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Pathways to carbon neutral energy systems at the University of California, Davis

Steven Wiryadinata, Josh Morejohn, Kurt Kornbluth

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1 Pathways to Carbon Neutral Energy Systems at the University of California, Davis

2 Steven Wiryadinata¹, Josh Morejohn², Kurt Kornbluth³

3 ¹ Mechanical and Aerospace Engineering, University of California, Davis. Corresponding author.

4 Email: swirya@ucdavis.edu. Tel: (415)568-5015. Address: 1605 Tilia St, #1311 (PIET lab), Davis, CA 95616.

5 ² Facilities Management – Energy & Engineering, University of California, Davis

6 ³ Biological and Agricultural Engineering, University of California, Davis

7
8 Abstract

9 To achieve carbon neutrality by 2025 the University of California, Davis (UCD) seeks to eliminate its dependence
10 on fossil energy sources. This study outlines a methodology to identify optimal equipment phase-in and capacities,
11 and the major technical and economic drivers influencing the implementation of a carbon-neutral energy system.
12 The analysis, focused on UCD, considers solar photovoltaic and thermal, biomass combined heat and power,
13 biomass boiler, heat pump and electric boiler as replacement systems. Three cases besides the baseline are
14 presented: 1) biomass-based system, 2) combination of biomass and electrification, and 3) electrification. Analysis
15 period spans 2016-2035, with equipment phasing limited to the 2020-2025 period, and capacity limited to the peak
16 campus loads of 40 MW_e for electricity and 80 MW_t for thermal. Results indicate that balancing the supply-demand
17 mismatch is the greatest challenge for high renewable penetration at UCD, thus making thermal storage and
18 generation systems which can modulate with variable loads crucial. The cost of carbon credits offset has negligible
19 influence in the results due to its low value in the present market. Relative to the baseline 20-yr present cost of
20 \$634M, the 3 alternate cases are projected to incur between \$629M (Case 1) and \$704M (Case 3).

21 Keywords: techno-economic analysis, renewable penetration, energy system, university low carbon transition,
22 system phasing

23
24 Nomenclature

25 Alt = alternate

26 BM = biomass

27 BTE = biomass-to-energy

28 B/C = benefit/cost ratio

29 CHP = combined heat and power

30 CNI = carbon neutrality initiative (UC system initiative)

31 COP = coefficient of performance

32 CF = capacity factor

33 CPI = consumer price index

34 eBoiler = electric boiler

35 eChiller = electric chiller

36 GHG = greenhouse gas

37 GT = gas turbine

38 HRSG = heat recovery steam generator

39 HVAC = heating, ventilation and air conditioning

40 HW = hot water

41 IGCC = integrated gasification combined cycle

42 IRR = incremental rate of return

43 LCOS = levelized cost of service

44 LHV = lower heating value, kJ/kg

45 NG = natural gas

46 NPC = net present cost, \$

47 NOCT = nominal operating cell temperature

48 O&M = operations and maintenance

49 PC = point of maximum curvature, related to demand duration curve

50 PPA = power purchase agreement

51 PV = photovoltaic

52 SRCC = Solar Rating & Certification Corporation

53 ROR = rate of return

54 ST = solar thermal

55 STM = steam turbine

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