Sustainable Energy Economics

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University of Maine, Orono

EnergyVision Forum
Augusta, Maine
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Who am I?

- Associate Professor, School of Economics, UMaine, since 2011
- Interdisciplinary energy researcher/teacher: economics, engineering, public policy, environmental science
- Teach 2 sustainable energy classes/yr (service-learning)
- Research: sustainable energy that
  - Helps environment
  - Helps people
  - Saves money
- Member, Board of Directors, WindowDressers, since 2018
- Member, Advisory Board, Greater Bangor Solarize, since 2017
- Previously: middle & high school teacher (CA, Ecuador), Americorps volunte[illegible]rew up in MA

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Sustainable Energy Economics

- Financial, Social & Environmental Costs & Benefits
- Of any potential solution that may improve technical, economic, environmental, social sustainability
- Multi-criteria decision analysis (MCDA) & social benefit-cost analysis (SBCA)
- State, federal, local policy influences
- Stakeholder-engaged decision support
- Community-engaged solutions

MCDA of US Electricity Options, 2015

13 electricity options:
Coal
Natural Gas
Nuclear
Biopower
Geothermal (2 types)
Hydropower
Wind (2 types)
Solar (4 types)

Energy Policy 79 (2015) 127–149

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Comparing the sustainability of U.S. electricity options through multi-criteria decision analysis

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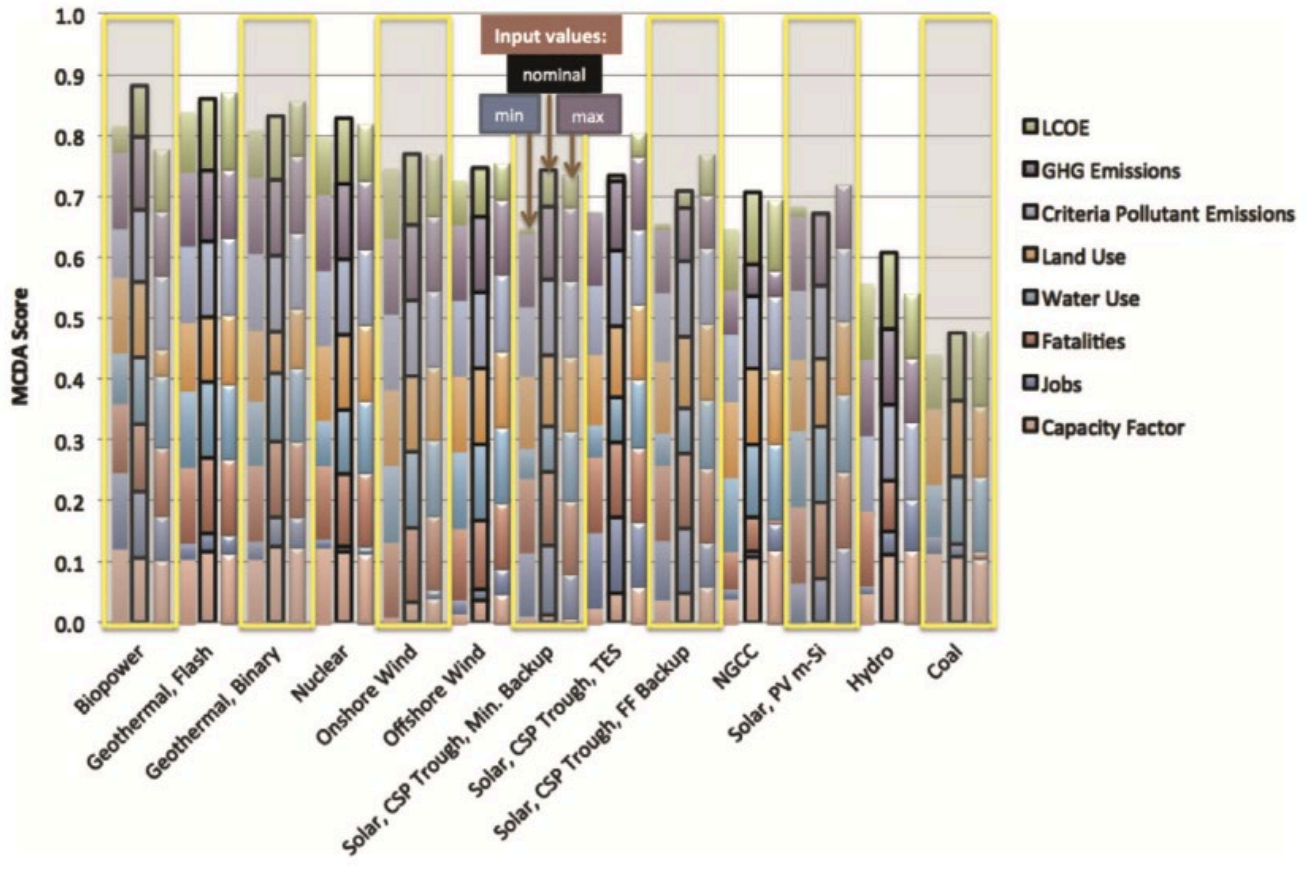
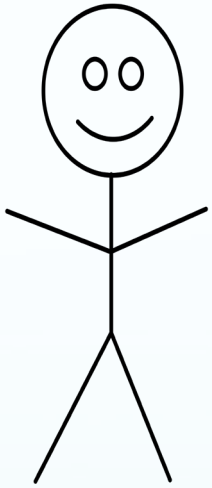
8 sustainability criteria:
Levelized cost of energy
Life cycle GHG emissions
Air pollution
Land use
Water use
Fatalities
Jobs
Capacity Factor

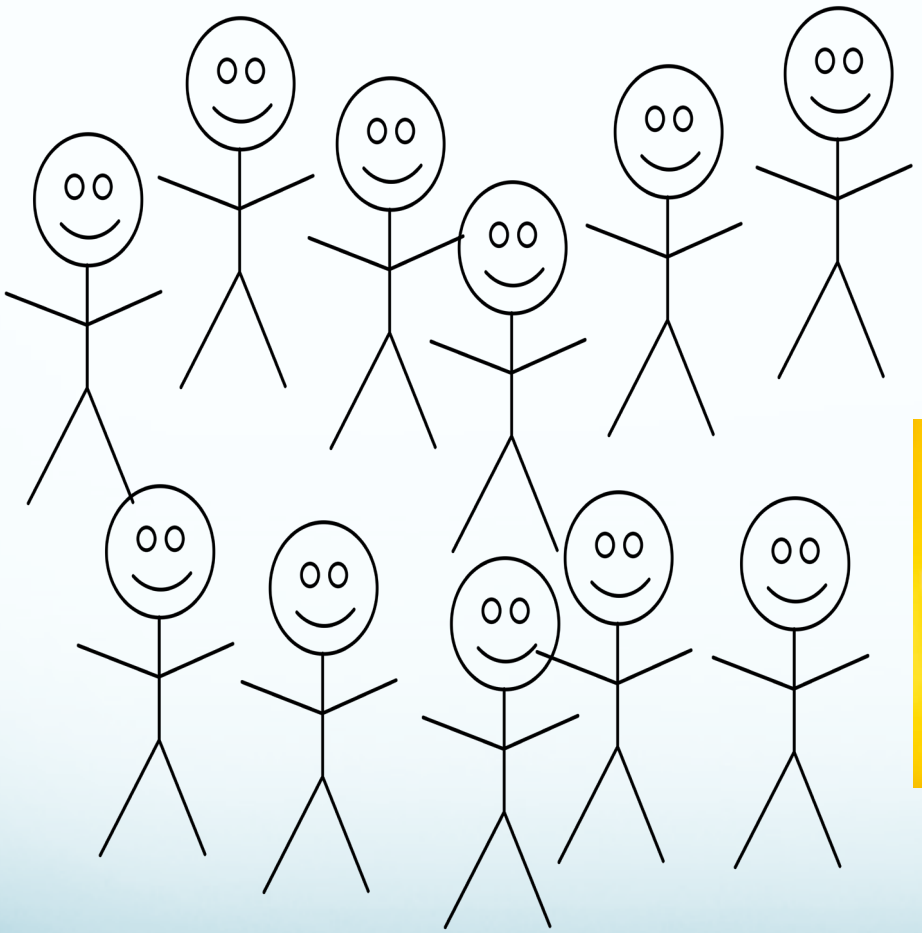


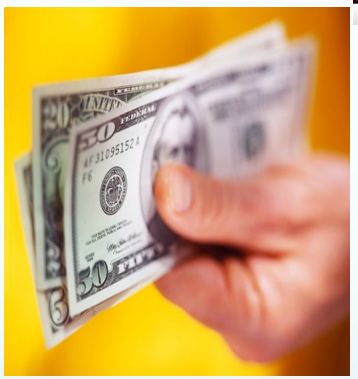
How do we get people to change?



***Klein**, S.J.W. and S. Coffey, 2016, Building a sustainable energy future, one community at a time, Renewable and Sustainable Energy Reviews, vol. 60, pp. 867–880, doi: 10.1016/j.rser.2016.01.129.*

How do we get people to change?





Behavioral Economics, Game Theory, Neuroscience, Anthropology, Sociology, Diffusion of Innovation Theory, Social Practice Theory, Strategic and Social Niche Management Theory

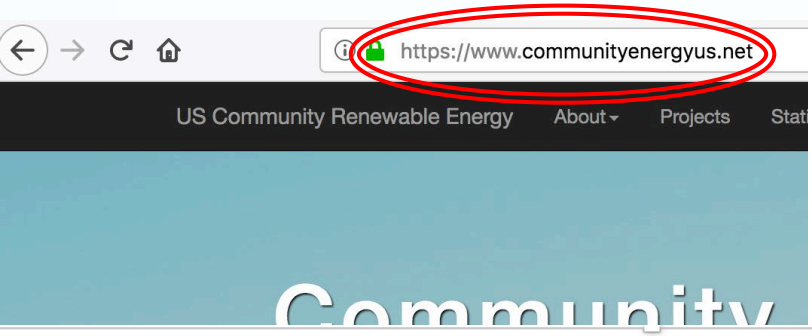
What is Community Sustainable Energy?

- Renewable energy or energy efficiency
- Provides energy **or** energy savings with financial **or** other benefits to a **group** of people
  - Common local geographic area (town level or smaller)
  - Common set of interests
  - Some costs and/or benefits shared by group

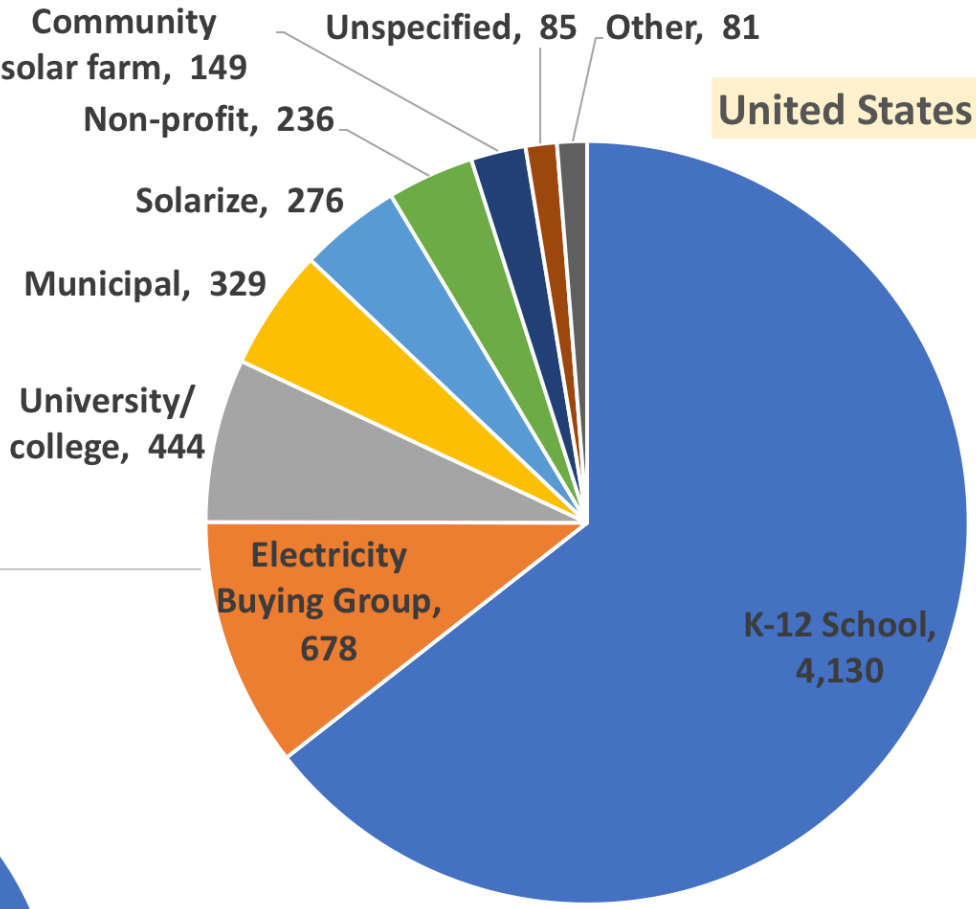
Coughlin et. al, 2012

Walker & Devine-Wright, 2008

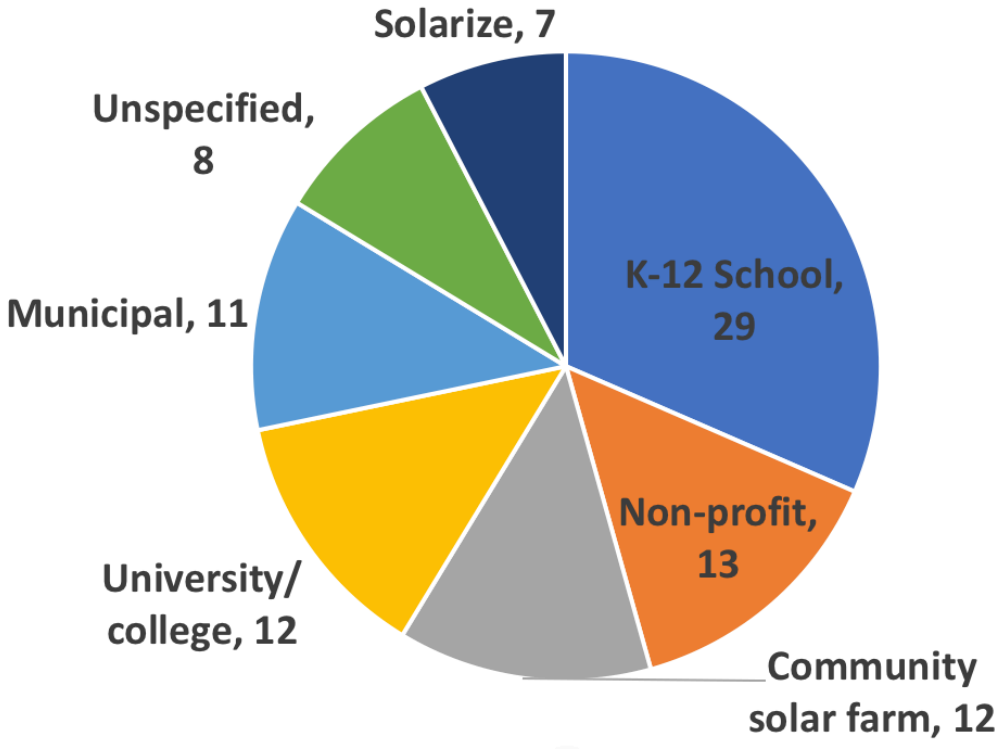
US Comm
Ener



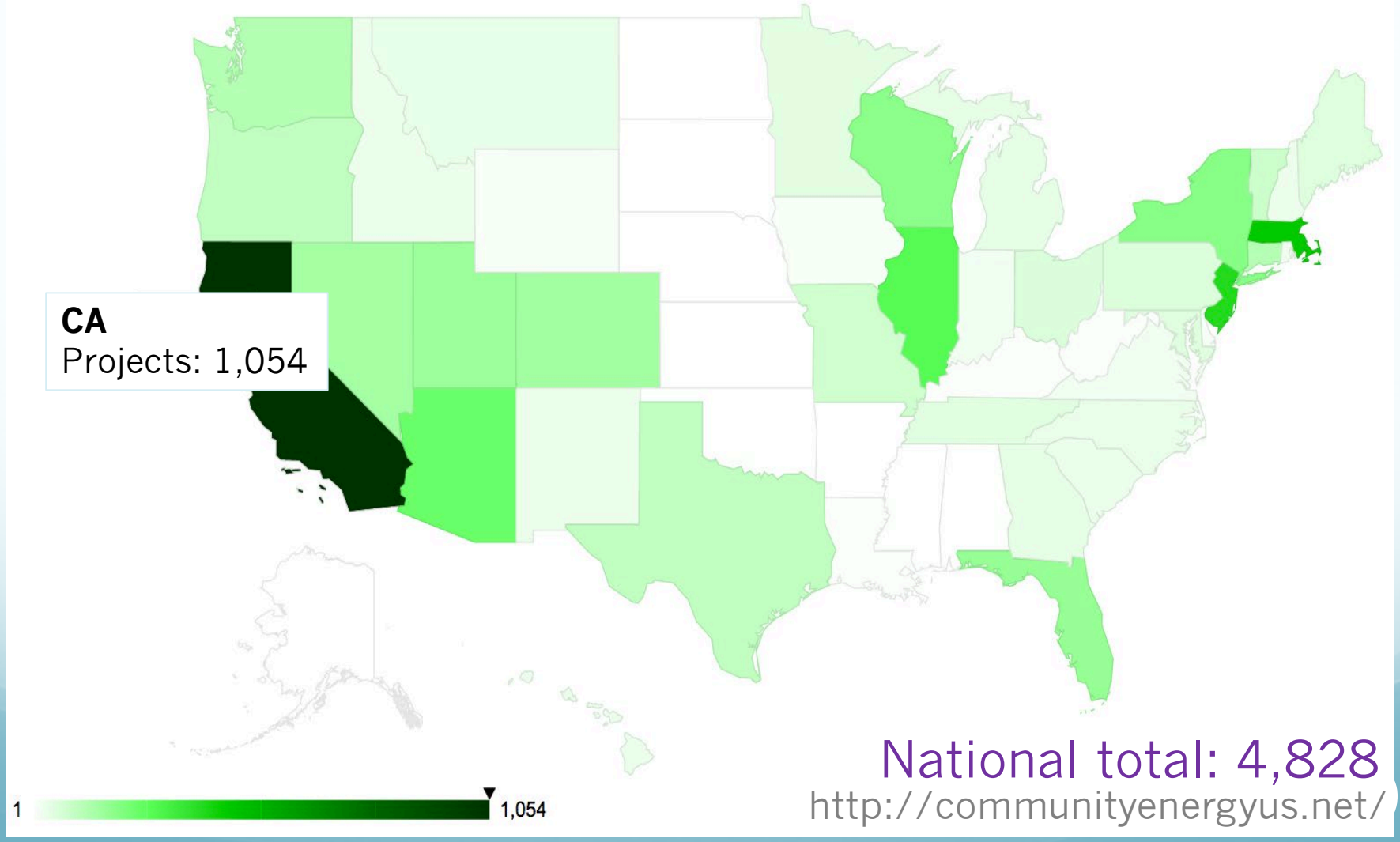
United States



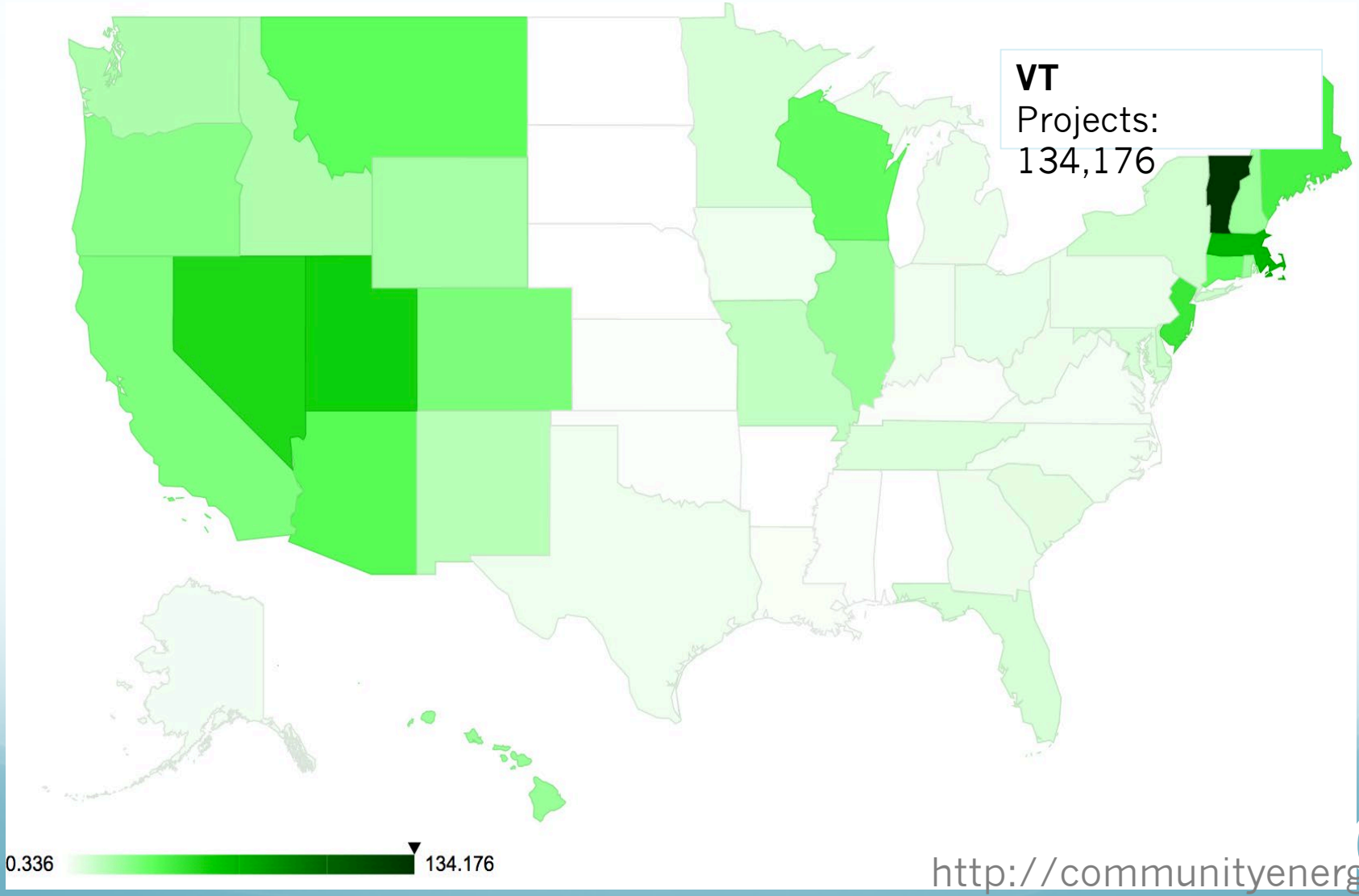
Maine



Total completed community-based solar projects



Total completed community-based solar projects per million people



Community solar

http://energy.gov/eere/sunshot/community-and-shared-

Community-serving institutions

http://efc _nonprofits

http://cityofwoodland.org/gov/depts/pw/areas/enviro/climate/water_pollution_control_facility_solar_power_project.asp

Massachusetts & Vermont lead bulk purchase groups (Solarize, coops)

MA
Completed Projects: 39
Total: 63

1 39

National total: 117 completed
(270 total)

Solarize Mass: top-down

- Started in 2011
- ~10 communities/yr
- MassCEC & MA Department of Energy Resources AND:
  - Solar PV installers
  - Town officials
  - Local civic groups and volunteers
  - Individual homeowners and business owners.
- Solarize Mass Plus (2017): PV + thermal + heat pumps

Solarize MA: 3,200 contracts, 22 MW

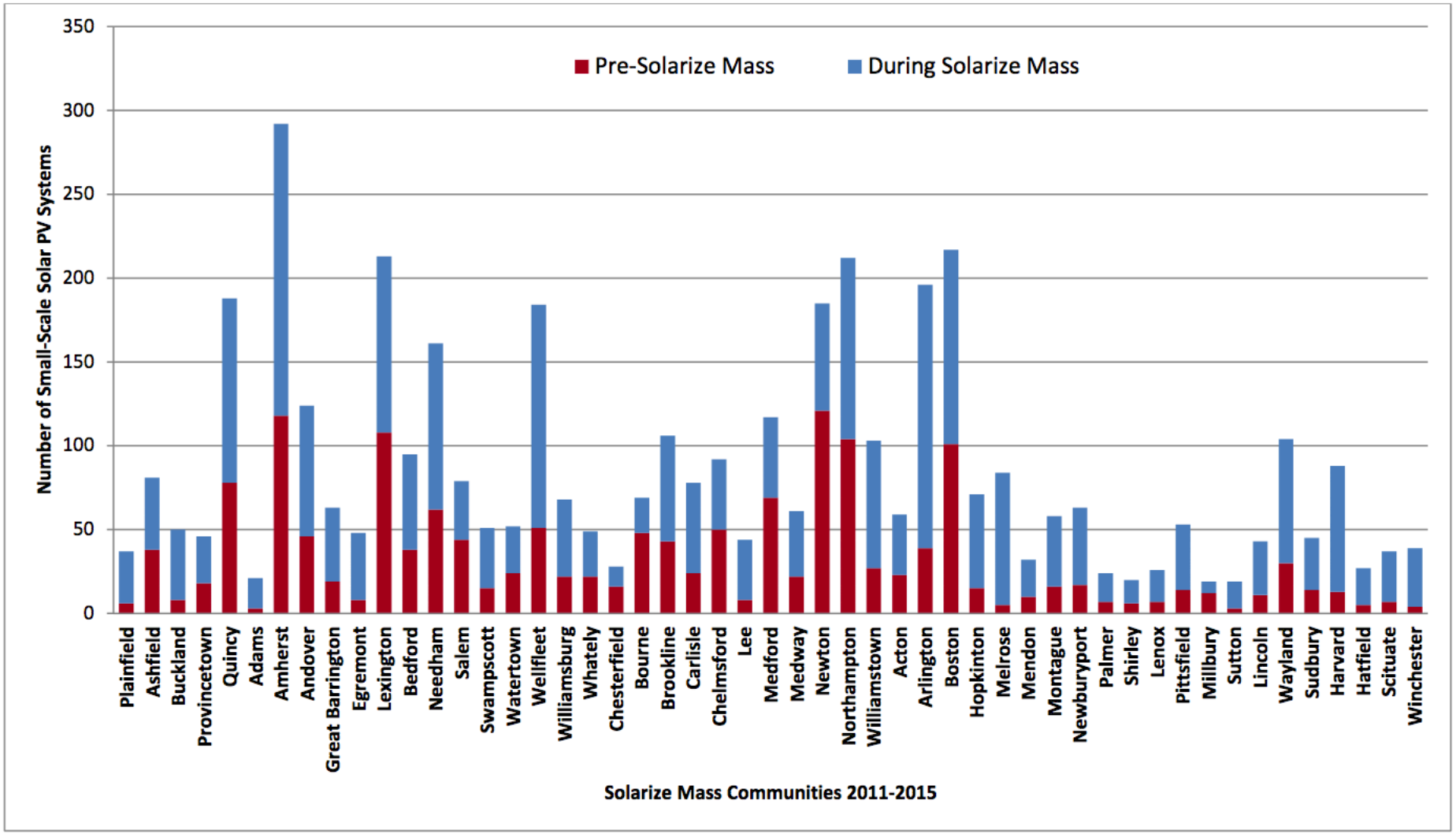


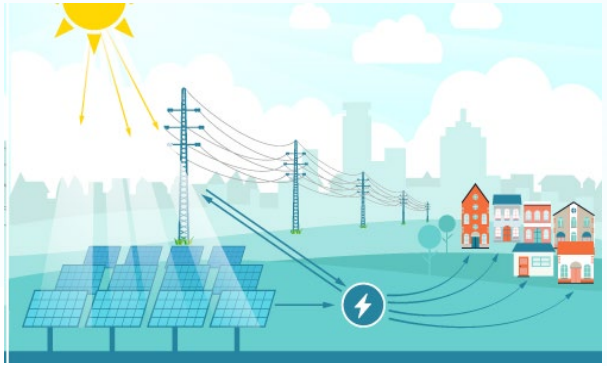
Figure 2. Number of solar PV systems 15 kW and smaller installed prior to Solarize Mass, and systems contracted during Solarize Mass, by community

http://www.masscec.com/solarize-mass

Vermont Solarize: grassroots

- 12 Vermont PIRG campaigns (2010-2011)
  - >285 installations
- 5 Vital Communities campaigns (2014-20
  - 24 towns
  - 370 installations
  - 2.2 MW
  - John Merck Fund
  - *http://vitalcommunities.org/energy/solarize/*
- VECAN: Vermont Energy & Climate Action Network
  - >125 town energy committees
  - Partnership
    - Efficiency Vermont
    - New England Grassroots Environment Fund
    - Vital Communities
    - VT Natural Resources Council
  - Funding Resources
  - Community Solar Toolkit (solar farms & bulk purchase)

Colorado leads in shared solar



CO
Completed Projects: 39
Total: 47

1 39

National total: 107 complete
(*149 total*)

Community Solar in Maine

- 7 Solarize campaigns

  (63 in MA, 26 in VT)

- 12 shared solar (community solar farm) projects

  (11 in MA, 22 in VT)

- No direct incentive for solar

- Active barriers
  - Scaled-back net-metering policy
  - Gross metering equipment fee
  - 10-meter limit on community solar farms
  - Knowledge barrier

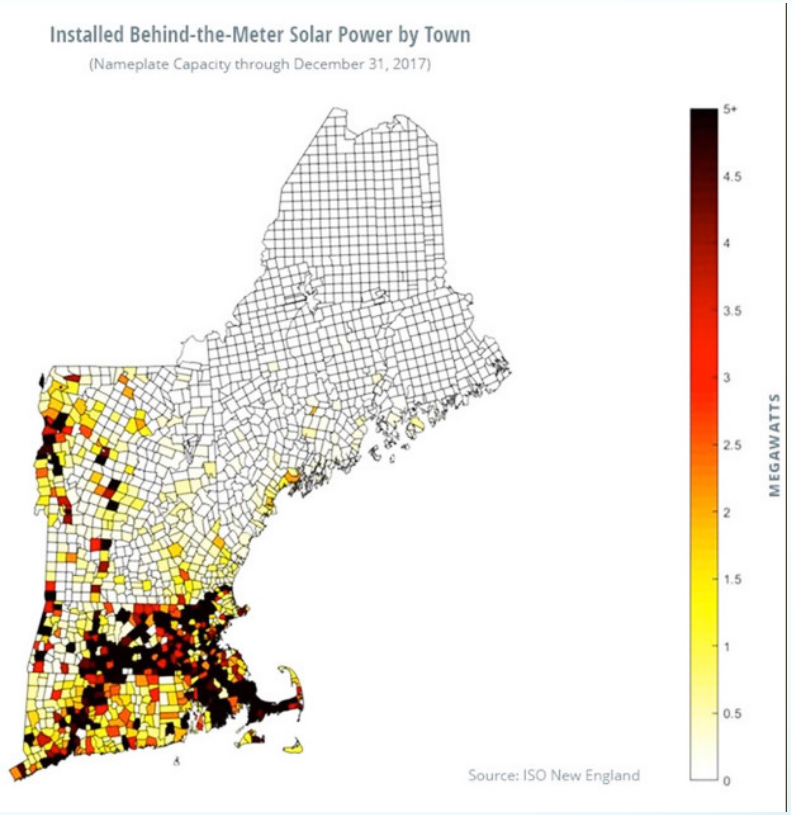
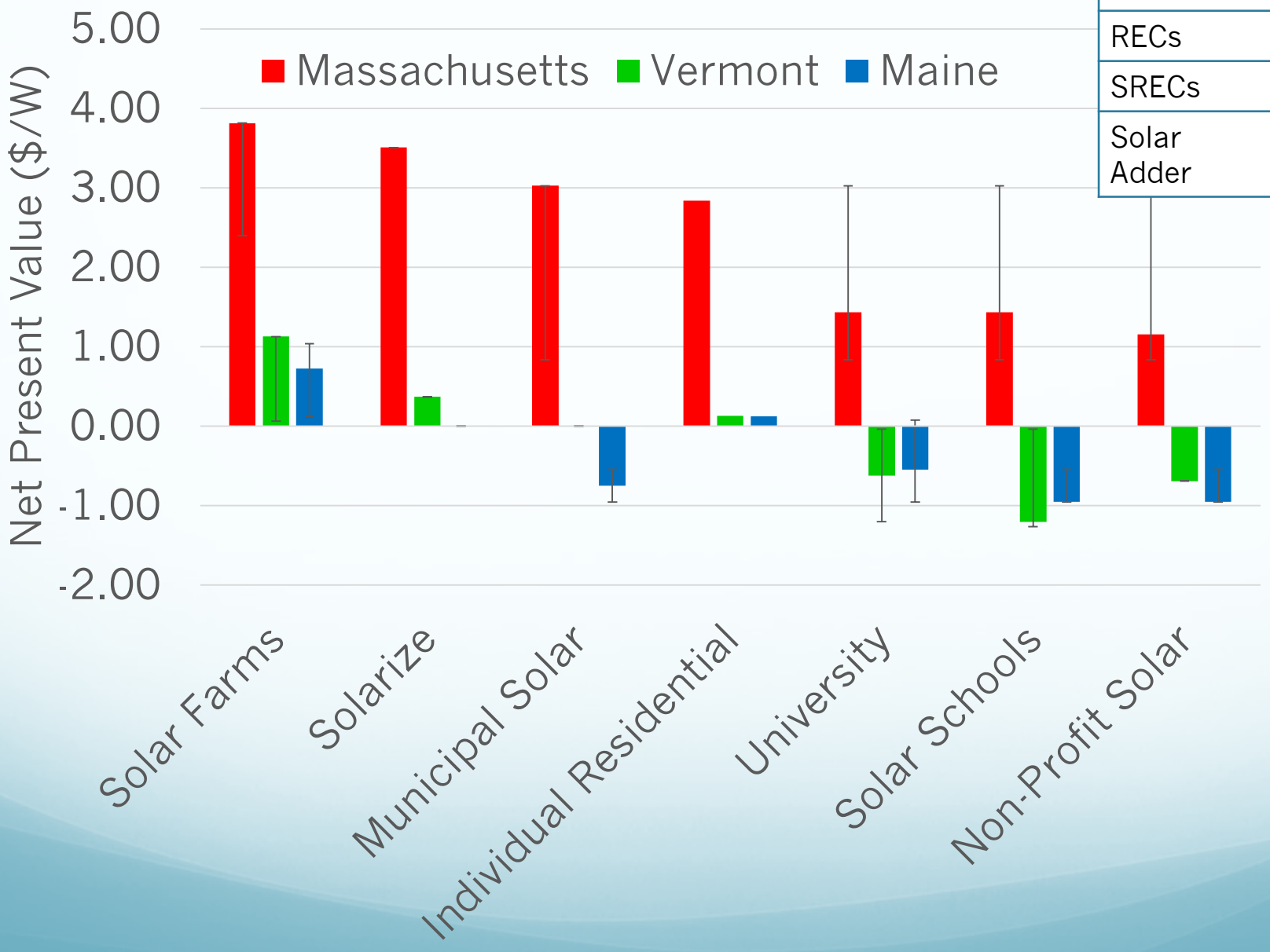


Image from: J. Black, "Understanding the Impact of Behind-the-Meter Solar on Grid Operations and Regional Planning," ISO-NE, p. 14, https://www.iso-ne.com/static-assets/documents/2017/05/clg_meeting_black_panelist_presentation_june_1_2017_final.pdf.

Results: NPV at 25 Years

Incentive	MA	VT	ME
FTC	✓	✓	✓
STC	✓		
RECs	✓	✓	✓
SRECs	✓		
Solar Adder		✓	



Community window insert workshops in Maine

Custom pine frame (white or natural)

Transparent film on both sides - creates 2 layers of "still air"

Weatherstripping around edge

28 workshops across Maine in 2018

Size	Pine	White
Small: 20" x 36"	$19.44	$23.71
Medium: 30" x 52"	$27.81	$36.96
Large: 44" x 68"	$44.05	$47.63

FREE for low-income clients!

Volunteer-made in "community workshops"

SIGN UP: http://windowdressers.org/

Student-developed license plate

$26.99/plate

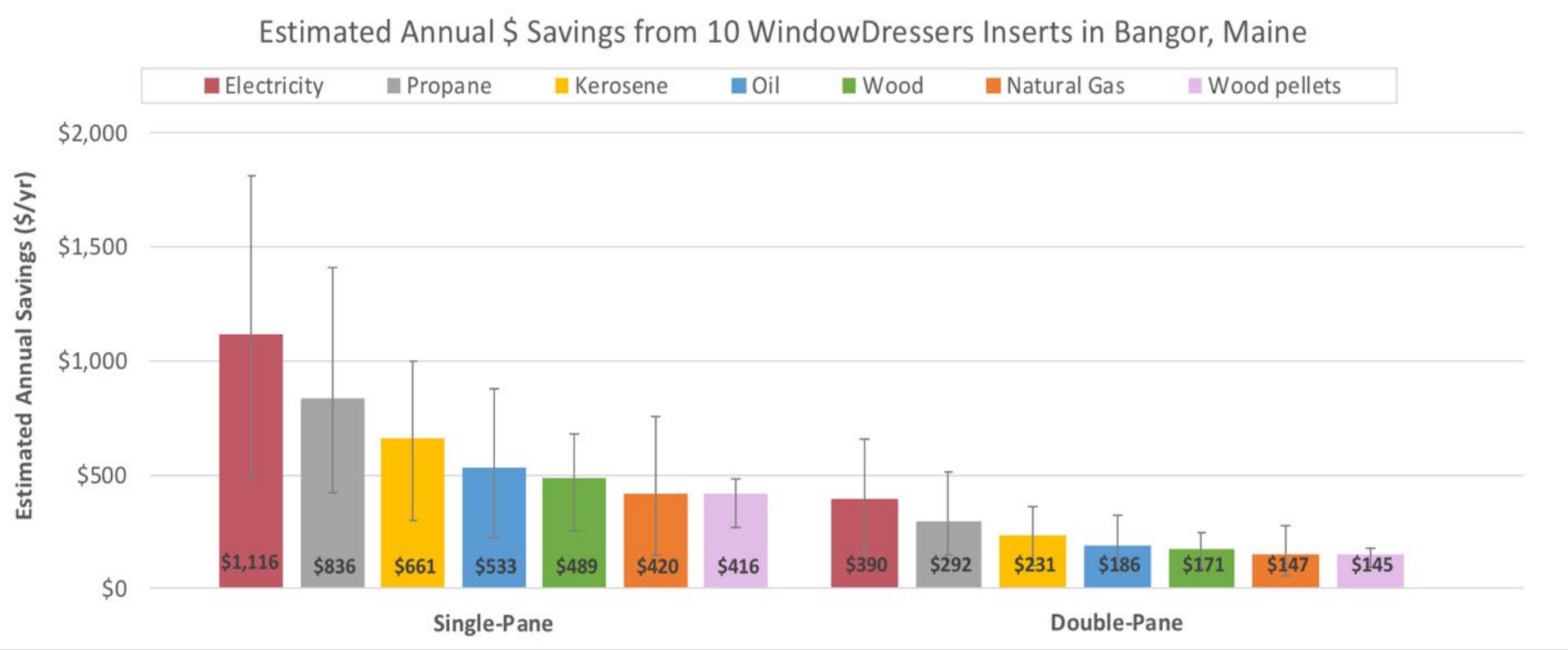
Pre-order at **https://sustainmaineplate.com/**

Need 2,000 pre-order by September 2019!

My research related to this topic has been supported by

- The USDA National Institute of Food and Agriculture, Hatch project 0230040
- The Senator George J. Mitchell Center for Sustainability Solutions, UMaine
- The School of Economics, UMaine

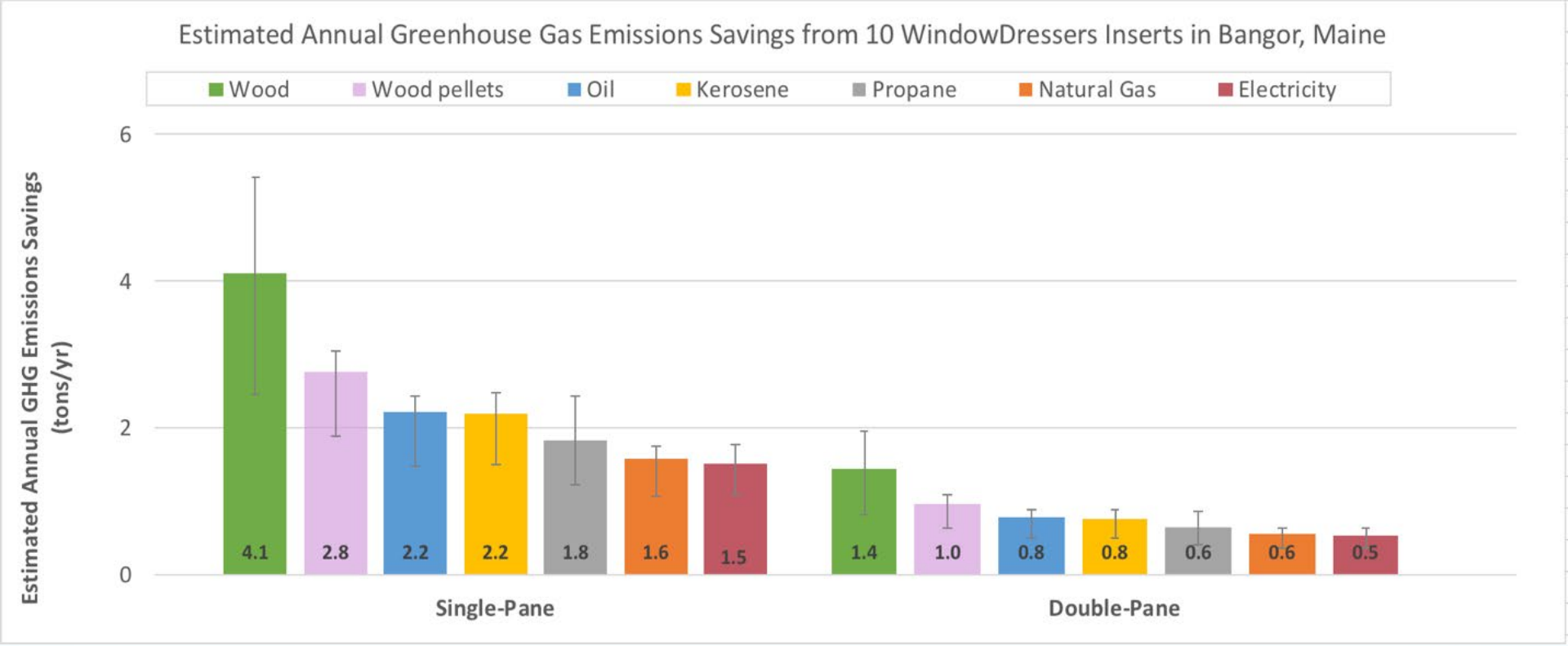
BACKUP SLIDES



*Error bars show range of uncertainty associated with heating degree days (i.e., daily difference between inside and outside temperatures), R-value of insert, fraction of energy savings from infiltration, fuel prices, and boiler/furnace/stove efficiency.

**Key assumptions:

- 10 inserts of 36" x 60" size each; 5,812-7,148 heating degree days (http://www.weatherdatadepot.com/)
- 1.47-2.3 R-value of insert
- 0.91 & 1.93 R-value of single- and double-pane windows, respectively (http://www.coloradoenergy.org/procorner/stuff/r-values.htm)
- 7-13% energy savings associated with reduced infiltration (Sailor, D., 2013, Development, Testing, and Pilot Scale Evaluation of a New Retrofit Window Insulation Product – The Indow Window, March 19, 2013, https://www.energystar.gov/sites/default/files/Indow_Attachment_OREGON%20BEST%20COMMERCIALIZATION%20GRANT%20PROGRAM.pdf)
- Default heating unit efficiencies: 78% oil, gas, propane; 80% kerosene, wood pellets; 100% electric; 54% wood; min-max ranges from: heatcalculatorMEv3_1.xlsx, https://www.maine.gov/energy/fuel_prices/heating-calculator.php; downloaded 7/11/18
- Default fuel prices = current (July 2018) values from https://www.maine.gov/energy/fuel_prices/index.shtml for everything except for electricity, which comes from the sum of the standard offer and total delivered price for Emera from https://www.maine.gov/mpuc/electricity/standard_offer_rates/current_sorates_bhe.shtml
- Min and max fuel prices from the min and max of historical data sets obtained from: http://www.eia.gov/electricity/data.cfm#sales (electricity), https://www.maine.gov/energy/fuel_prices/archives.shtml (propane, kerosene, fuel oil, wood, wood pellets), https://www.eia.gov/dnav/ng/hist/n3010me3m.htm (natural gas), all inflation-adjusted to $2016
- When default fuel price value is greater than max historical data value (electricity and wood pellets), the max value is calculated as the default value plus the same % increase as that observed between the low historical value and default value.



*Error bars show range of uncertainty associated with heating degree days (i.e., daily difference between inside and outside temperatures), R-value of insert, fraction of energy savings from infiltration, fuel prices, and boiler/furnace/stove efficiency.

**Key assumptions – same as $Savings graph, plus:

CO_2, CH_4, N_2O emissions factors (not life cycle) for all fuel sources other than electricity from: https://www.epa.gov/sites/production/files/2015-07/documents/emission-factors_2014.pdf

Global Warming Potentials for CH4 and N2O from https://unfccc.int/process/transparency-and-reporting/greenhouse-gas-data/greenhouse-gas-data-unfccc/global-warming-potentials

Maine-specific CO_2 emissions factor (not life cycle) for electricity calculated from data and instructions obtained from: https://www.eia.gov/tools/faqs/faq.php?id=74&t=11

2010-2011

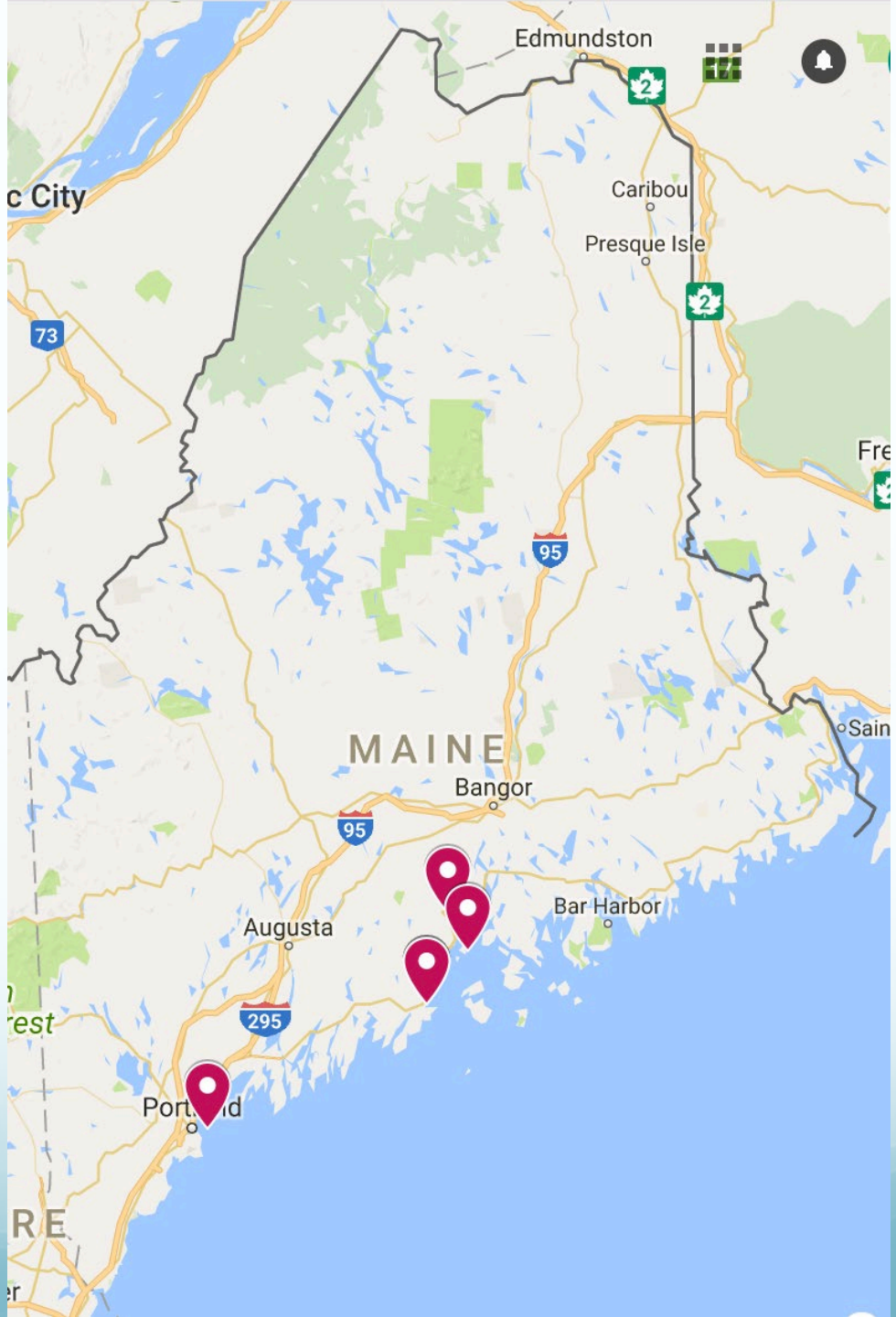
1 Workshop

- Rockland

2012

5 Workshops

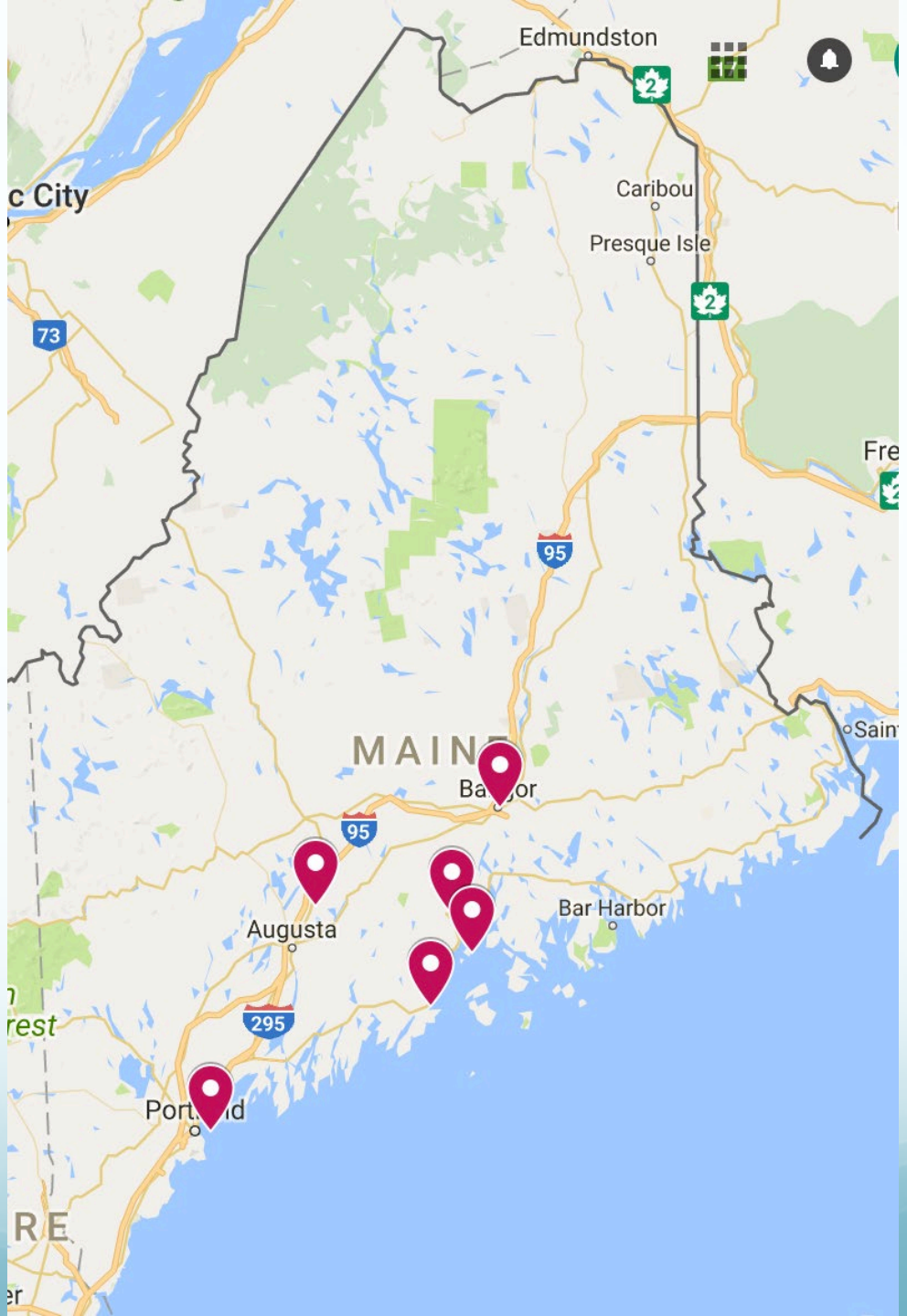
- Rockland x 2
- Belfast
- Islesboro
- Peaks Island



2013

6 Workshops

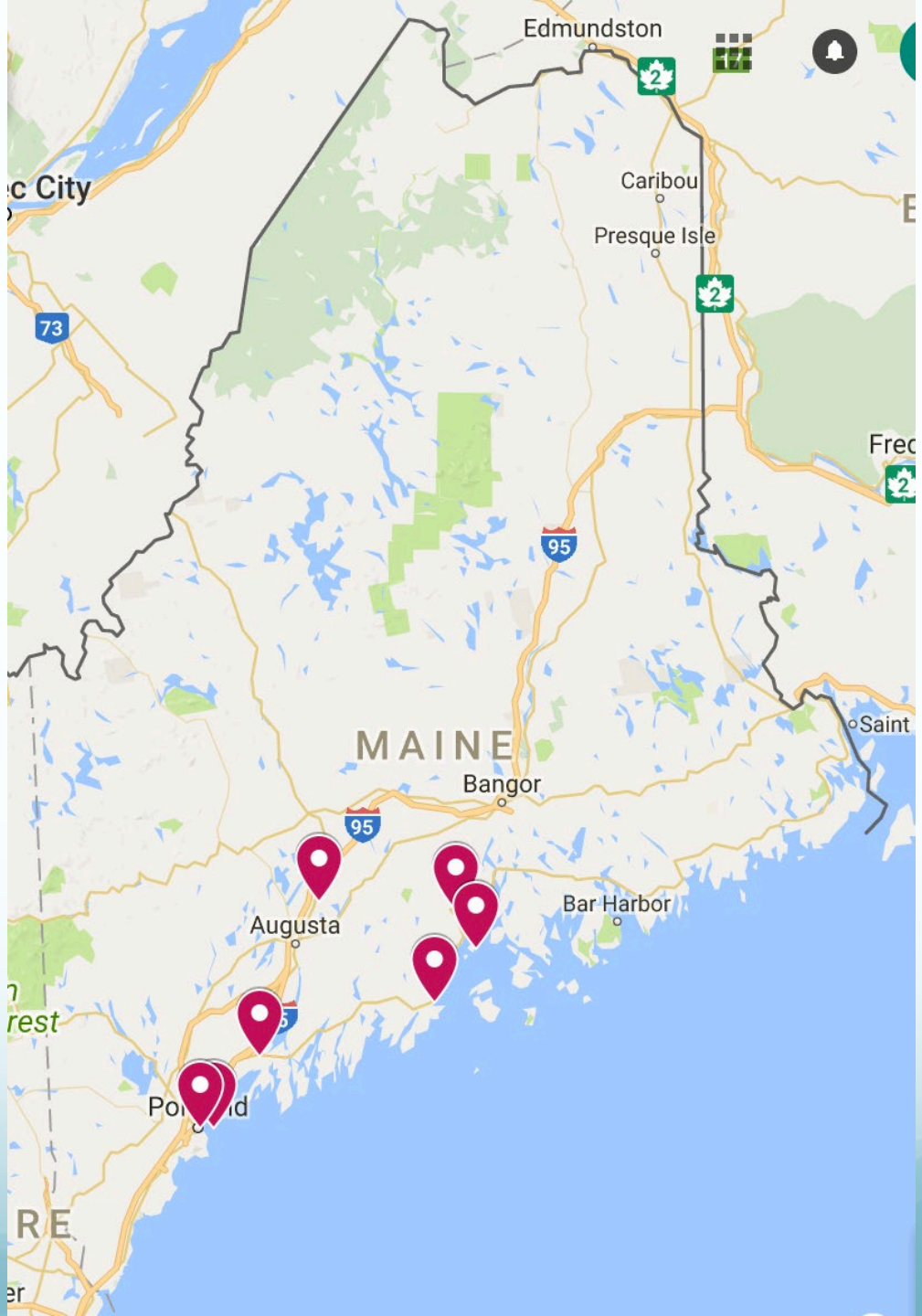
- Rockland
- Bangor
- Belfast
- Islesboro
- Peaks Island
- Vassalboro-Liberty



2014

7 Workshops

- Rockland
- Belfast
- Brunswick
- Islesboro
- Peaks Island
- Portland
- Vassalboro-Liberty

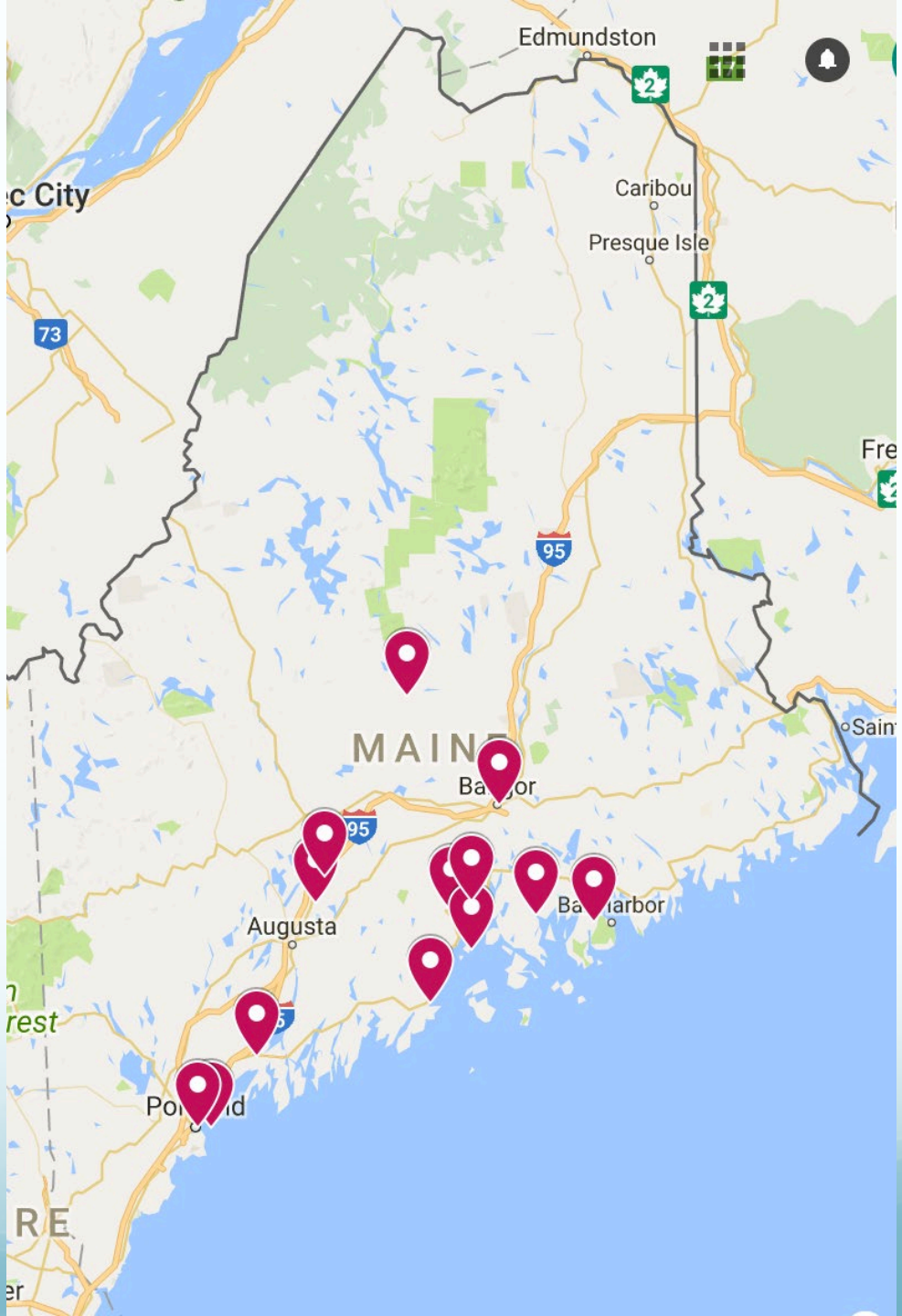


2015

13 Workshops

- Rockland
- Bangor
- Belfast
- Blue Hill
- Brunswick
- Dover-Foxcroft
- Islesboro
- Mt Desert Island
- Peaks Island
- Portland
- Searsport
- Vassalboro-Liberty
- Waterville

1st UMAINE workshop

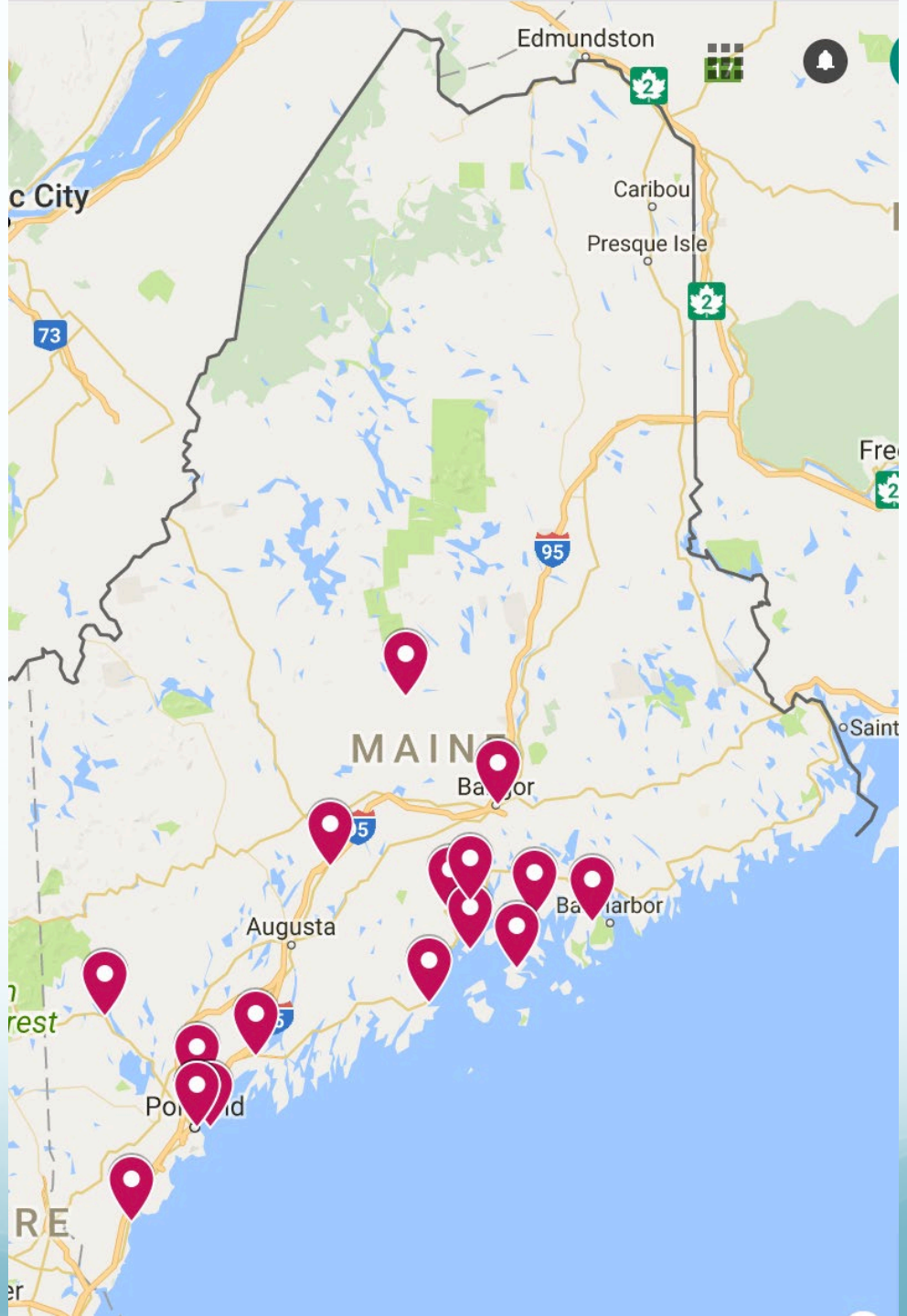


2016

17 Workshops

- Rockland
- Bangor
- Belfast
- Blue Hill
- Bridgton
- Brunswick
- Cumberland
- Deer Isle
- Dover-Foxcroft
- Fairfield
- Islesboro
- Mt Desert Island
- Peaks Island
- Portland x 2
- Searsport
- Wells

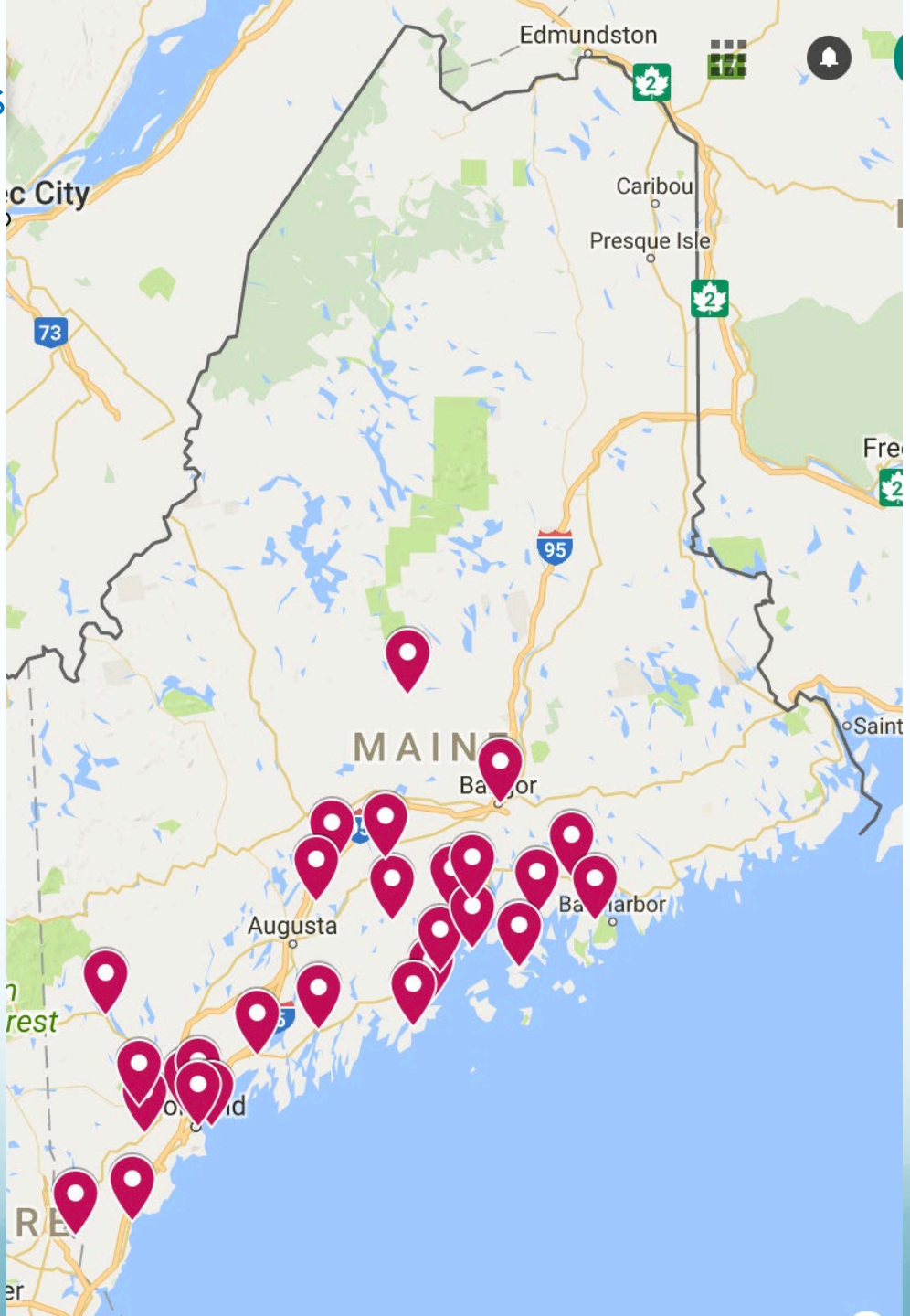
2nd UMAINE workshops



2017

28 Workshops

- Rockland
- Allagash Brewing
- Bangor x 2
- Belfast
- Berwick
- Blue Hill
- Bridgton
- Brunswick
- Buxton
- Camden
- Deer Isle
- Dover-Foxcroft
- Ellsworth
- Fairfield
- Falmouth
- Islesboro



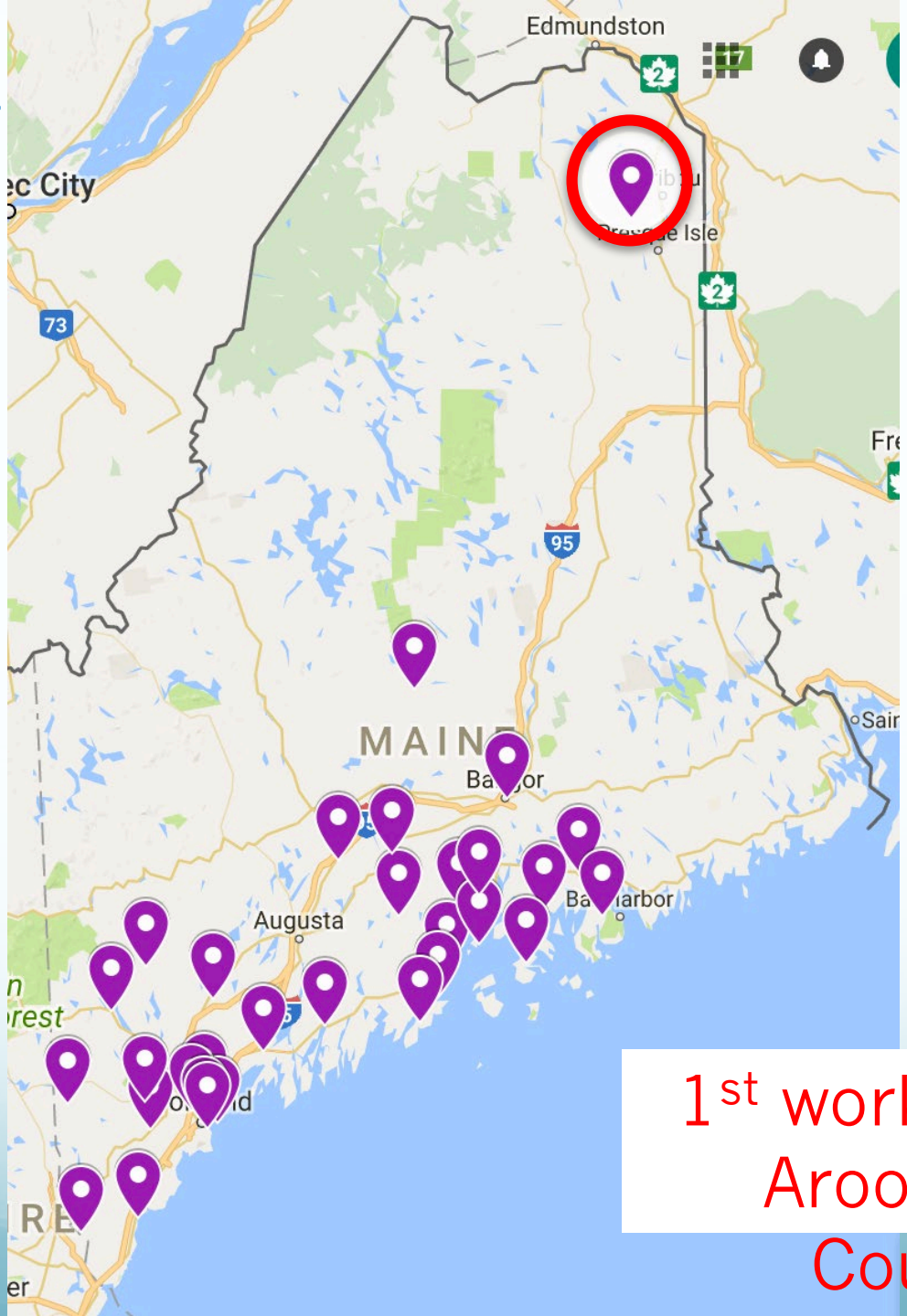
- Liberty
- MDI
- Peaks Island
- Portland
- Searsport
- St George
- Standish
- Unity
- Vassalboro
- Wells
- Wiscasset

3rd, 4th UMAINE workshops

2018

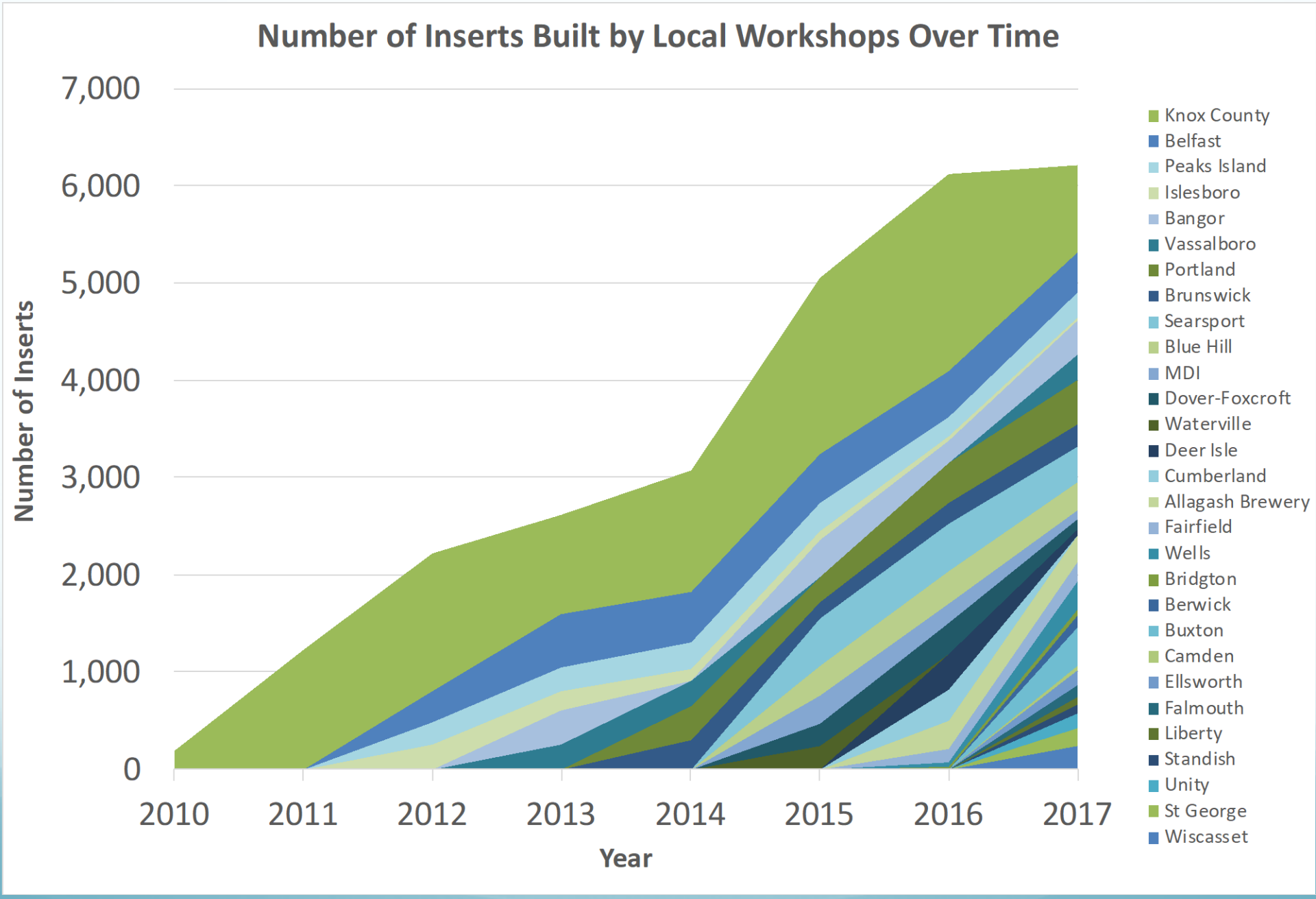
29 Workshops

- Rockland
- Allagash Brewing
- Bangor
- Belfast
- Berwick
- Blue Hill
- Bridgton
- Brunswick
- Buxton
- Camden
- Deer Isle
- Dover-Foxcroft
- Ellsworth
- Fairfield
- Falmouth
- Islesboro



- Liberty
- MDI
- Norway
- Peaks Island
- Portland x 2
- Searsport
- St George
- Standish
- Unity
- **Washburn**
- Wells
- Wiscasset

1st workshop in Aroostook County


Number of Inserts Built by Local Workshops Over Time
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Number of Inserts
2010
2011
2012
2013
2014
2015
2016
2017
Year
Knox County
Belfast
Peaks Island
Islesboro
Bangor
Vassalboro
Portland
Brunswick
Searsport
Blue Hill
MDI
Dover-Foxcroft
Waterville
Deer Isle
Cumberland
Allagash Brewery
Fairfield
Wells
Bridgton
Berwick
Buxton
Camden
Ellsworth
Falmouth
Liberty
Standish
Unity
St George
Wiscasset