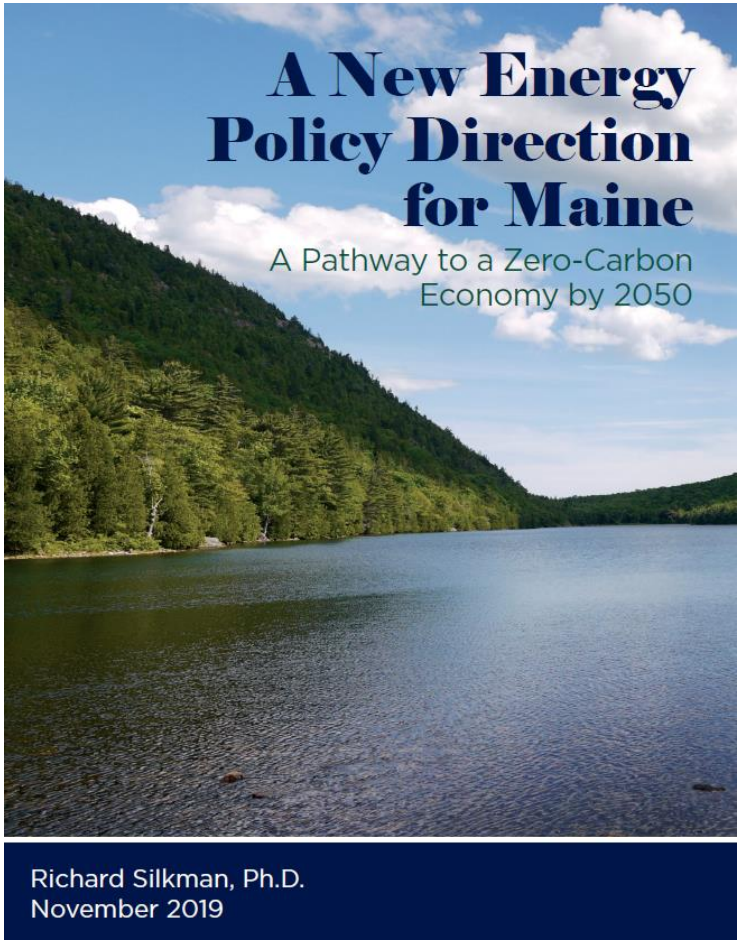
E2TECH ENVIRONMENTAL & ENERGY TECHNOLOGY COUNCIL OF MAINE



Blueprint for a Zero Carbon Economy: Achieving Maine's Climate Goals

June 10, 2020
8 am – 10 am

The Zero-Carbon Objective

The fundamental policy question of our time – the question that will determine nothing short of the future of the planet – is whether it is possible to transition to a zero-carbon economy by 2050 **without jeopardizing the health and vitality of our economy.**

Zero-Carbon by 2050

I believe that it is.

Specifically, in my book I show that it is possible to transition Maine's economy to zero-carbon by 2050 and in the process spend no more during each of the 30 years of this transition than we are spending on energy today.

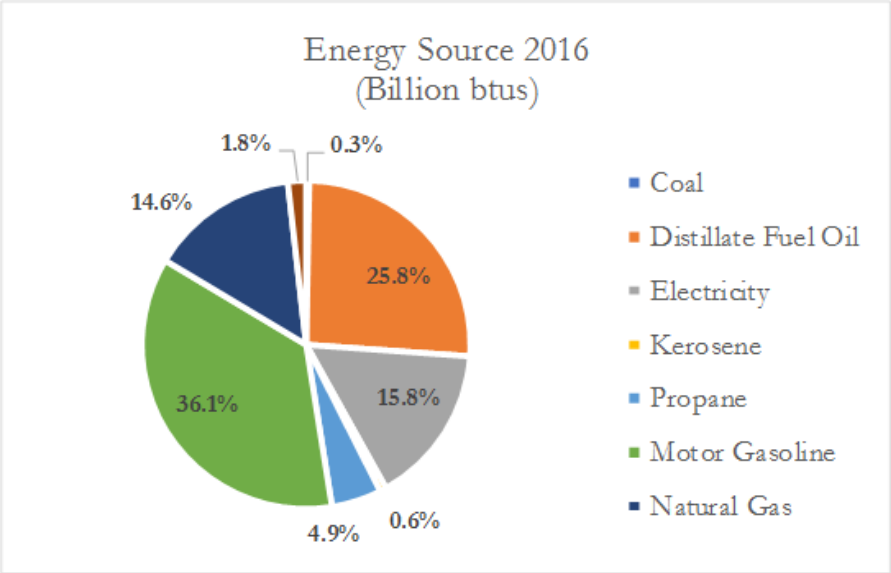
Zero-Carbon by 2050

To accomplish this objective requires the following:

1. Beneficial Electrification of the Transportation, Heating and Process Sectors of the economy.
2. Decarbonization of Generation through the build-out of renewable generation – solar PV and on-shore and off-shore wind
3. Large-scale Battery Storage systems
4. Commensurate expansion of the transmission and distribution grid – and conversion of that "grid" into a smart, multi-directional electric network
5. The ability to access unprecedented amounts of capital to support the transition

Maine's Energy Use

Energy Source	Consumption (Billion btus)
Coal	815
Distillate Fuel Oil	66,955
Electricity	40,953
Kerosene	1,638
Propane	12,801
Motor Gasoline	93,608
Natural Gas	37,959
Residual Fuel Oil	4,639
TOTAL	259,368



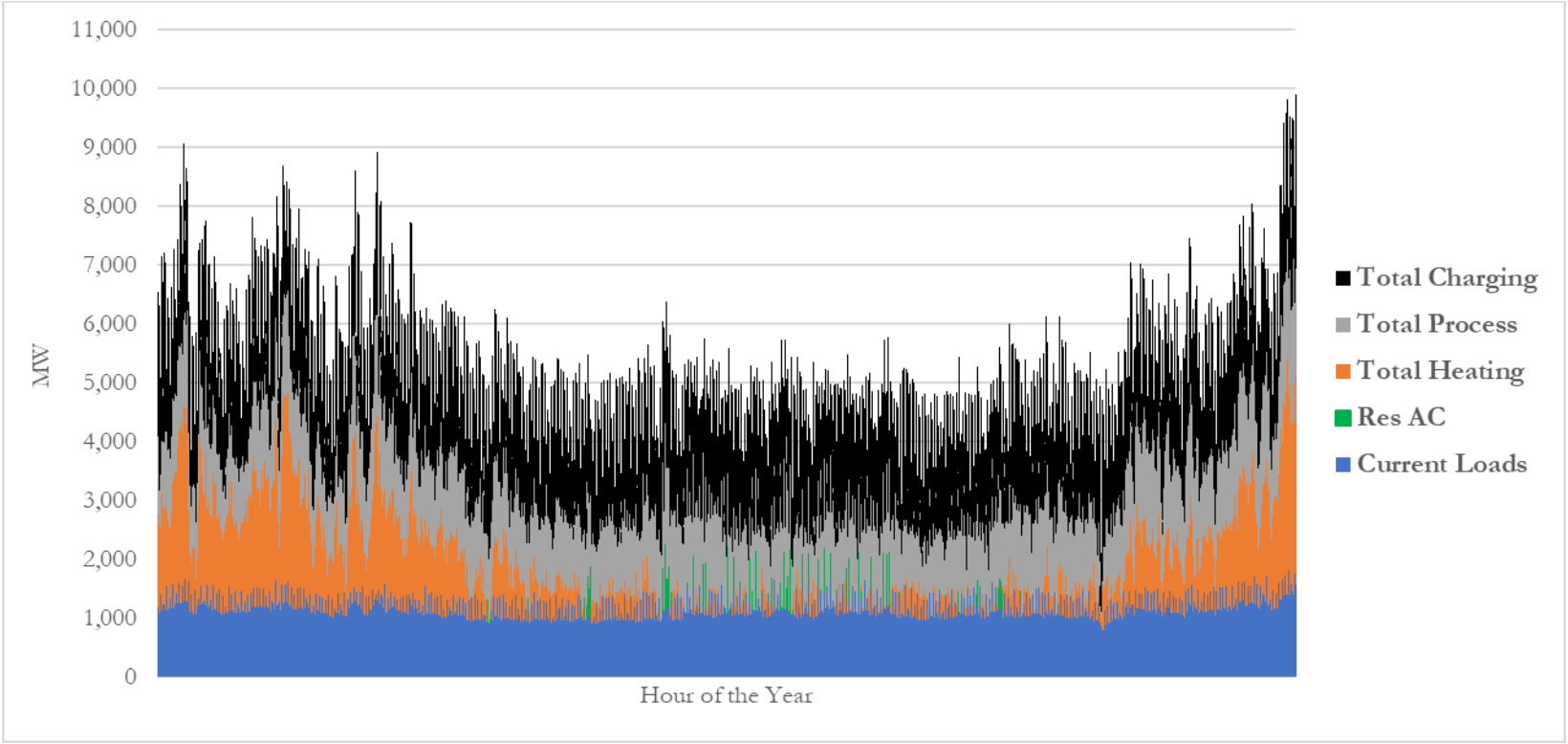
To eliminate CO_2 emissions, Maine needs to convert all energy use to electricity – Beneficial Electrification

Beneficial Electrification

Load Type	Total Loads (GWh)	Maximum Demand (MW)	Minimum Demand (MW)	Average Demand (MW)	Capacity Factor (%)
RNS	12,048	1,961	789	1,375	70.1%
Total Heating	7,453	4,954	0	851	17.2%
Residential AC	598	714	0	68	9.5%
Total Process	11,910	2,512	135	1,360	54.1%
Total EV Charging	8,272	2,486	102	944	38.0%
Passenger Vehicles	4,177	1,125	102	477	42.4%
Buses	340	233	0	39	16.7%
Trucks	3,755	1,622	0	429	26.4%
Total Loads	40,280	9,893	1,449	4,598	46.5%

Converting all end-uses of energy to electricity results in a more than 3-fold increase in total MWhs and an almost 5-fold increase in maximum peak demand.

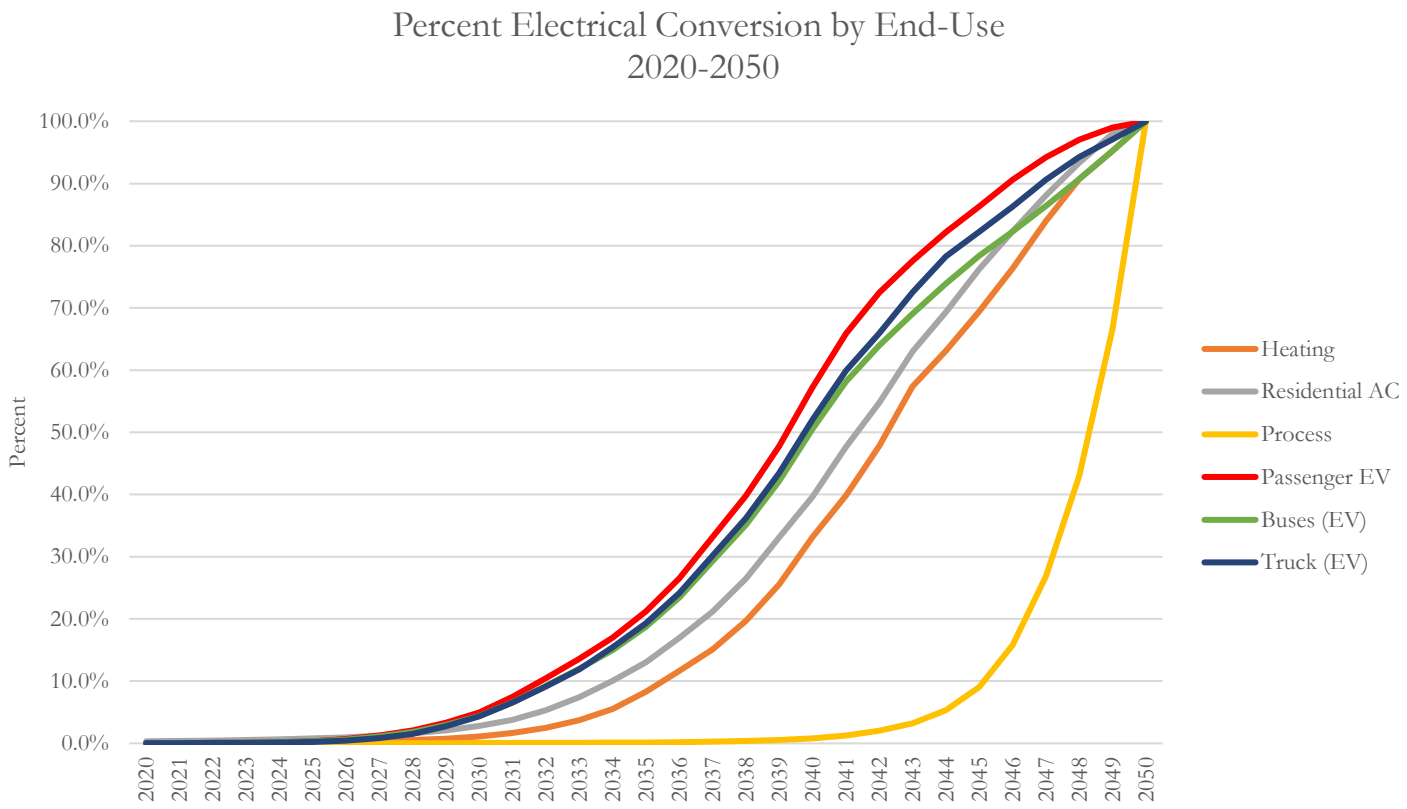
Beneficial Electrification



Note the key role played by heating loads. It represents the single most important factor in the ability of northern latitude regions to move to zero-carbon.

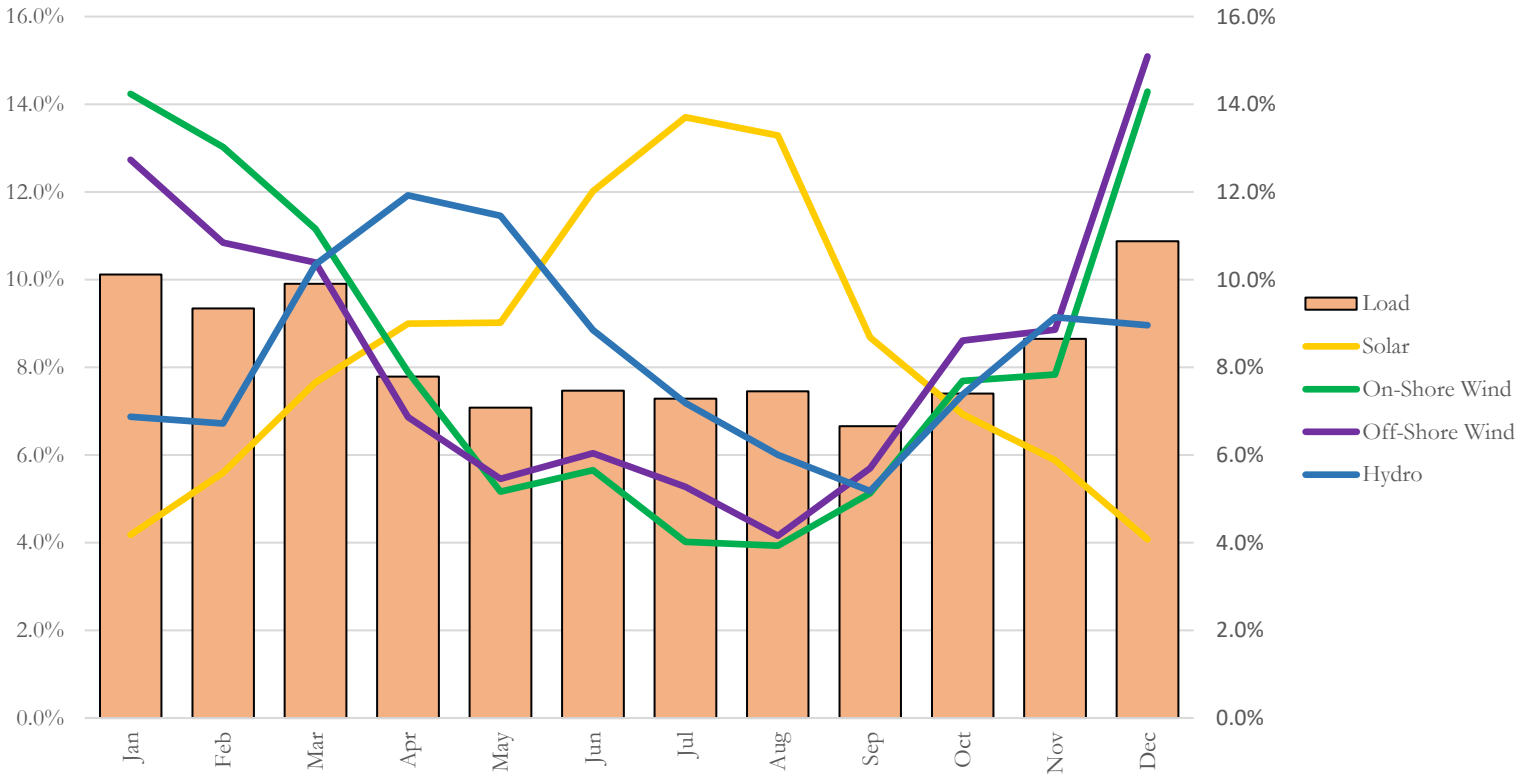
The 30-year Transition Period

Beneficial Electrification – Assumed Conversion Rates



Decarbonization of Generation

Monthly Distribution of Generation Output by Renewable Generation Technology and Total Electric Load



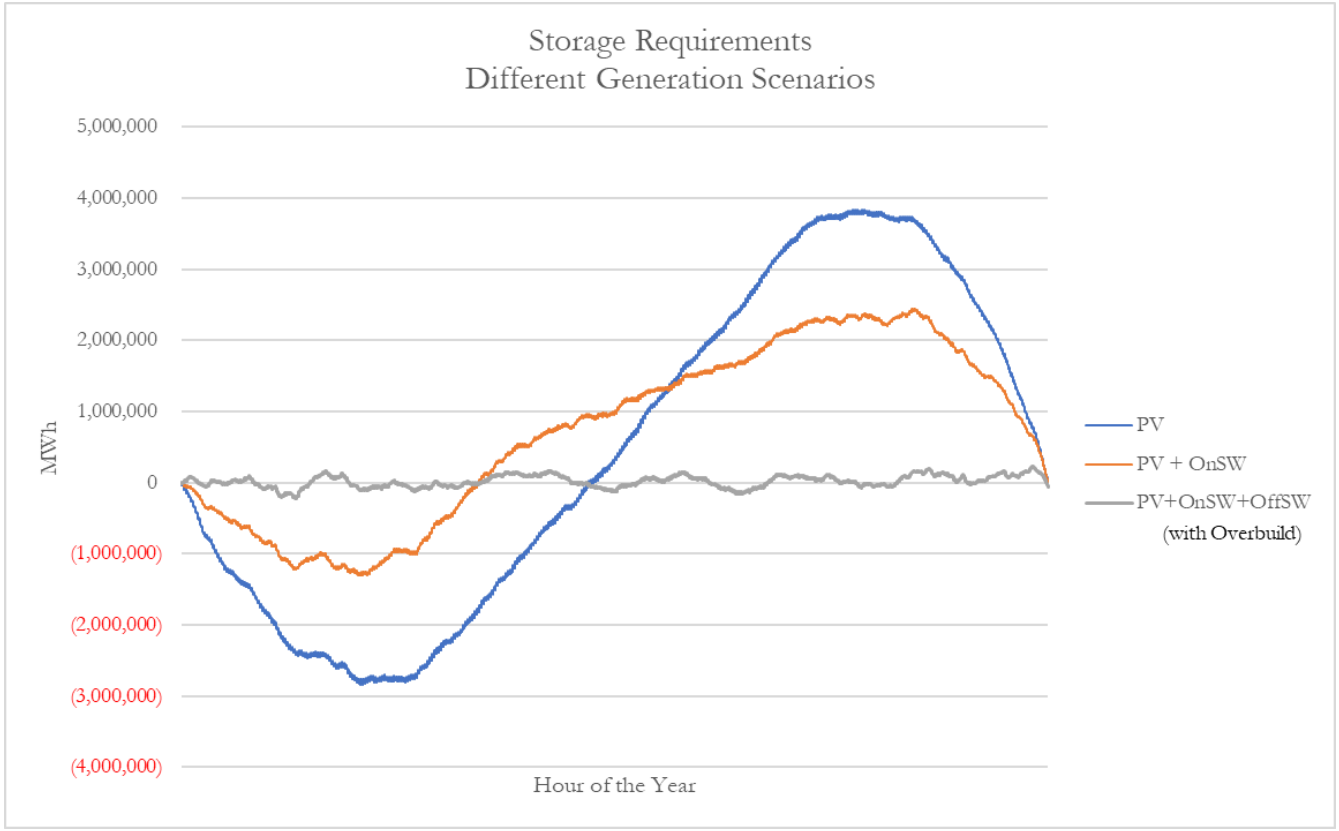
Meeting Electric Loads

Develop renewable generation capacity so that annual energy generated is equal to total annual electric load, plus reserve margins.

Battery Storage is used to match hourly loads and hourly generation.

- Hour-by-hour matching
- Diurnal cycling
- Multiple day weather variability
- Seasonal Loads/generation

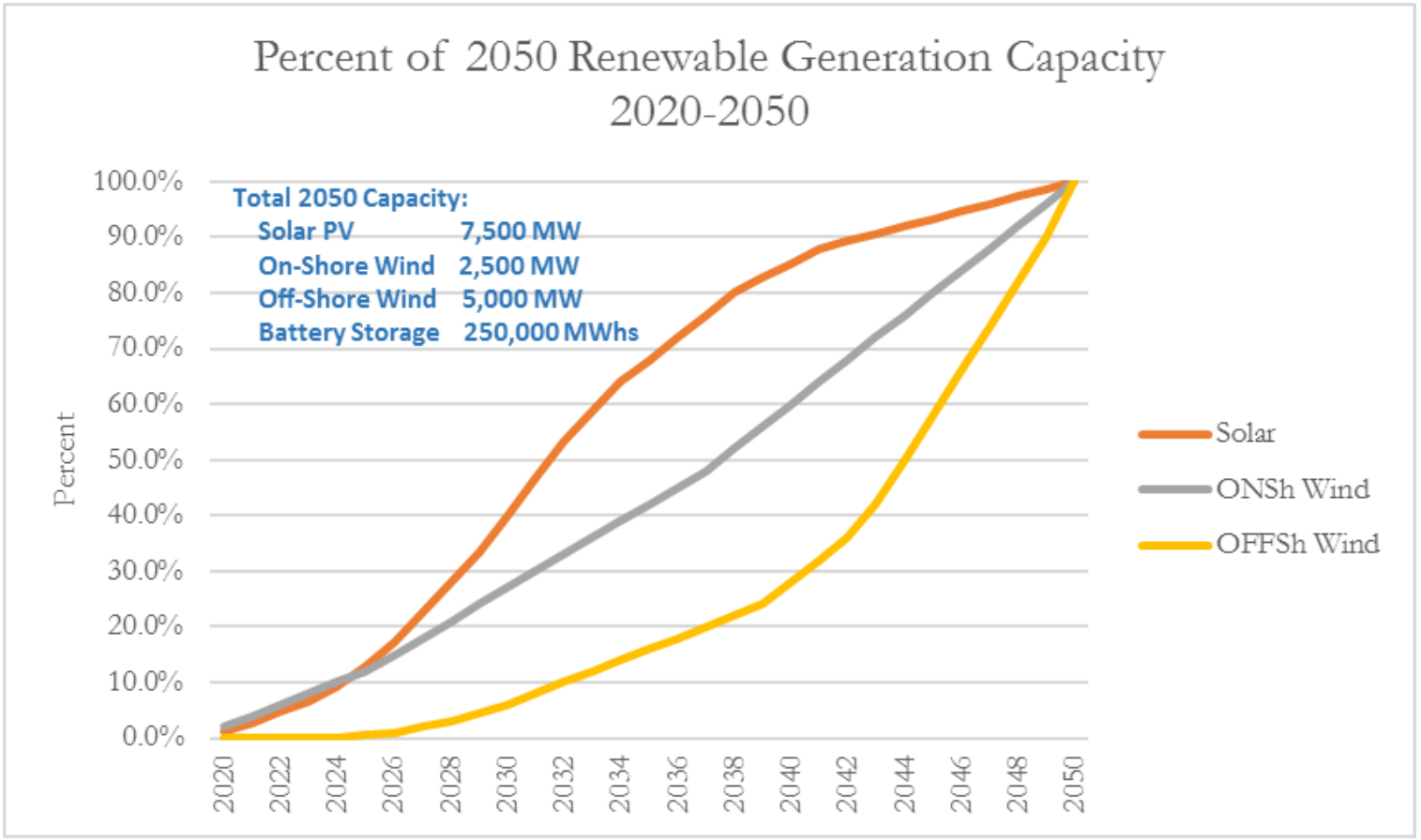
100% Solar PV Generation



Up to a limit, overbuilding renewable generation capacity substitutes for long-term storage.

The 30-year Transition Period

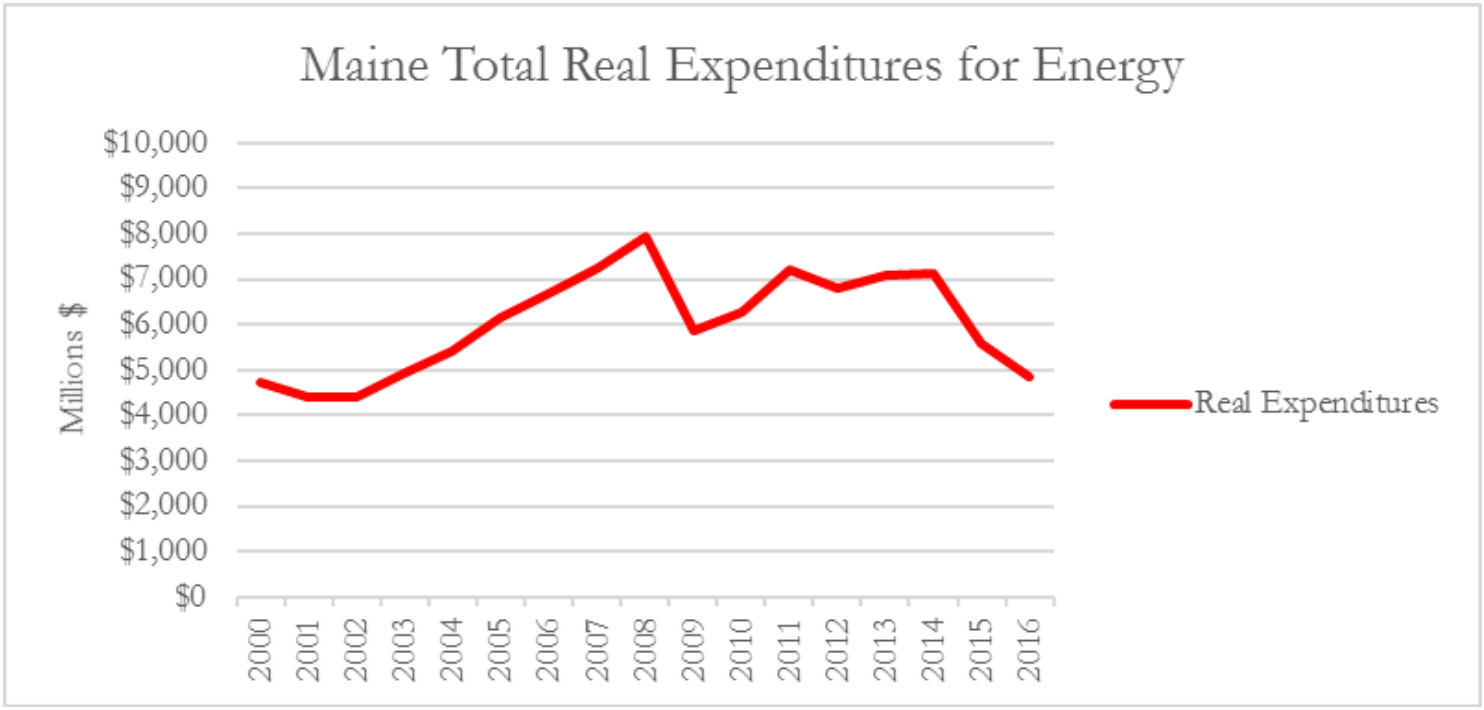
Decarbonization - Build-Out of Renewable Generation



Key Cost/Financing Assumptions

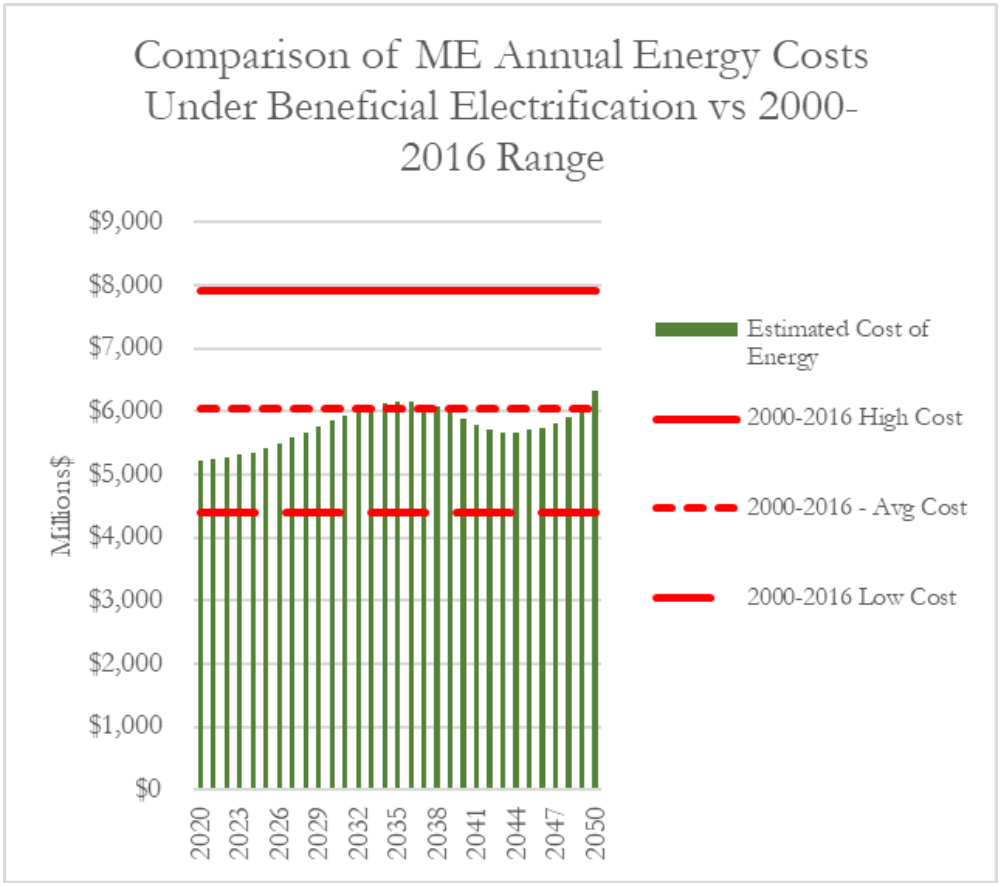
		Installed Capital Cost 2020	Installed Capital Cost 2050		Fixed O&M 2020	Fixed O&M 2050
Existing Hydro	($/kW)	$0	$0	($/MWh)	$20	$20
Solar PV	($/kW)	$1,500	$602	($/kW/yr)	$10	$10
On-Shore Wind	($/kW)	$2,000	$2,000	($/MWh)	$10	$10
Off-Shore Wind	($/kW)	$4,000	$4,000	($/MWh)	$20	$20
Battery Storage	($/kWh)	$500	$41	($/kW/yr)	$10	$10
Battery Storage - Round-Trip Efficiency Losses					12.5%	12.5%
Financing Costs						
Wgtd. Avg. Cost of Capital		3.0%	3.0%			
Financing Term (years)		30	30			
Debt Service Cost per Million		$51,019	$51,019			
Effective Property Tax Rate		$0	$0		(per thousand of valuation)	

Total Energy Expenditures



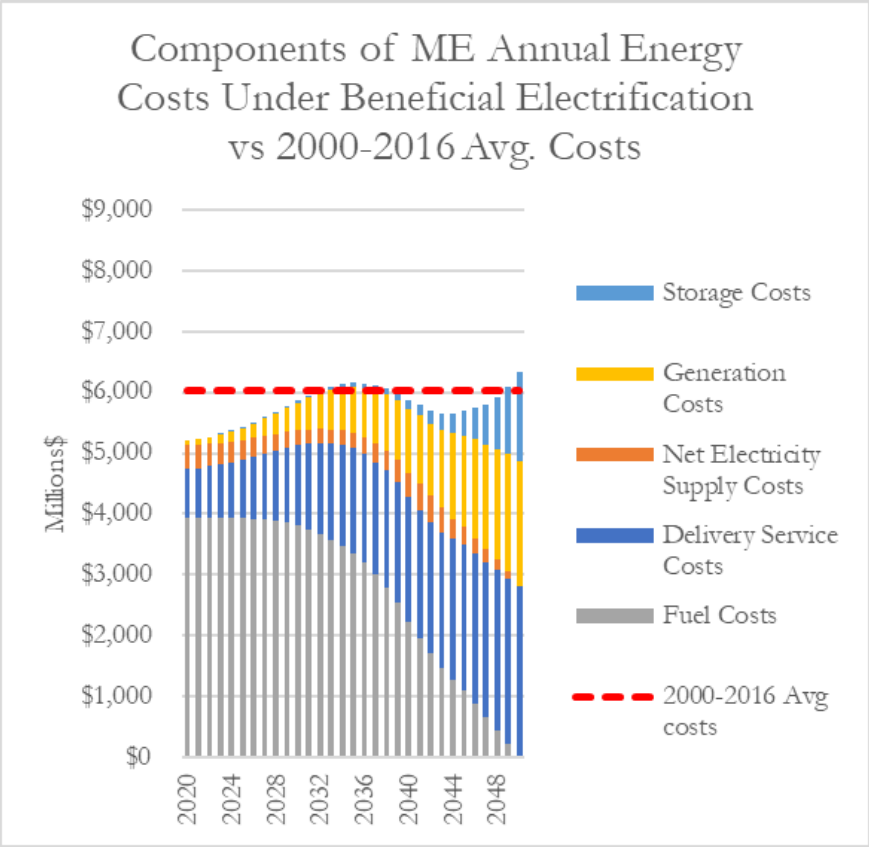
Average real expenditures across all forms of energy in Maine have averaged roughly $6 billion – about 10% of GSP …

The 30-year Transition Period



Total Energy Spending each year is close to the average amount spent each year over the period 2000 – 2016

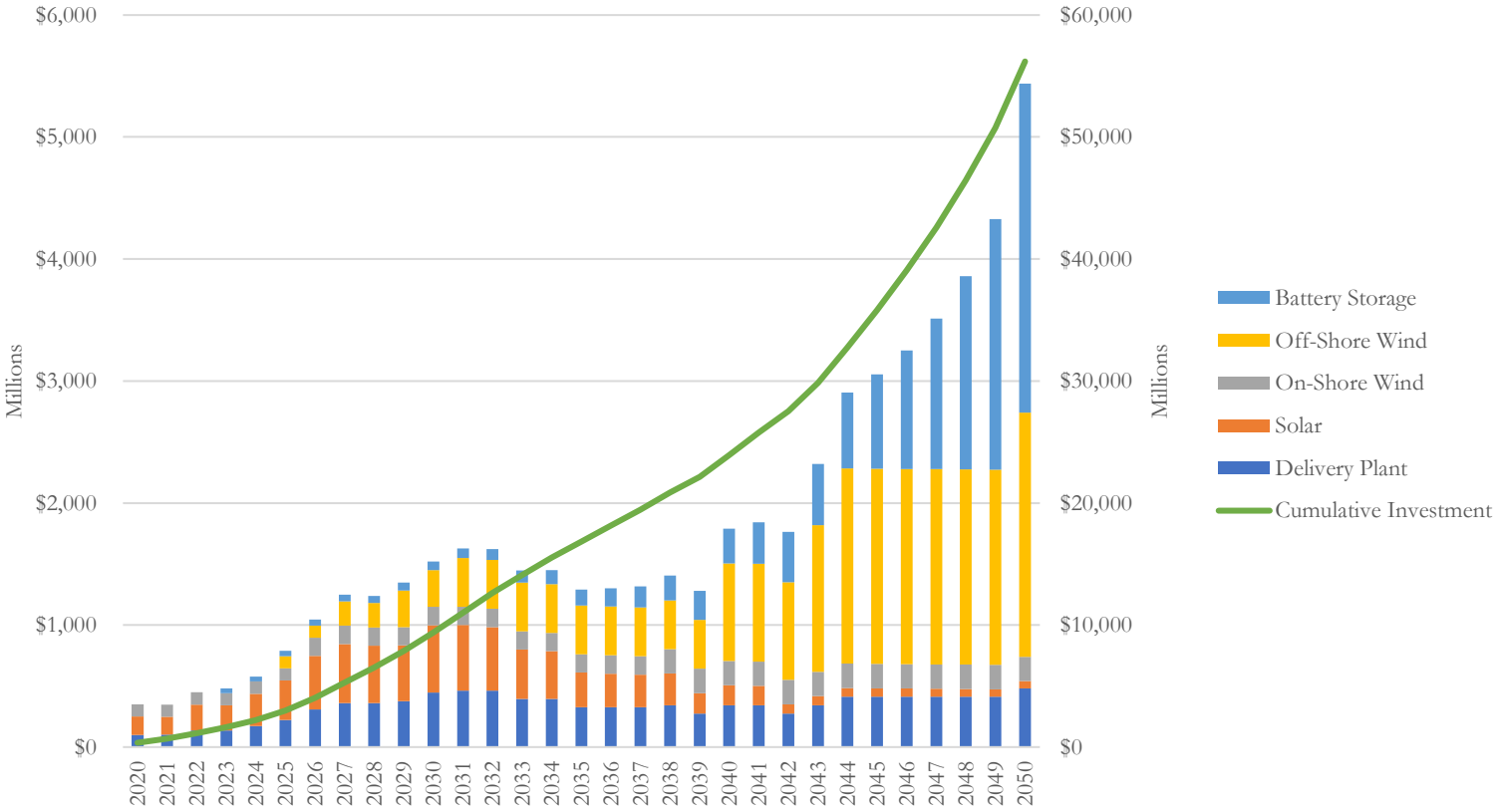
The 30-year Transition Period



However, the nature of how money is spent on energy changes from fuel costs to capital costs – from variable costs to fixed costs

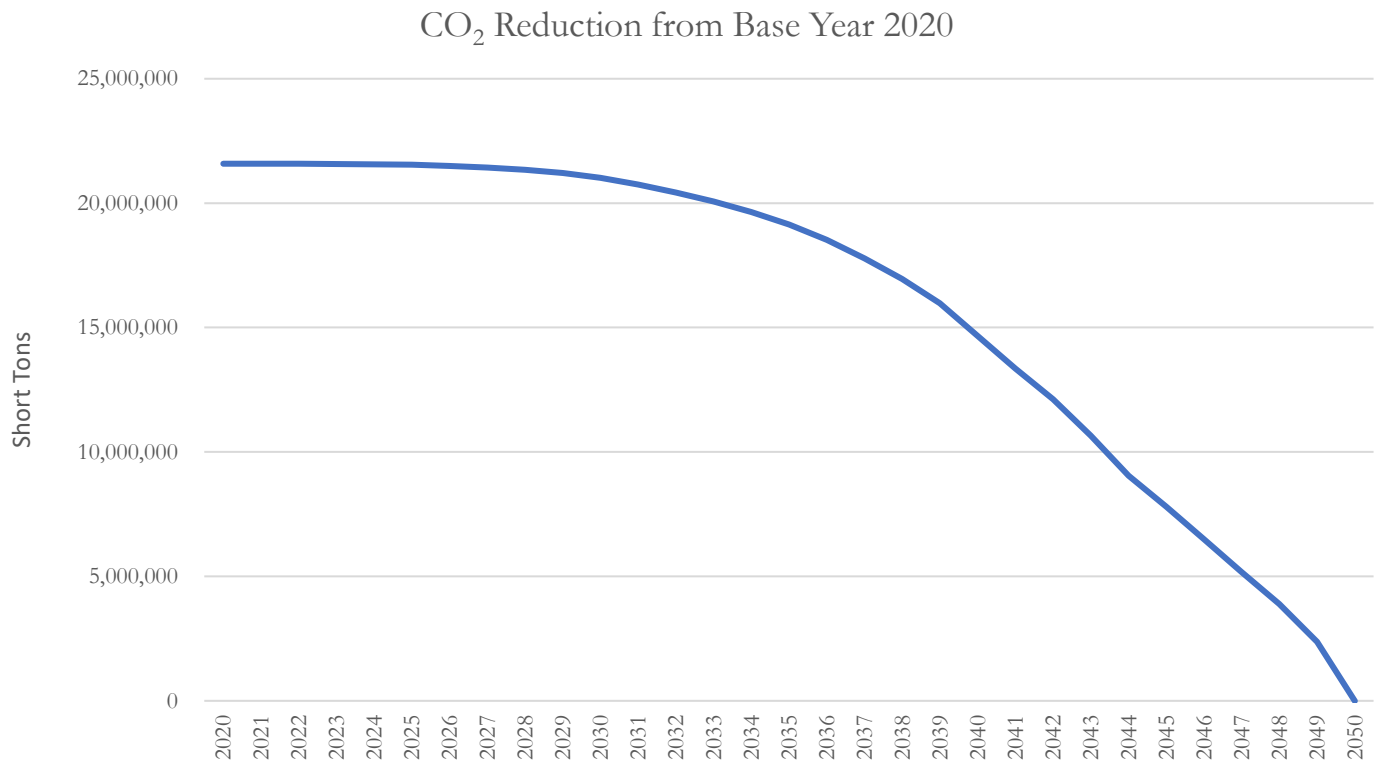
The 30-year Transition Period

Annual and Total Capital Requirements are very significant. The process of getting to zero-carbon can be summarized as the substitution of capital for fuel and O&M in the energy sector.



The 30-year Transition Period

Path of CO_2 Emissions is determined by the speed of both Beneficial Electrification and Renewable Energy Development.



Thank You

For electronic copies of my book – visit https://www.competitive-energy.com/zero-carbon-maine

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