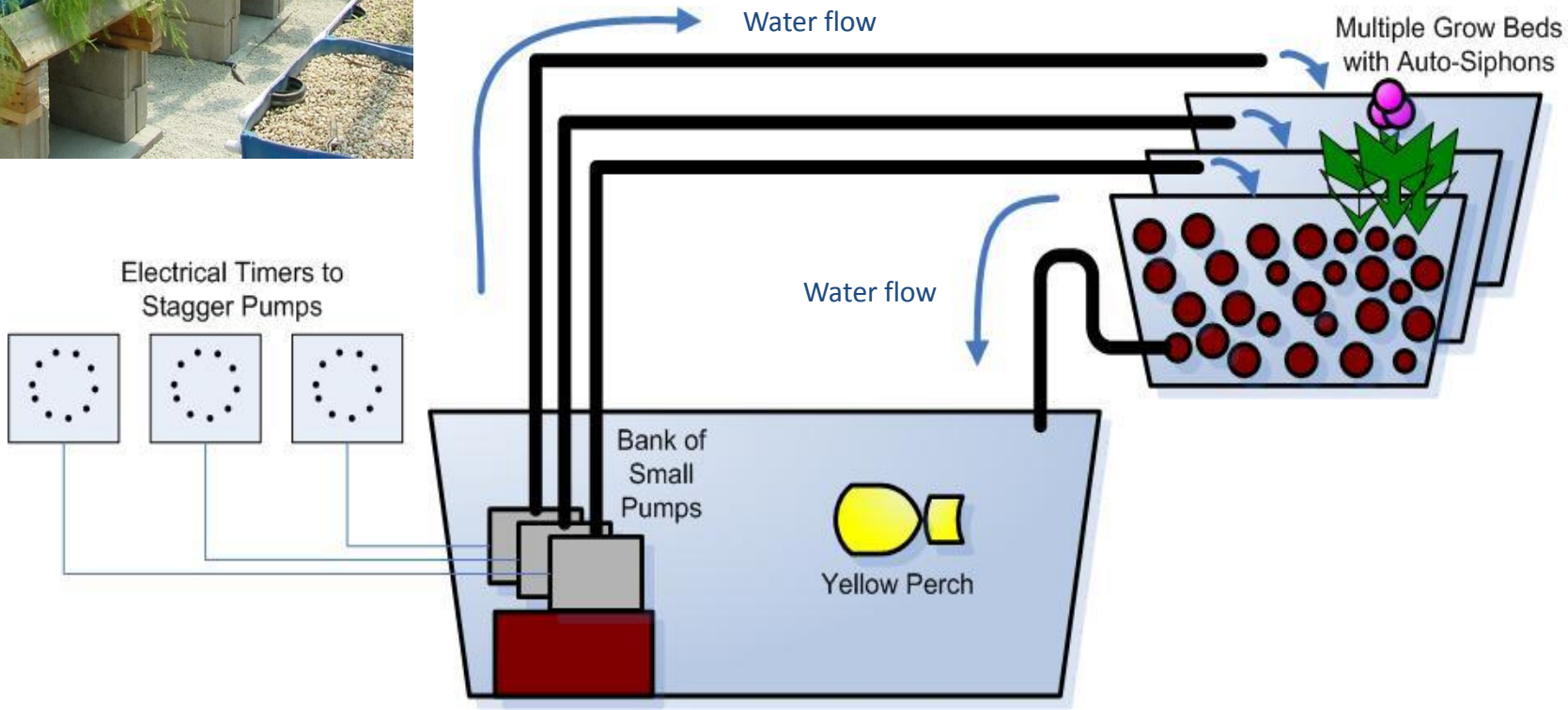
Greenhouses integrate hydroponics and vermiculture for year-round fruit and vegetable production, such as tomato plants (left).

BIOCYCLE
ADVANCING COMPOSTING, ORGANICS RECYCLING & RENEWABLE ENERGY

Feburary 2009, pp. 27-29.

Why Aquaponics?

- **Produces many types of fish & plants.**
- **The only chemical input is fish food.**
- **Costly petrochemicals not needed.**
- **Lacking soil, close control of system chemistry is easy. Water is conserved too.**



Conserves water & fertilizer

…..but uses energy

SVSU aquaponics experiment

Source: www.backyardaquaponics.com

Australia is pioneering this method to combat food inflation caused by draught.

Picture this in Michigan

New building full of aquaponics

British family farm sells fish, fruits & herbs

Solar heater is essential.

Source: www.herbsfromwales.co.uk

Vol. III No. 4 July / August 2009

Soil & Mulch Producer NEWS

Serving Soil, Mulch, Compost, & Biofuel Professionals

Vermicomposting with Spent Coffee Grounds

By G. Roekle, C. Schilling, E. Meisel, B. Thomas, and B. Jorgensen
Saginaw Valley State University, University Center, Michigan

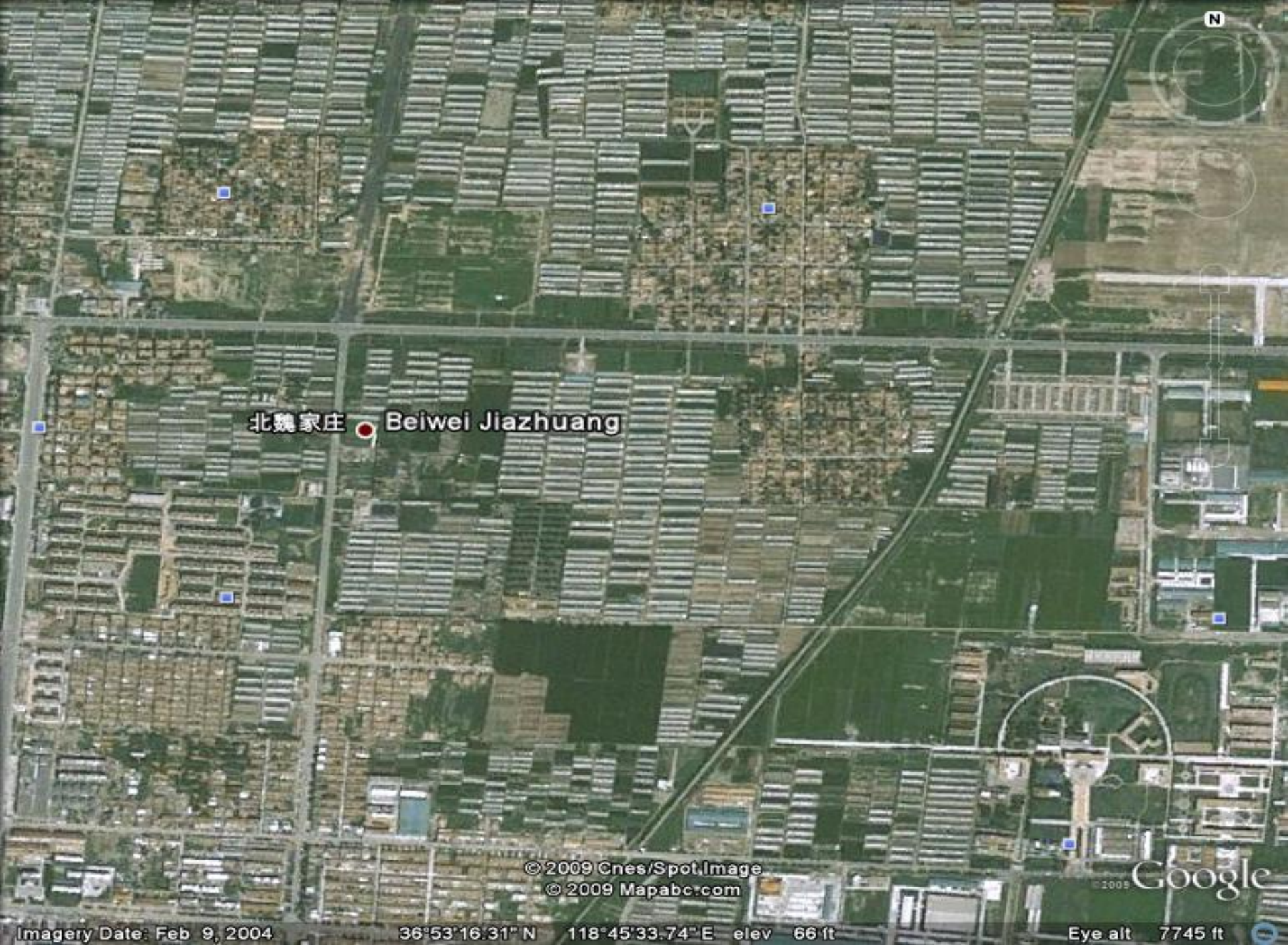
When cheap oil and natural gas became widely available in the 20th century, this stimulated the so-called green revolution – the creation of inexpensive chemical fertilizers, pesticides, and herbicides, which in turn guaranteed record American crop yields continuing to the present. Food has never been so plentiful.

It turns out natural gas is one of the most significant raw materials in this regard: during the late 20th century, natural gas prices remained low and stable, stimulating the mass production of cheap nitrogen-based fertilizer,

Three worm bins in the Saginaw Valley State University greenhouse are used to study the role of coffee concentration on vermicompost chemistry.

06/10/2009

06/10/2009


N
北魏家庄
Beiwei Jiazhuang
© 2009 Cnes/Spot Image
© 2009 Mapabc.com
Google
Imagery Date: Feb 9, 2004
36°53'16.31" N
118°45'33.74" E
elev 66 ft
Eye alt 7745 ft

1,003.8 square miles (642,474 acres) of Chinese solar greenhouse were in use in the year 2000.

During that winter, they produced 90% of the vegetables eaten in northern China.

Reference: Tong et al., Computers & Electronics in Agriculture 68 (2009) 129-139.

Used with little or no auxiliary heating where daily temps fall below 14 F.

Mainly sited at latitudes of 32 to 41 degrees north with some beyond 43 degrees.

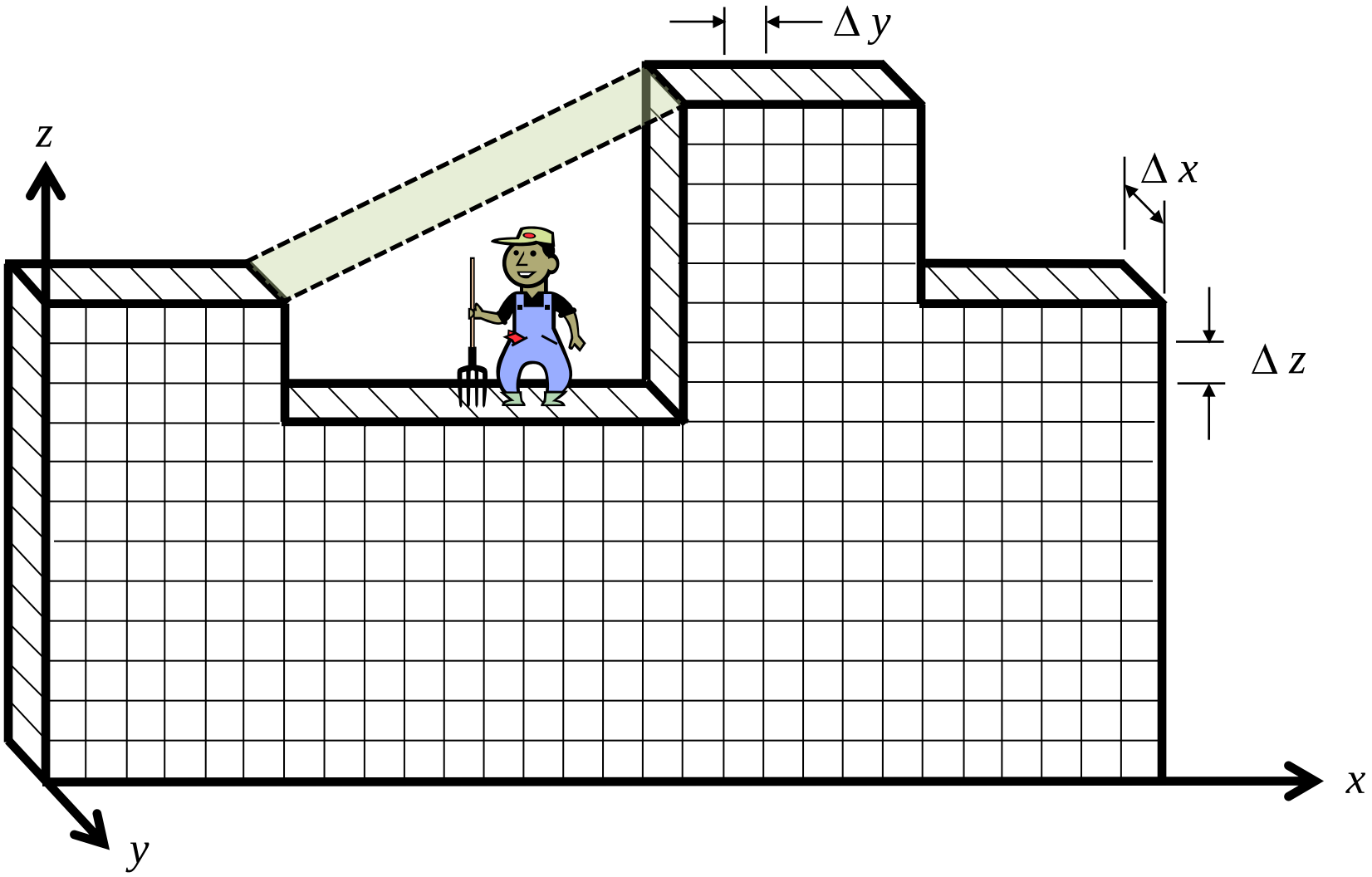
For comparison, Saginaw's latitude is 43.4.

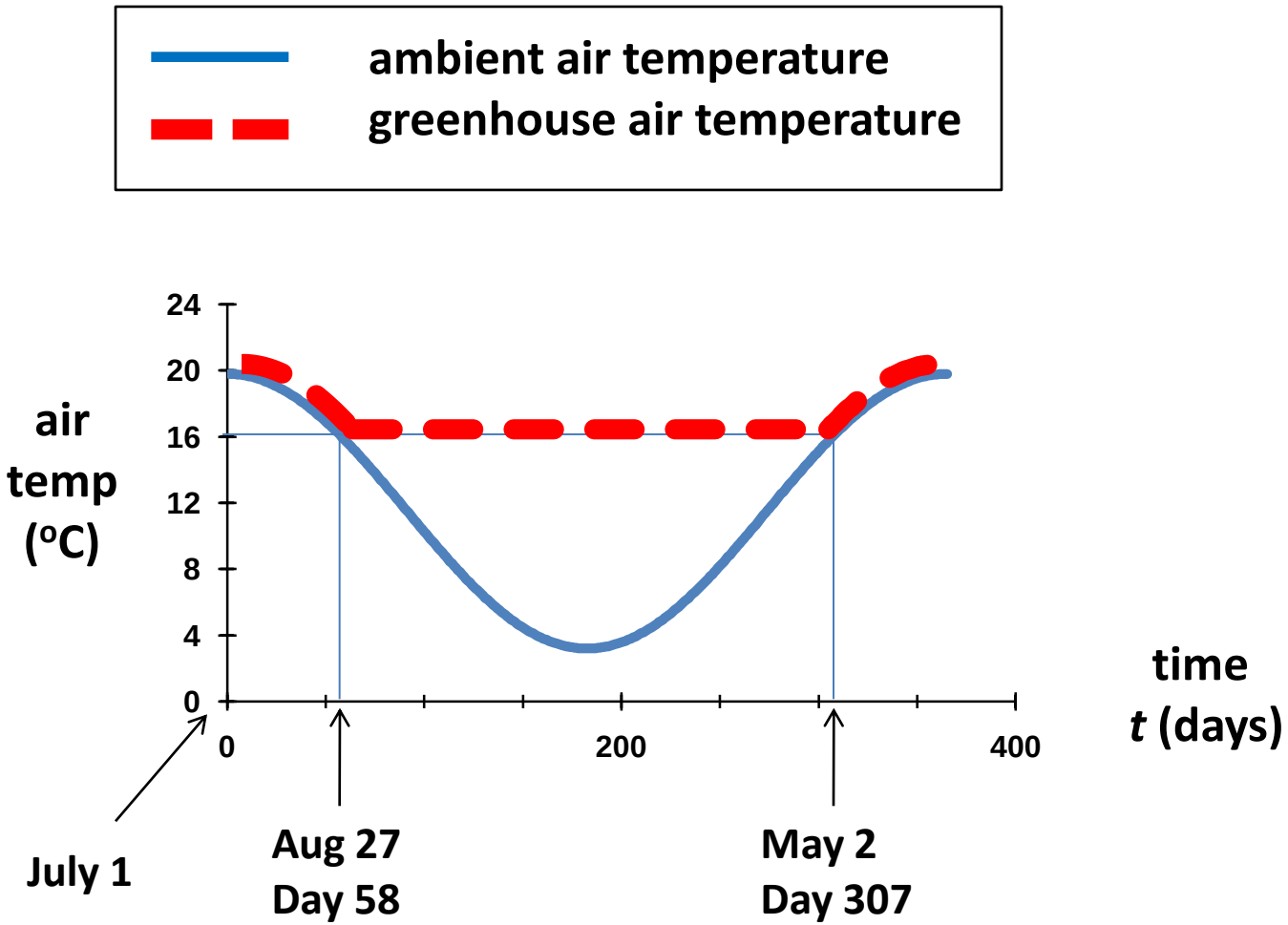
Reference: Tong et al., Computers & Electronics in Agriculture 68 (2009) 129-139.

To what extent is greenhouse thermal efficiency controlled by:

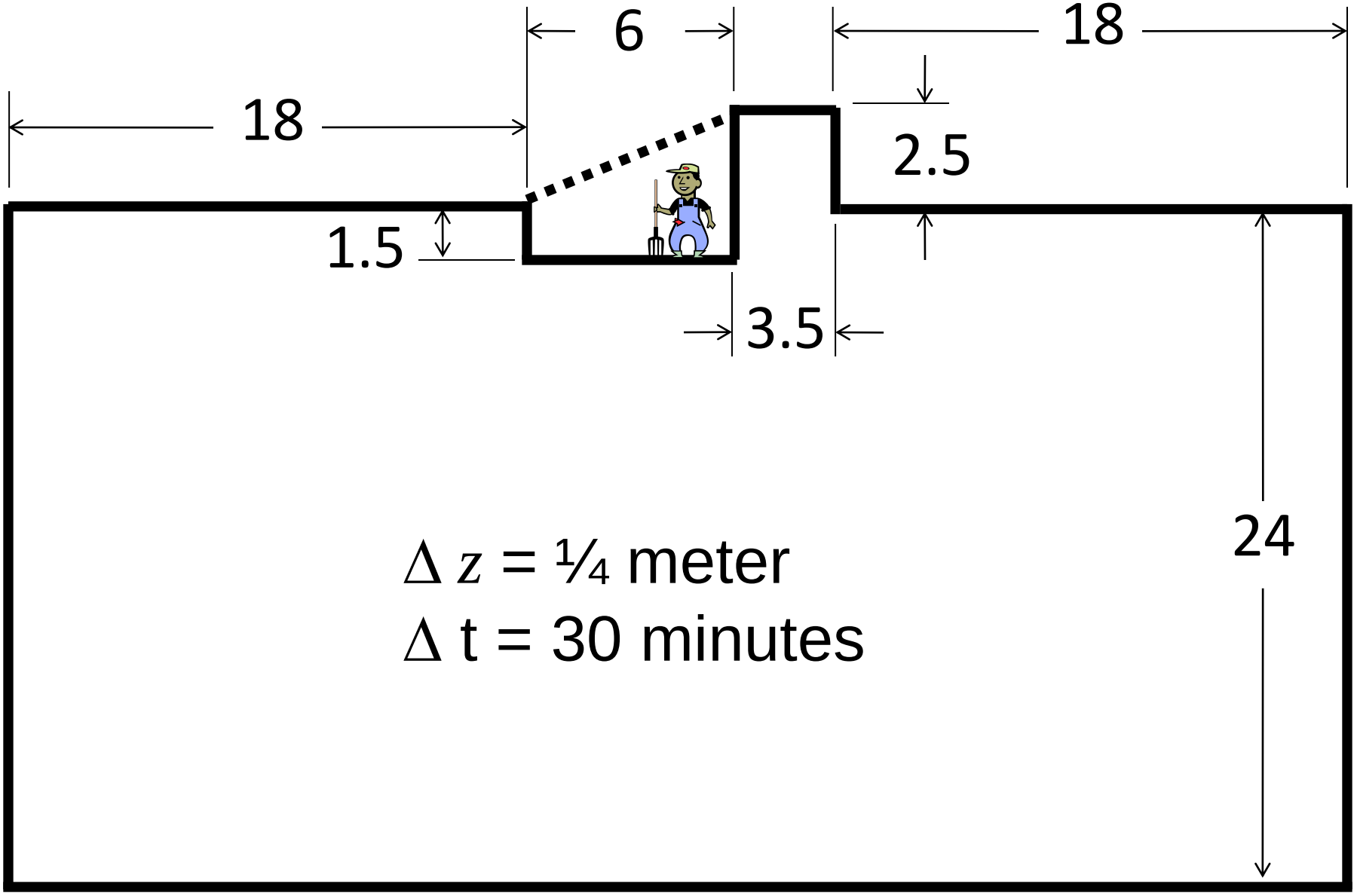
- **foundation dimensions**
- **soil type and moisture level**
- **regional climate**
- **changes in roof design**

Simulating soil heat transfer




ambient air temperature
greenhouse air temperature
air temp (°C)
24
20
16
12
8
4
0
0
200
400
time t (days)
July 1
Aug 27
Day 58
May 2
Day 307

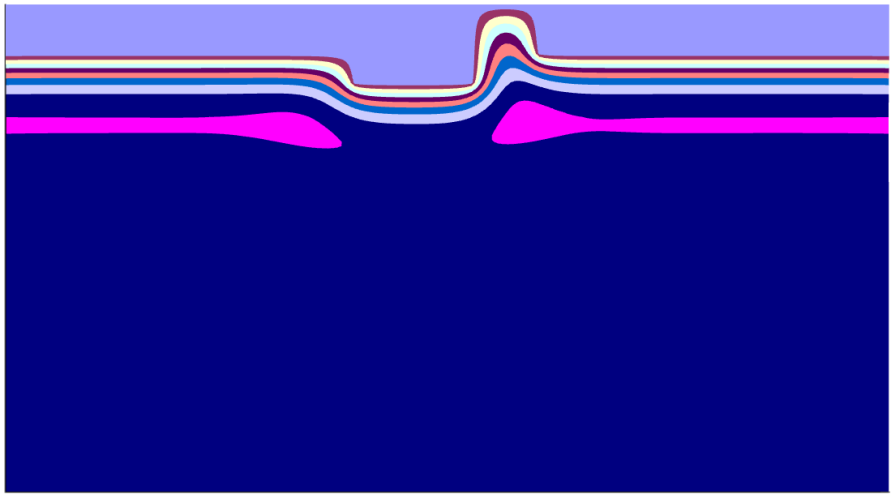
all dimensions in meters

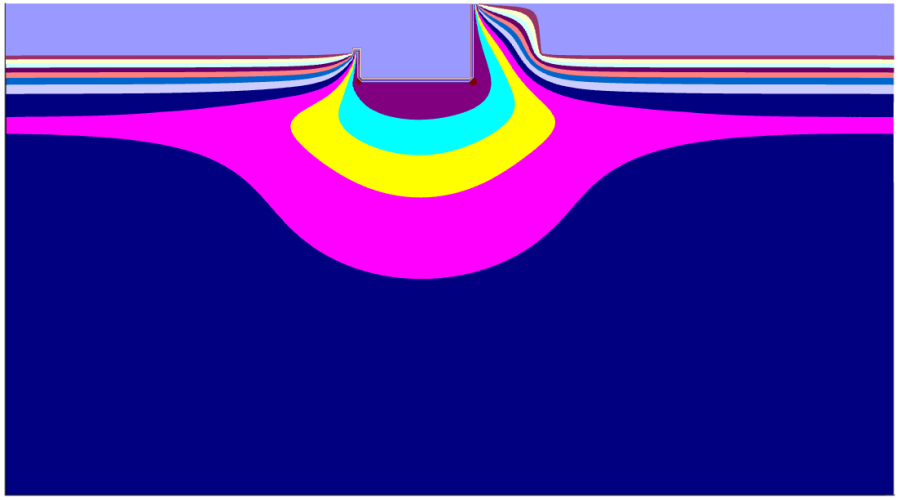


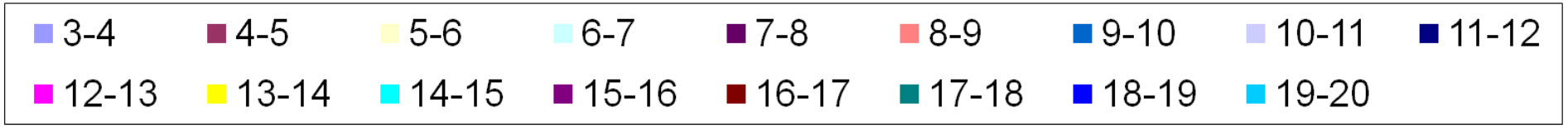
Jan 1 dry sand

no winter heat

16C winter set point





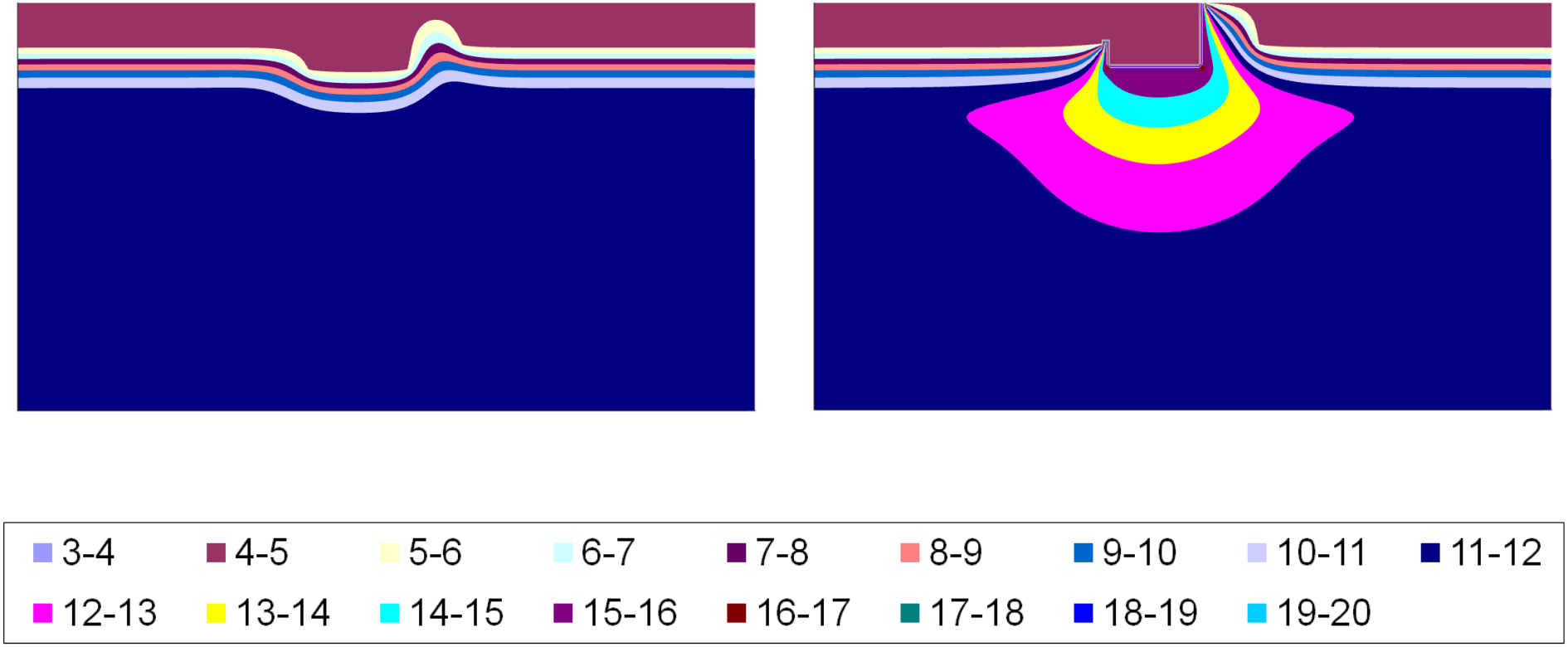


temperatures in degrees Centigrade

Feb 1 dry sand

no winter heat

16C winter set point

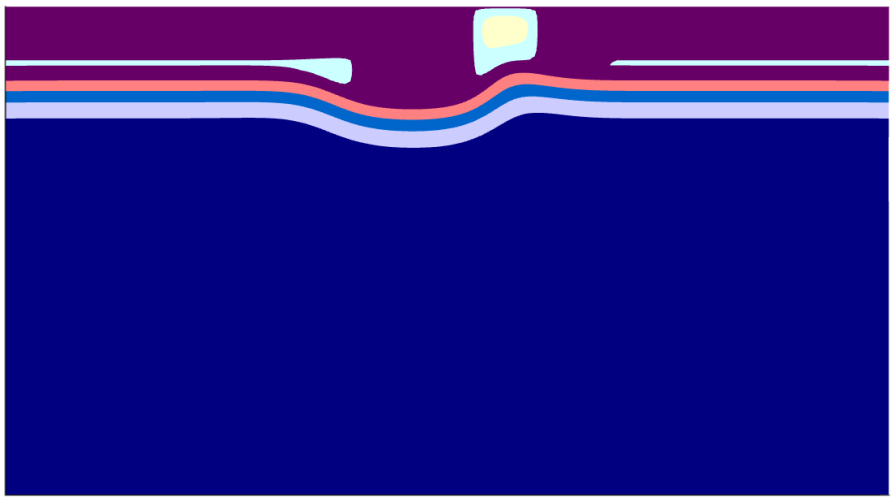


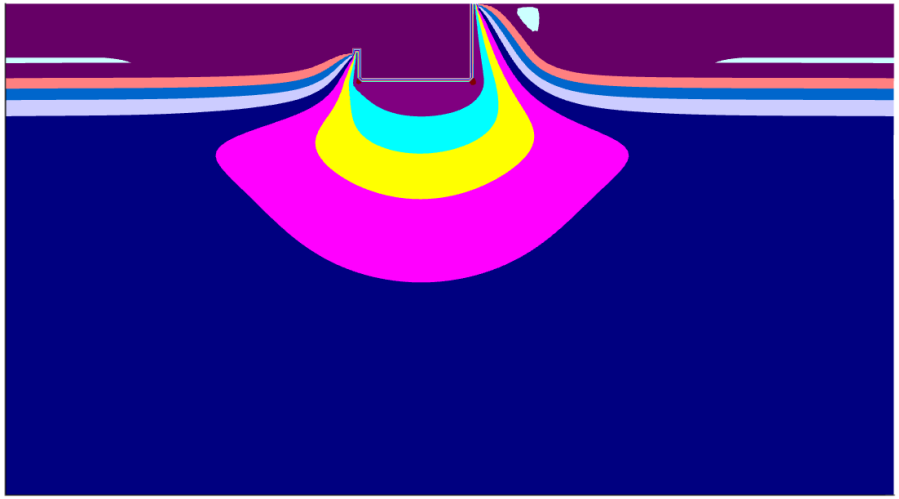
temperatures in degrees Centigrade

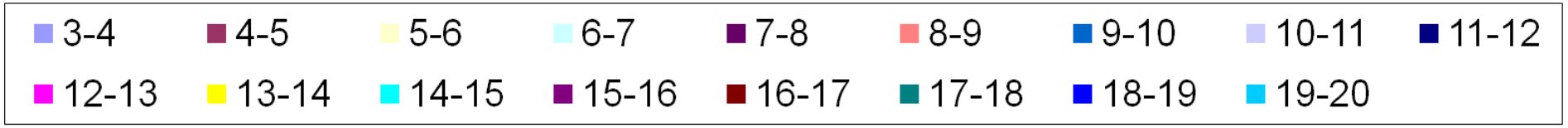
Mar 1 dry sand

no winter heat

16C winter set point





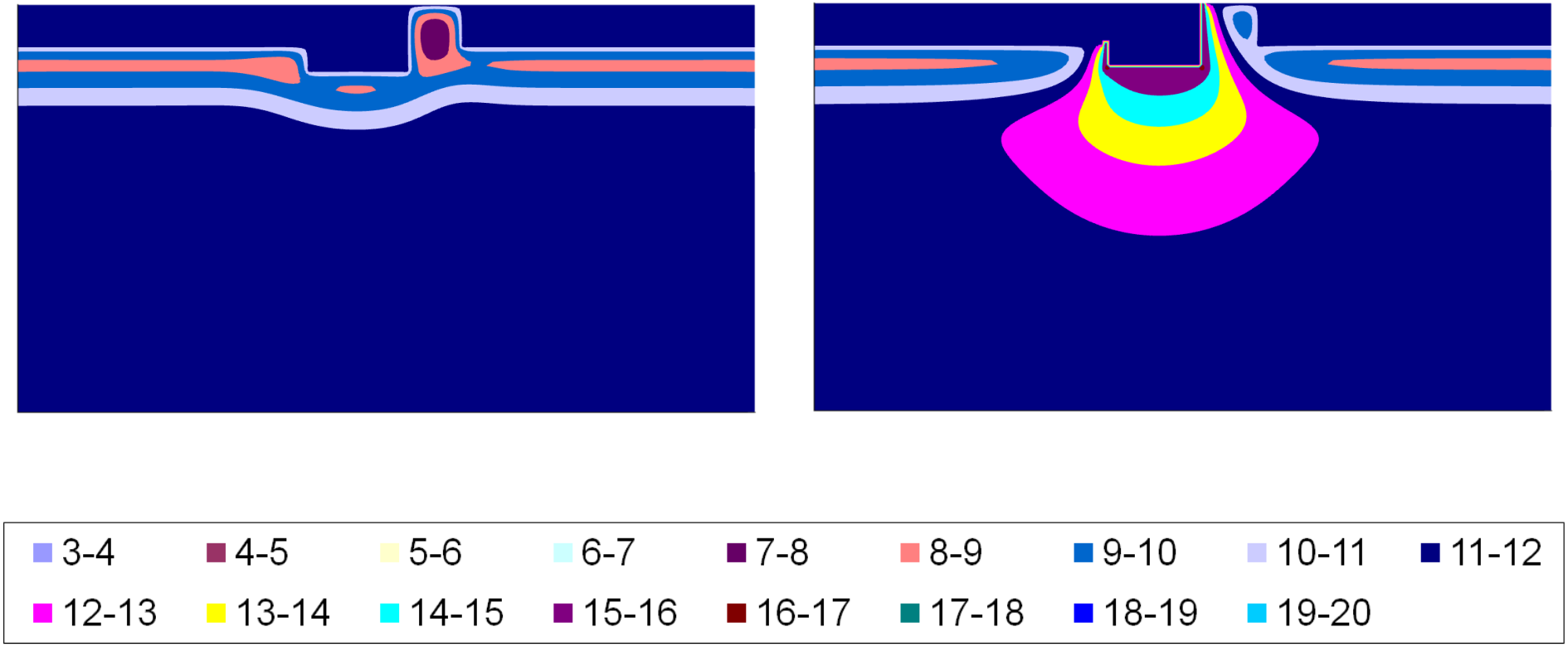


temperatures in degrees Centigrade

Apr 1 dry sand

no winter heat

16C winter set point

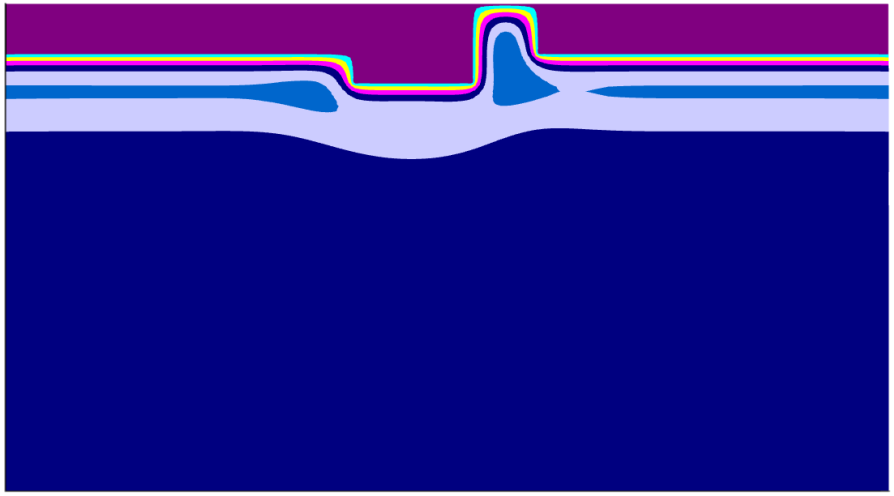


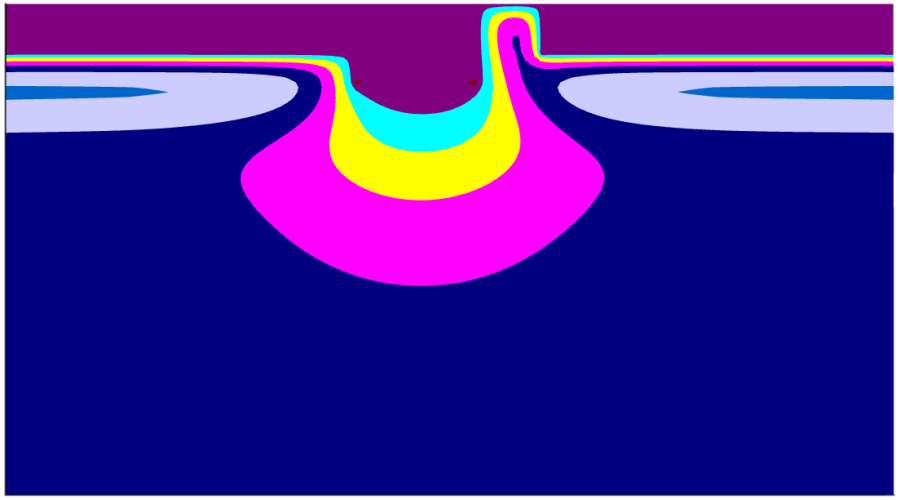
temperatures in degrees Centigrade

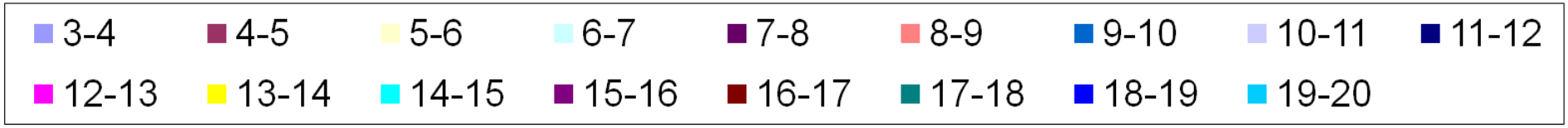
May 1 dry sand

no winter heat

16C winter set point





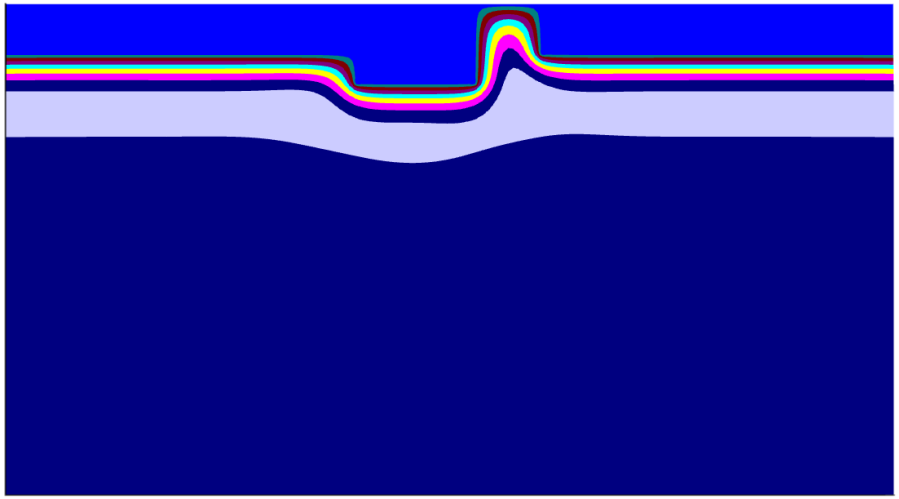


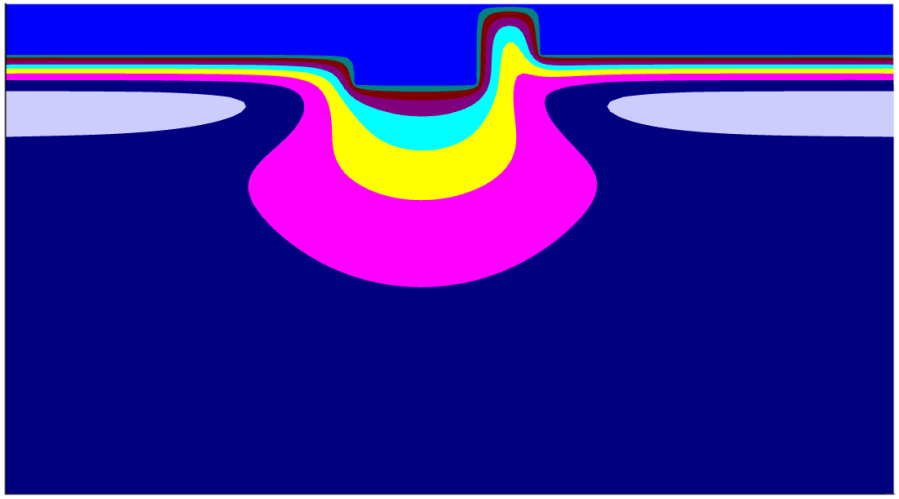
temperatures in degrees Centigrade

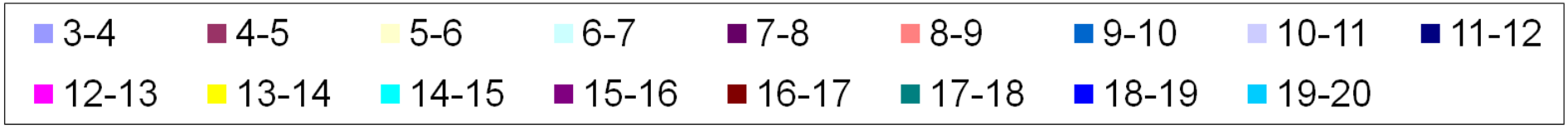
Jun 1 dry sand

no winter heat

16C winter set point





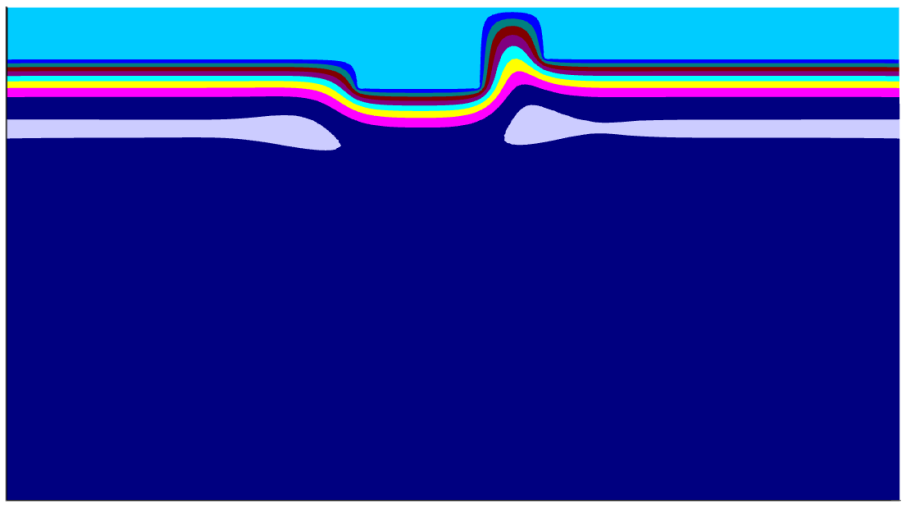


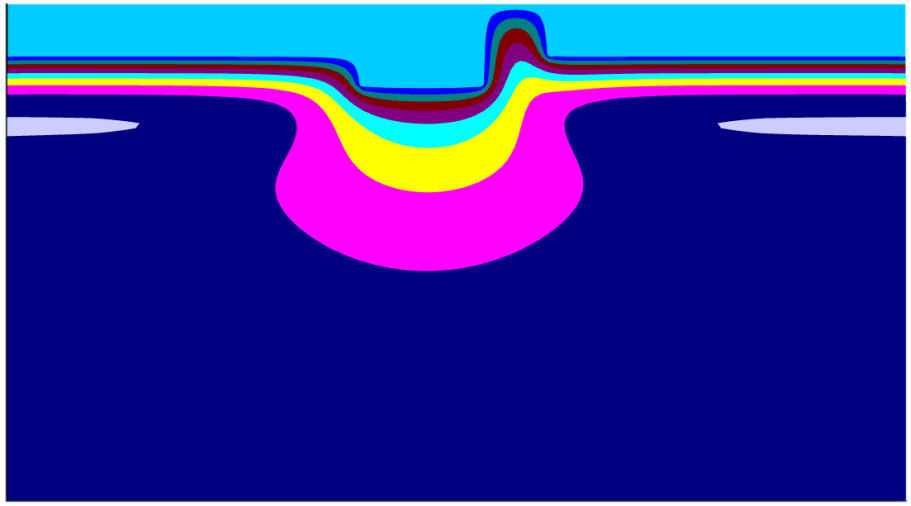
temperatures in degrees Centigrade

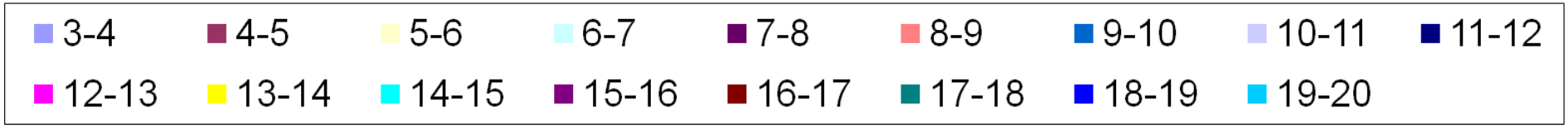
July 1 dry sand

no winter heat

16C winter set point





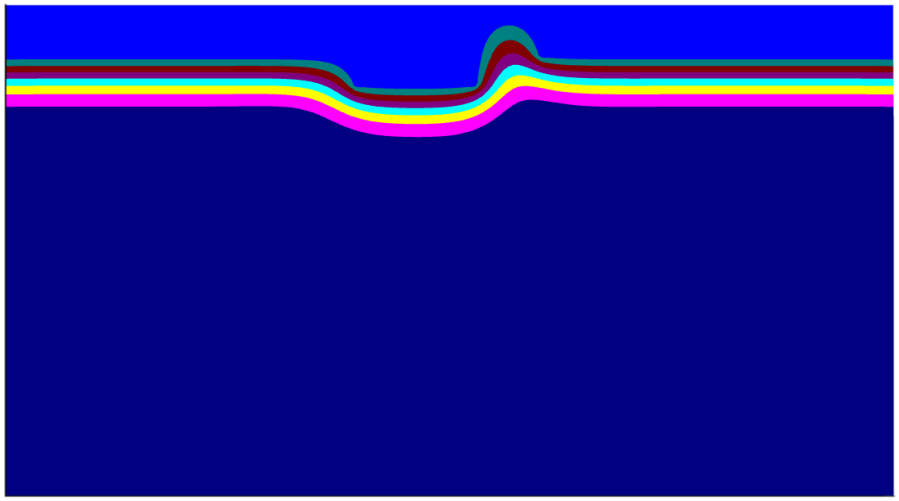


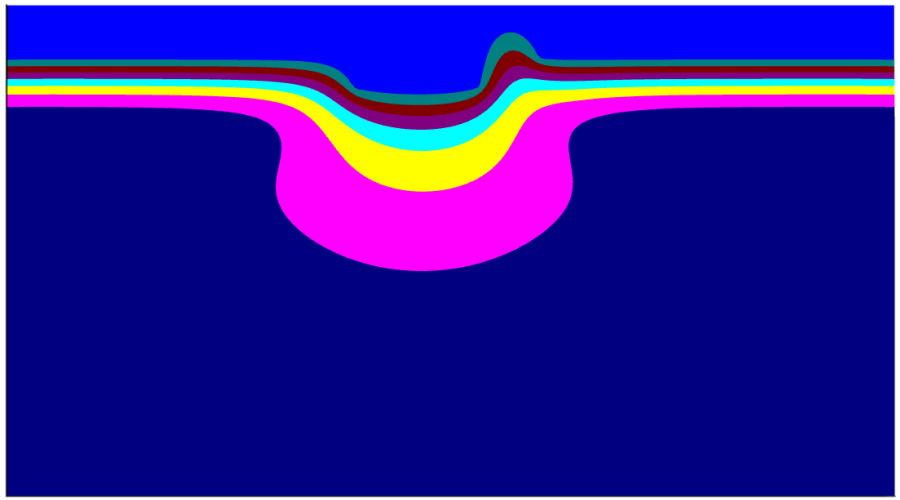
temperatures in degrees Centigrade

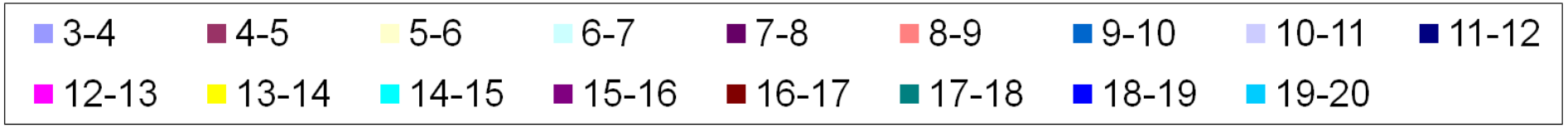
Aug 1 dry sand

no winter heat

16C winter set point



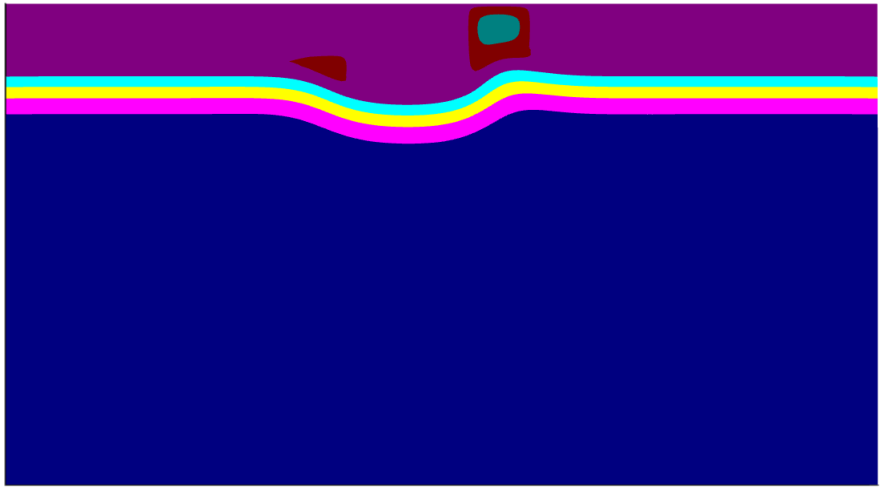




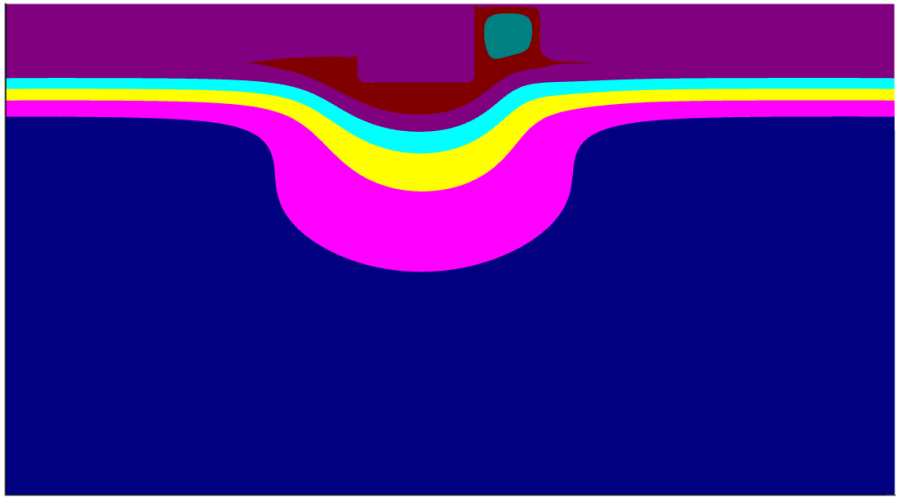
temperatures in degrees Centigrade

Sept 1 dry sand

no winter heat



16C winter set point



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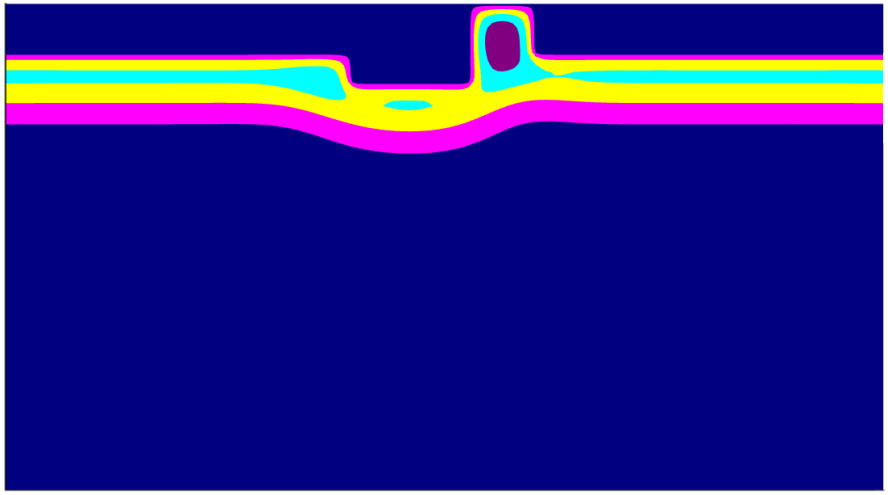
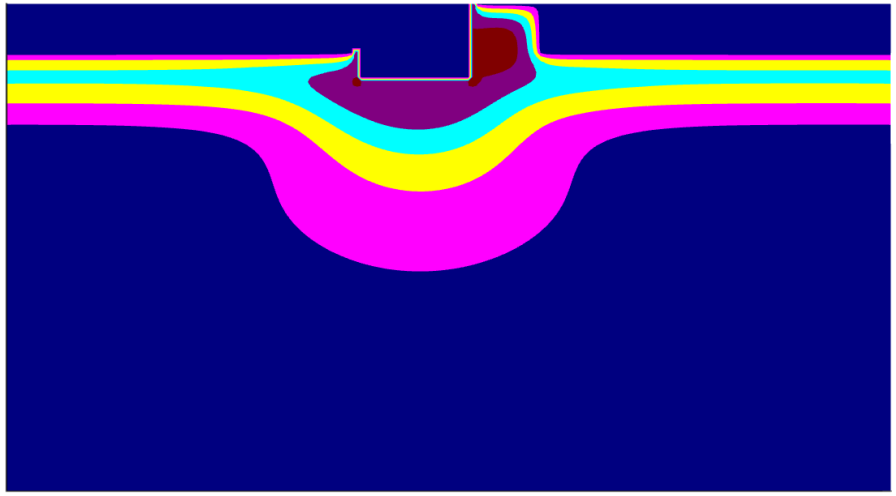
temperatures in degrees Centigrade

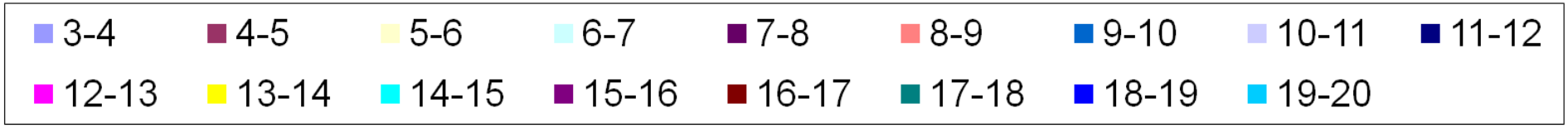
Oct 1 dry sand

no winter heat

16C winter set point



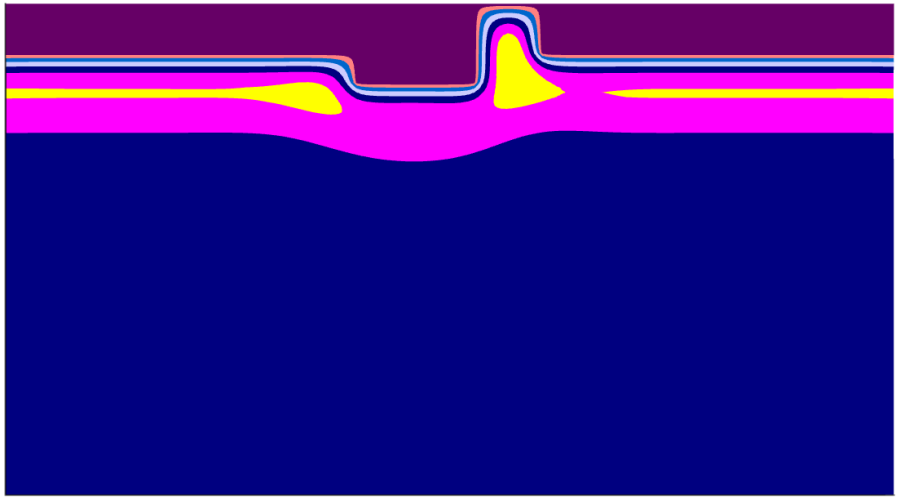




temperatures in degrees Centigrade

Nov 1 dry sand

no winter heat



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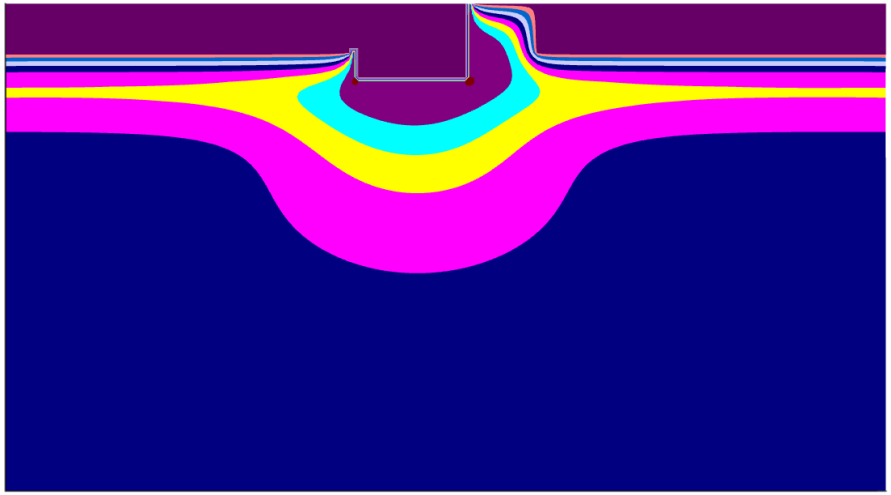
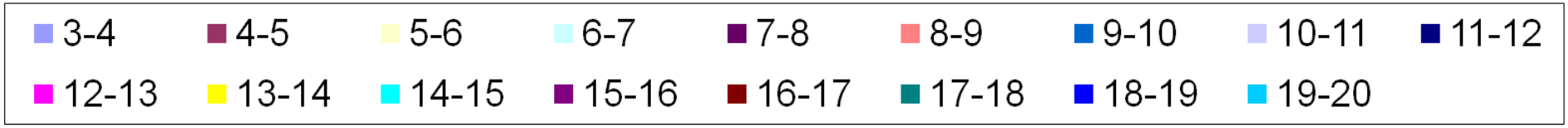


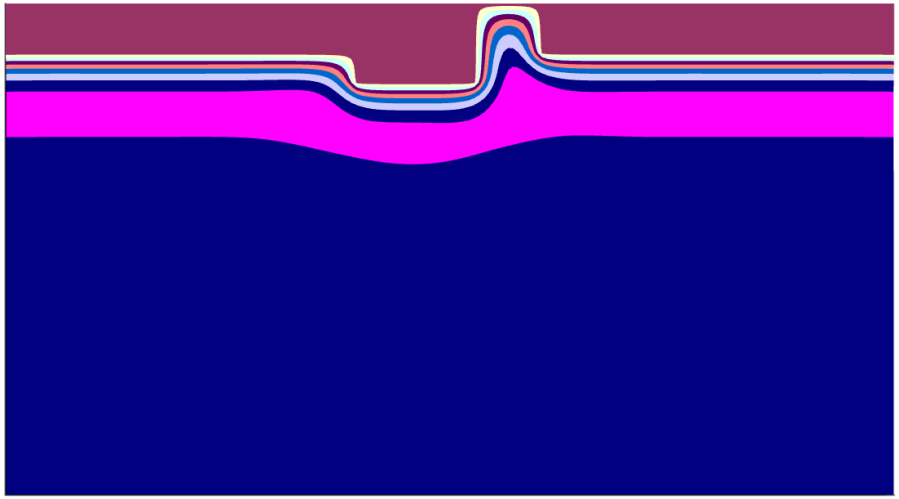


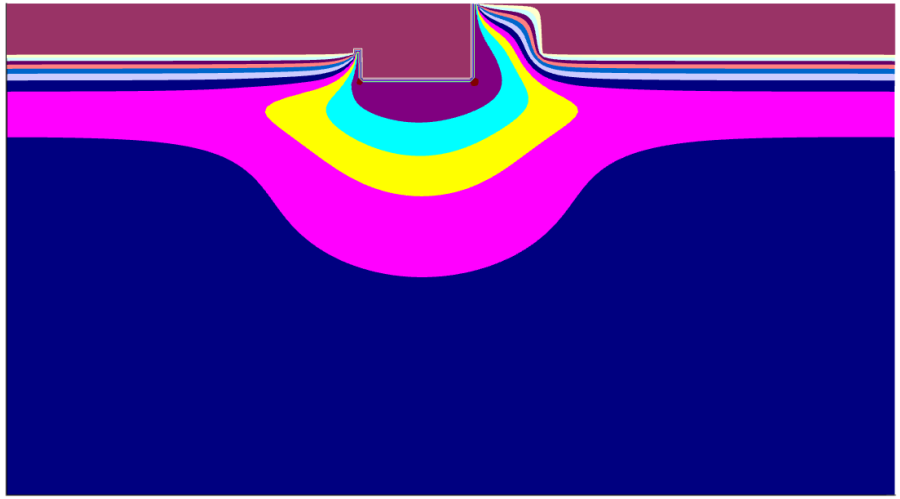
temperatures in degrees Centigrade

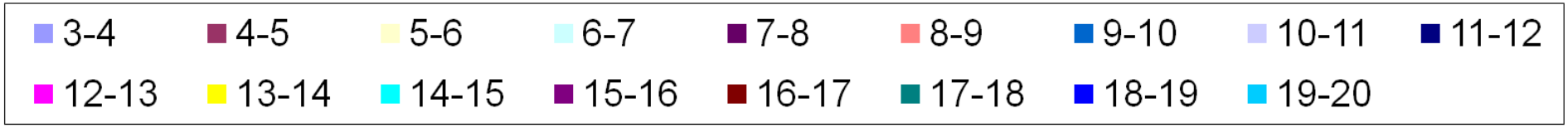
Dec 1 dry sand

no winter heat

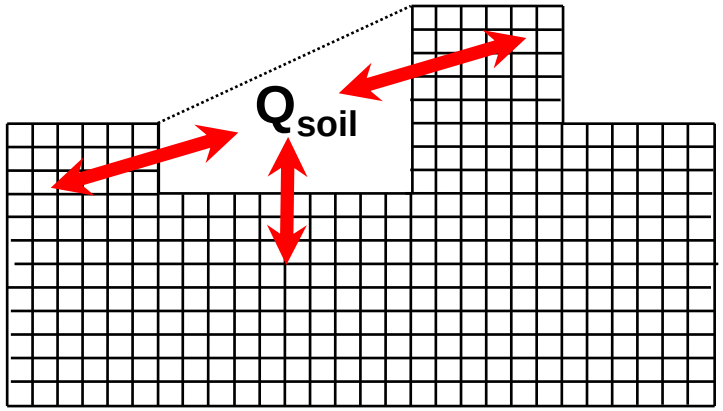
16C winter set point



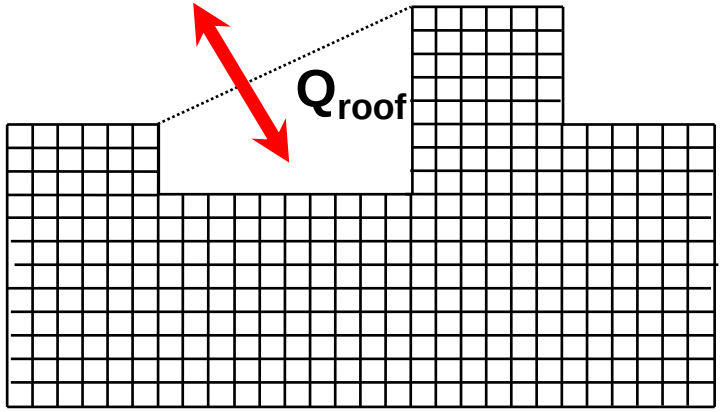




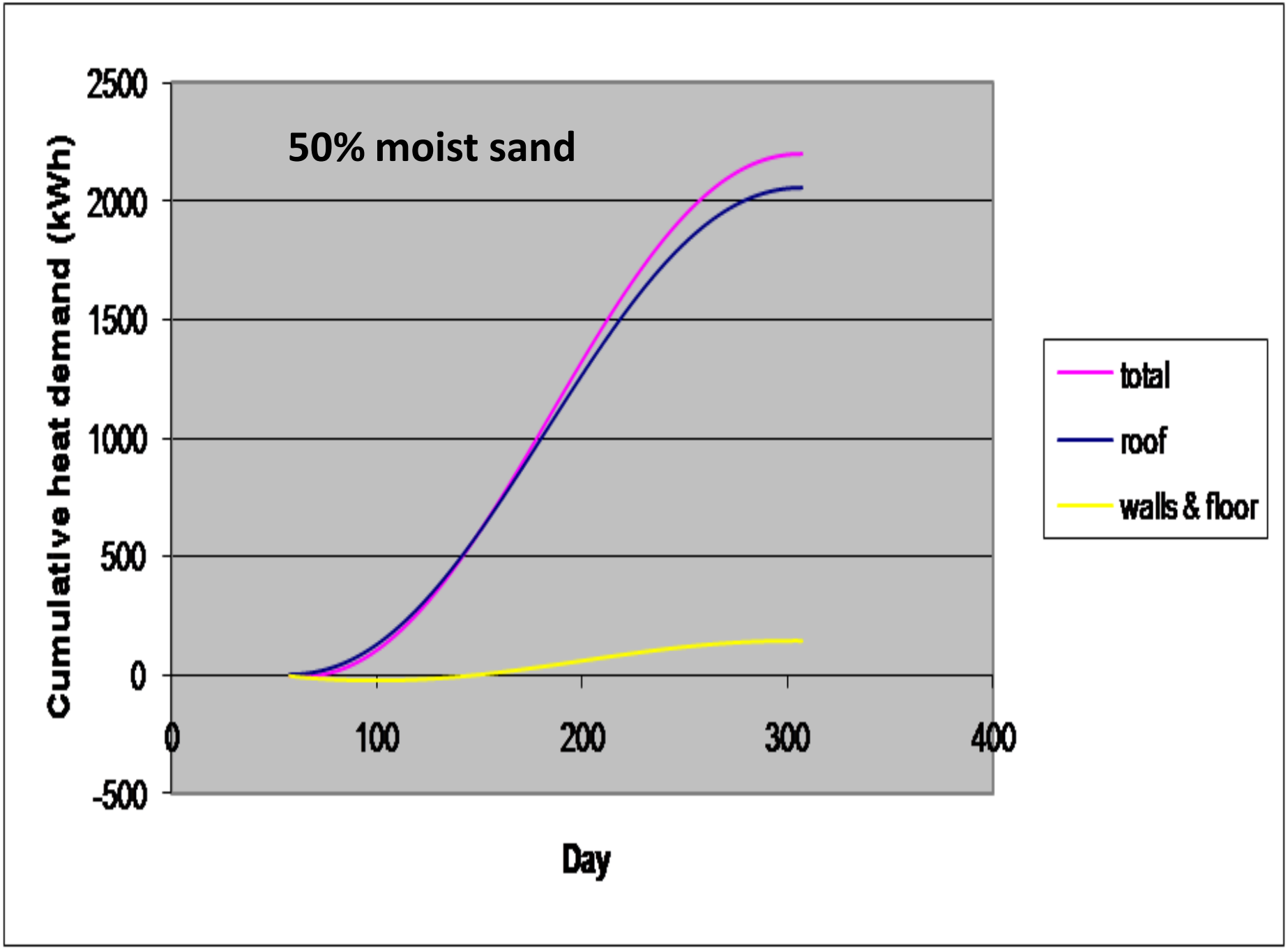
temperatures in degrees Centigrade



Q_{soil} = **Convection across air/soil interfaces**



Q_{roof} = **Conduction through roof**


50% moist sand
Cumulative heat demand (kWh)
2500
2000
1500
1000
500
0
-500
0
100
200
300
400
Day
total
roof
walls & floor

Sustainable intensification:

Growing more food with the same land area, less environmental impacts, less fossil fuel.

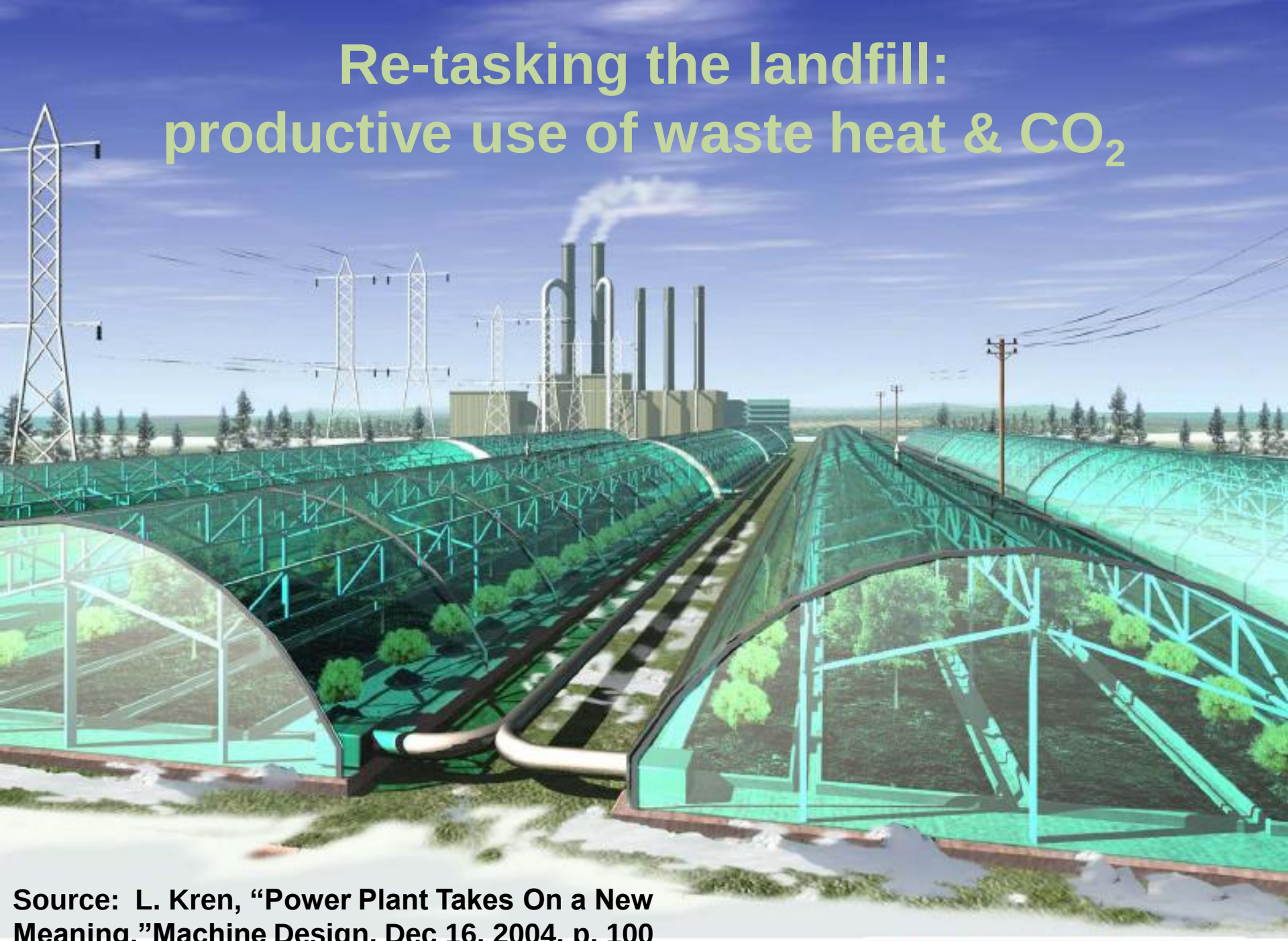
C. Godfray et al., "Food Security: The Challenge of Feeding 9 Billion People," Science, Feb 12, 2010, p. 812-18

Today's grand challenge: Producing more food & energy with less fossil resources.

Biodigester in Laholm, Sweden.

Biogas-fueled train in Sweden.

Re-tasking the landfill: productive use of waste heat & CO_2



Source: L. Kren, "Power Plant Takes On a New Meaning,"Machine Design, Dec 16, 2004, p. 100

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MACHINE Design
BY ENGINEERS FOR ENGINEERS .com

“Currently, each megawatt production of electric power results in the wasteful creation of another megawatt of thermal energy.”

Source: L. Kren, “Power Plant Takes On a New Meaning,”Machine Design, Dec 16, 2004, p. 100

MACHINE Design
BY ENGINEERS FOR ENGINEERS .com

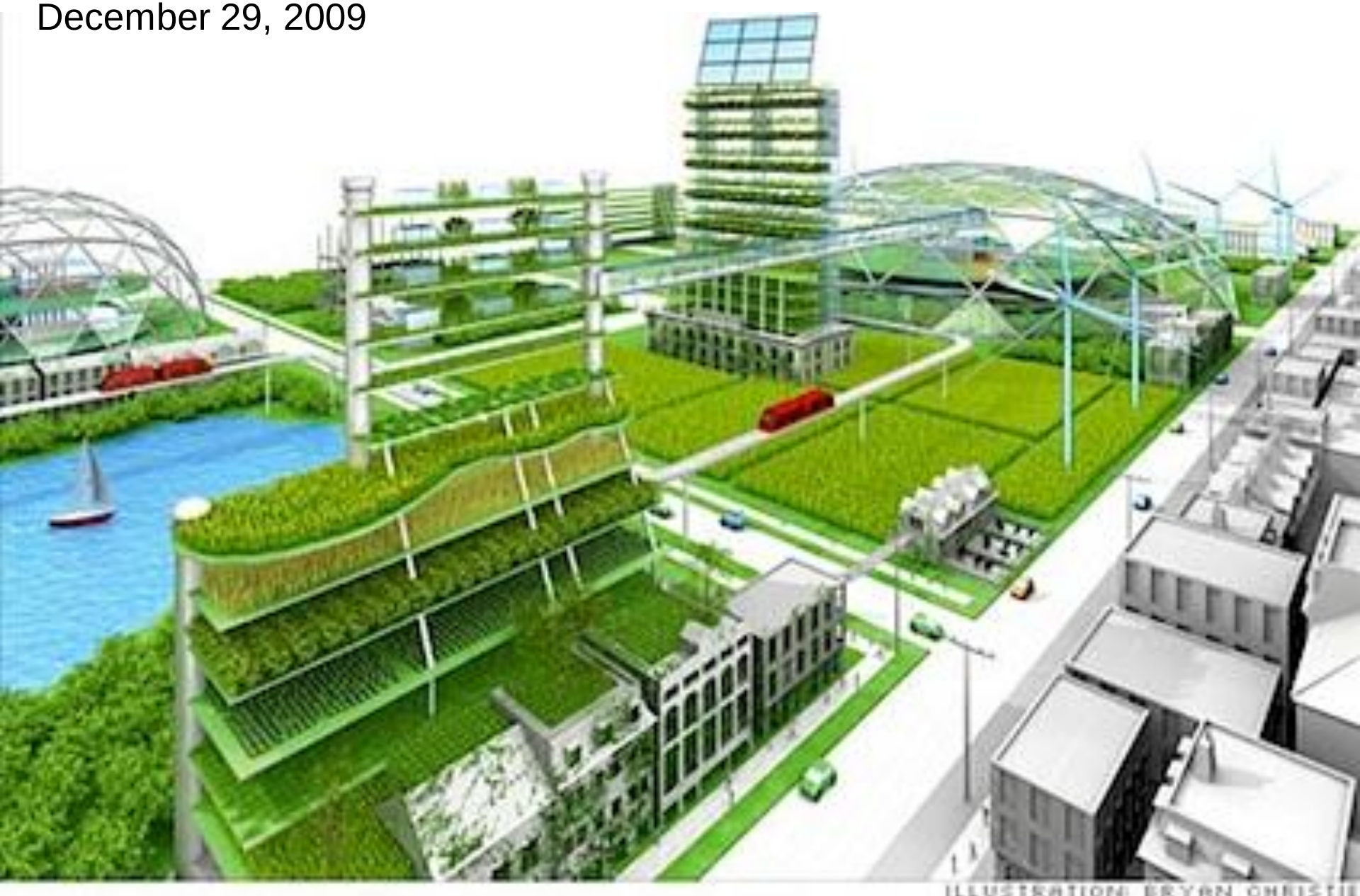
“There are hundreds of power plants in the US that can provide waste heat and (CO_2) emission to a substantial greenhouse industry, helping to develop a new agricultural sector.”

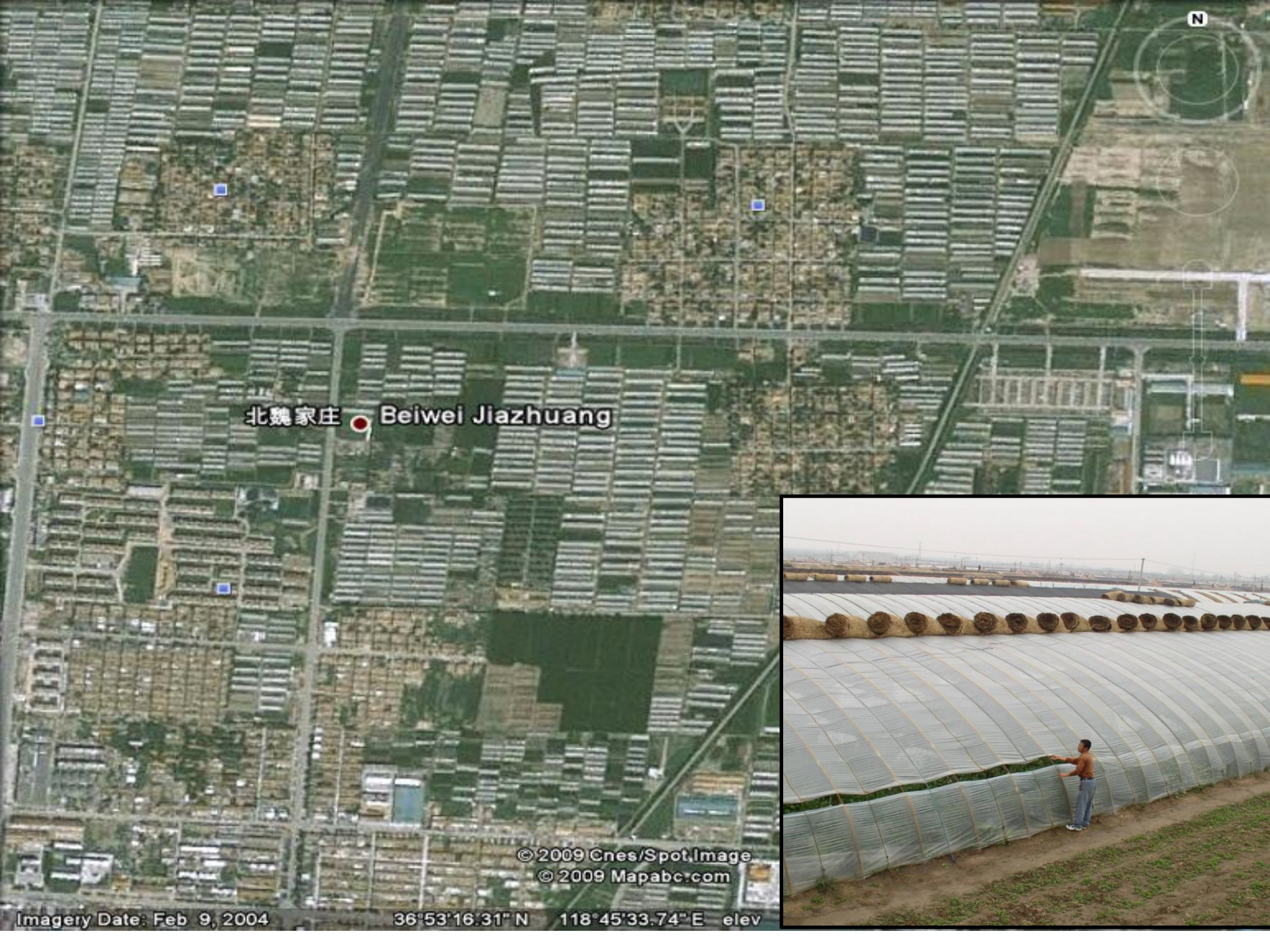
Source: L. Kren, “Power Plant Takes On a New Meaning,”Machine Design, Dec 16, 2004, p. 100

Fortune Magazine – Can farming save Detroit?

David Whitford

December 29, 2009

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Imagery Date: Feb 9, 2004
36°53'16.31" N
118°45'33.74" E
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SVSU Projects

- **Biofuel from glycerin residues of biodiesel processing.**
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- **Sustainable intensification by integrating renewable energy with aquaponics.**
- **Modeling geothermal heating in partly subterranean greenhouses of Asian design.**
- **Economic prospects of re-tasking waste management operations with greenhouse agriculture.**