

*An epiphany can be defined as “a moment of sudden revelation or insight.” A group of Sustainable Hanover Committee and Dartmouth folks may very well have experienced a “sustainable epiphany” on a recent trip to Denmark, arguably one of the worlds leading nations in energy sustainability. This special issue of Sustainable Hanover describes their visit. Special thanks to Julia Griffin and Judi Colla for their reporting and pictures and to Rob Taylor for editing.*

## **Sustainable Hanover and Dartmouth College Tour Green Denmark**

*Julia Griffin, Hanover Town Manager*

In early September of 2019, a group of Hanover and Dartmouth colleagues traveled to Denmark together on a week-long quest – to tour several different types of community-based, hot water heating plants fueled by various types of biomass in a country that is leading a transition to 100% green power in electricity, heating and transportation fuels. The delegation included Sustainable Hanover volunteers Yolanda Baumgartner, Judi Colla and Fletcher Passow, Hanover Selectboard members Nancy Carter and Joanna Whitcomb (doing double duty as a Dartmouth staff member as well), Town staff Rob Houseman and manager Julia Griffin, senior Dartmouth staff members Rick Mills, Josh Keniston, Frank Roberts, Rosi Kerr, Abbe Bjorklund, John Steidl and Susan Boutwell, Tuck’s Revers Center for Energy staff member Madeleine Bothe, Tuck



*One of world's first offshore wind farms - Middelgrunden(2)*

students Kevin Yuan and Peter Cahill and Dartmouth undergraduates Hannah McGrath and Camilo Toruno.

Day 1 of our visit took the group to Copenhagen’s Amager Resource Center, a large trash-to-energy facility that incinerates locally generated trash and provides heat to 160,000 Copenhagen households along with electricity for 62,500 residents. The facility is situated in the city’s central harbor area, just minutes from Downtown Copenhagen. We also visited a small aquifer thermal energy storage facility that heats a large hotel and conference complex in a suburb of Copenhagen. This type of technology reduces the facility’s need for primary heating and cooling fuel by recovering, storing and utilizing thermal energy in the



*Participants on way to Middelgrunden Offshore Wind Farm.(1)*



*View from the Amager Resource Center(3)*

subsurface below the hotel complex to help provide heating and cooling.

Day 2 of our visit was spent visiting the Technical University of Denmark and the Danish Office of the State of Green where we witnessed firsthand the impressive green power technology research that is occurring in Scandinavia, both at the university level and at the government and private sector level.



*Woodchip storage for Halsnaes (4)*

Day 3 took us to the Halsnaes district heating plant which provides hot water heat for 14,000 residents in the area of Frederiksvarke, located about 90 minutes' drive northwest of Copenhagen. The plant uses wood chips, wood pellets and rapeseed (canola) oil as heating sources and is situated in the middle of the small city. We then travelled another 60 minutes northward to the St. Merlose central heating plant in the small community of Holbaek. The plant burns waste straw which is the residual agricultural product left after wheat is harvested in the region and provides heat for 400 homes immediately adjacent to the plant. Later that afternoon, we toured the Frederiksberg Utility in a large suburb of Copenhagen, which uses oil and wood biomass to provide district heating to 110,000 homes and businesses.

Day 4 took us on a bicycle tour of Copenhagen, led by the Cycling Embassy of Denmark. We



*Bike storage at Copenhagen metro stop.(5)*

all came away impressed by the city's massive commitment to facilitating bicycle transportation as the residents look to significantly reduce their use of cars. The City spends \$20 million per year on bicycle infrastructure improvements and is rapidly converting vehicle travel lanes into bicycle lanes as Copenhagen residents readily turn to bicycle

transportation. More than 60% of daily trips in Copenhagen are made on bicycles. That afternoon we visited officials at the University of Copenhagen to hear about their work to become the world's greenest university campus. We were astounded to descend into a parking garage for 2,000 bicycles which students, faculty and staff use to travel to the campus each day. Cars are relegated to a more distant, remote parking garage which is far less convenient for users.

Day 5 took a smaller contingent by air to the northern tip of Jutland, Denmark's mainland, to visit the brand new, current state-of-the-art, wood chip biomass fueled hot water central heating plant in Sindal. The facility serves some 1,200 households and businesses in the small community, has extremely low emissions and



*Fletcher Passow & Rob Houseman admire landscaping at St. Merlose (6)*

runs exclusively on waste wood biomass generated from local logging operations.

Without exception, what we saw in Denmark was a wide range of hot water heating plants, fueled by a variety of different biofuel and traditional fossil fuel heat sources, all operating well below national emissions standards and embedded in the communities they serve. We also heard that just as the country relies on

biomass of various types to provide both heat and co-generation electricity for their communities at a central location, Denmark also recognizes that biomass as a source of heat is only one option available to generate heat and electricity. The country, and northern Europe in general, is deeply committed to diversifying its green power sources and is leading the technological research around green power. During our trip we heard presentations from traditional oil drilling companies that are now transitioning to well drilling for both deep geothermal and closed loop, low temperature geothermal as options for heating hot water to provide heat to communities. We also toured one 20 MW offshore wind farm which is cooperatively owned by Copenhagen residents and is located just 1/2 mile off Copenhagen harbor. On our travels around both Zealand (the island which hosts Copenhagen) and Jutland, including our flights to and from Jutland, we observed dozens of offshore and onshore wind farms. We learned that more than 30% of Denmark's electricity is generated by wind power, with a national goal of reaching 50% by 2030.

The U.S. and New England have much to learn from Scandinavia, Germany and the Netherlands. An opportunity to travel beyond our borders to parts of the world that are leading the transition to renewable energy provides both inspiration and helps us to develop connections with other individuals, companies and communities that are far ahead of us in this transition. The entire delegation returned from our trip with a profound respect for the progress being made in Denmark, for the technological leadership being fostered in that country and for the national commitment to green power.



## Take Homes!

*Judi Colla, Chair Energy Committee*

- Oil crisis of 1970's had severe adverse impact on Denmark's economy and triggered efforts to disengage from fossil fuels.
- Given geography, Denmark has an abundance of wind and good "ventilation."
- Danish buildings are generally well insulated.
- Hot water district heating systems are prevalent throughout Denmark and are an efficient way to heat. This confirms Dartmouth's decision to convert from steam to hot water.
- There are a variety of biomass plants (chips, pellets, straw). The newer ones are increasingly clean and efficient. They are backed up by older biomass plants, natural gas, or oil -- often fired up only once a year to test/maintain the system.
- Denmark is similarly struggling with the carbon and sustainability issues surrounding biomass. They are well suited for geothermal. There are a couple of Danish companies that are using their oil drilling expertise to drill deep wells for geothermal. This might be an option for Hanover but has not yet been used in the US and could be very expensive.
- Copenhagen brought back its cycling culture through thoughtful strategy and investment, for example, building bridges specifically for bikes and pedestrians, giving cyclists a head start at traffic lights, and providing spaces to park bikes (sometimes with showers) have made cycling the fastest way to get around the city. Denmark's more temperate climate and flat terrain facilitated these efforts.
- Denmark plans to have its electrical needs satisfied 100% by wind backed up by hydropower from Norway.

\*Expanded captions:

- (1) Participants on way to Middelgrunden Offshore Wind Farm. From L to R: Kneeling: Susan Boutwell, Madeleine Bothe, Nancy Carter, Niels Vilstrup (Denmark Embassy) Middle: Denmark official, Yolanda Baumgartner, Camilo Toruno, Frank Roberts, Judi Colla, Hannah McGrath, Kevin Yuan, Abbe Bjorklund, Julia Griffin, Peter Cahill, Denmark Official Back: Rob Houseman, Josh Keniston, Rick Mills, Joanna Whitcomb, Rosi Kerr, John Steidl Missing: Fletcher Passow (late flight/just missed the boat!)
- (2) One of world's first offshore wind farms, beautiful Middelgrunden consists of 20 2 MW Bonus turbines that provide 3 per cent of Copenhagen's electricity consumption. Attention to aesthetics facilitated buy-in.
- (3) View from Amager Resource Center, a large trash-to-energy incinerator providing heat to 160,000 and electricity to 62,500 Copenhagen households. Amaker is also an urban park with hiking trails, an 85 meter high climbing wall and a ski slope topped with artificial turf for year-round skiing.
- (4) Woodchip storage for Halsnaes District Heating Plant, one of four biomass heating plants visited.
- (5) Bike storage at Copenhagen metro stop. Cyclists comprise more than 60% of commuters. City spends \$20 million per year on thoughtful bicycle infrastructure improvements. City officials calculate annually that savings from bicycle usage more than outweigh the cost of infrastructure improvement.
- (6) Fletcher Passow and Rob Houseman admire landscaping at the St. Merlose waste straw burning central heating plant.

