Multi-Campus UC Course for Bending the Curve

Upper-Division Undergraduate Level Course for Majors in Engineering, Humanities, Math/Science, & Social Science

Bending the Curve:
Climate Change Solutions

Launch During Winter and Spring of 2018 at UCI, UCR, UCSC, UCSD, UCD, UCSB

Chair: V. Ramanathan, University of California, San Diego
Co-Chair: H. Han, University of California, Santa Barbara

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Produced by Alan Roper
Innovative Learning Technology Initiative
University of California

The Vision

"Bending the Curve: Climate Change Solutions" will focus on scalable solutions for carbon neutrality and climate stability. The course adopts climate change mitigation policies, technologies, governance and actions that California, the UC system, and cities around the world have adopted as living laboratories and challenges students to identify locally and globally scalable solutions. It also adopts the Ten Scalable Solutions as determined by fifty faculty from the 10-campus UC system under UC's Carbon Neutrality Initiative.

Bending the Curve: Climate Change Solutions

It will be launched in UC campuses beginning January 2018. In subsequent phases, the course will be offered to students across the state, the nation and the globe.

Climate change solutions provide tools to students, so they can bend the curve & preserve nature for future generations.

Ramanathan et al, 2015:
Executive Summary of the Report, *Bending the Curve: 10 scalable solutions for carbon neutrality and climate stability.*
Published by the University of California, October 27, 2015
https:// uccarbonneutralitysummit2015.ucsd.edu/_files/Bending-the-Curve.pdf

I. Course Organization

Climate Solutions is designed as a hybrid course. It combines the best elements of a traditional in-person class with that of online learning environments and flipped classrooms. It requires an in-person instructor.

Online Aspect: We have identified faculty from across the University of California system that are top experts in their field and worked with them to tape 20 lectures of about 1 hour each. The lectures cover the multi-dimensional aspect of the problem ranging from climate science, social science, societal transformation, technology, ecosystem management, governance, economics and market incentives (Table in Section IV). These lectures give students the opportunity to learn from some of the leading experts on climate change solutions. The course is currently designed for a 10 week quarter. The lectures are organized using the following hierarchy of terms:

Clusters: (the organizing principles for the solutions)
Lectures: (describing a unit of study)
Modules: (describing instructional delivery of content within a lecture)
Lessons: (describing sections within a module)

Flipped Class Room: The students are expected to have gone through each videotaped lecture before the class and come prepared to discuss the lectures in the classroom, with an in-person instructor. The students will be grouped into teams of about 5 each and, in an ideal setting, each team will have students majoring in natural science, engineering and social science.

In-person: The instructor will have flexibility in adapting and conducting the class; it can be a discussion of the video lecture, or a discussion of the questions given in the video lecture, or the instructor can choose to give his/her own perspectives on the subject matter. We require that at least 12 of the lectures from the video library be included in the course. The instructor can substitute the remaining lectures with topics of their own choice or use the class room time as lab sessions and guide students in their solutions projects. Core readings are 10 chapters from Bending the Curve: Ten scalable solutions for carbon neutrality and climate stability.

The course was originally offered as graduate level course at UCSD by V. Ramanathan during spring of 2016. About 16 lecturers from all ten UC campuses gave lectures in person at UCSD or remotely. Students were graded 1/3 for in class participations and 2/3 for a group project devoted to solutions on local to global scales. The student groups chose living laboratories of climate mitigation programs from around the world and analyzed them. The favorable response from the students provided the impetus to design this hybrid undergraduate level course beginning summer of 2016 in collaboration with the Innovative Learning Technology Initiative of the UC system. In order to test the appropriateness of the lecture materials for undergraduate students from all majors including humanities, Ramanathan in partnership with Professor Fonna Forman (UCSD-political science) adapted and piloted the course for undergraduates at UCSD during spring of 2017. The course was cross-listed between the Scripps Institution of Oceanography and the Department of Political Science, and attracted students from a dozen majors and minors across the UC San Diego campus.

Student Grading: Students will be grouped into interdisciplinary teams with 4-5 members maximum in each team. This course will require students to review lecture material and complete readings at home prior to class. Class time will focus on in-class discussions of the concept and the questions in the lecture notes as well as group project work. Interdisciplinary discussions will take place both online and in-person, with groups encompassing students from at least 3 different disciplines. Students can be graded using one of several options including the following two:

Standard procedure of quizzes, mid-terms and finals. To facilitate such a grading practice, each lecture has instructor guides with questions and class room discussion topics and issues.

Flipped Class room with group projects: Students will be graded based on 30% for in-class discussions, 50% for group project, and 20% for individual project Report. We attach Appendix-1 as a separate document which provides the syllabus, the guidelines for class projects and grading procedure for the version of the course that will be launched in Jan of 2018 at the University of California at San Diego.

We acknowledge financial support from UC office of the president (50%) and the UCSD education program (50%). Astrid Hsu played a critical role in designing the format for the video presentations, ensuring the time schedule was followed by all participants and in participating in the review of all the lectures for quality and consistency.

II. Organizing Structure for the Taped Lectures

The course lectures follow the topics in the Bending the Curve report. That report arrived at Ten Solutions for carbon neutrality and climate stability. The Ten Solutions are organized under Six Clusters as follows:

Clusters	Solutions
Science Solutions	1. Bend the warming curve immediately by reducing short-lived climate pollutants (SLCPs) and sustainably by replacing current fossil-fueled energy systems with carbon neutral technologies.
Societal Transformation Solutions	2. Foster a global culture of climate action through coordinated public communication and education at local to global scales. 3. Deepen the global culture of climate collaboration.
Governance Solutions	4. Scale up subnational models of governance and collaboration around the world to embolden and energize national and international action.
Market- and Regulations-Based Solutions	5. Adopt market-based instruments to create efficient incentives for businesses and individuals to reduce CO2 emissions. 6. Narrowly target direct regulatory measures — such as rebates and efficiency and renewable energy portfolio standards — at high emissions sectors not covered by market-based policies.
Technology-Based Solutions	7. Promote immediate widespread use of mature technologies such as photovoltaics, wind turbines, battery and hydrogen fuel cell electric light-duty vehicles and more efficient end-use devices, especially in lighting, air conditioning, appliances and industrial processes. 8. Aggressively support and promote innovations to accelerate the complete electrification of energy and transportation systems and improve building efficiency. 9. Immediately make maximum use of available technologies combined with regulations to reduce methane emissions by 50 percent and black carbon emissions by 90 percent.
Natural and Managed Ecosystem Solutions	10. Regenerate damaged natural ecosystems and restore soil organic carbon to improve natural sinks for carbon (through afforestation, reducing deforestation and restoration of soil organic carbon). Implement food waste reduction programs and energy recovery systems to maximize utilization of food produced and recover energy from food that is not consumed.

III. Learning Objectives

Course level learning objectives describe what students will be able to do at the end of the course.

Category	Course Objective
By the end of the course the student will be able to:	
Climate change drivers and impact	1. Explain basic concepts of climate change science.
	2. Explain some of the social, scientific and political antecedents that have led to the crisis driving the current need for climate stability.
	3. Compare the impact that climate change has on the world from various perspectives, including (but not limited to) scientific/technological, socio-economic, governance/regulatory.
Climate change mitigation and solutions	4. Identify various solutions for carbon neutrality and climate stability, and their interrelationships.
	5. Associate climate change mitigation strategies with the casualties that they can trigger, and consider nuanced variations on strategies that lessen the impact on victims.
	6. Organize climate mitigation under the six clusters and apply the ten pragmatic, scalable solutions from the Bending the Curve report in ways that address human dimensions of the problem.
Call to action	7. Identify some of the roles that individuals and groups can play in addressing climate change in one's community.
	8. Identify opportunities for action within one's community
	9. Articulate a statement of personal and societal responsibility for environmental equity, ethics, and justice which can guide decisions and behaviors.

IV. Expertise of Lecturers

Lecturer	Campus	Expertise
Max Auffhammer	UC Berekley	Economics
Jacob Brouwer	UC Irvine	Energy Technology
Jon Christensen	UC Los Angeles	Environmental journalism
Steven Davis	UC Irvine	Lowcarbon Energy Sources
Fonna Forman	UC San Diego	Political theory, global justice and equitable urban transformation.
Hahrie Han	UC Santa Barbara	Environmental politics, civic and political engagement
Mark Jacobsen	UC San Diego	Economics and environmental regulation; transportation economics
Jack Miles	UC Irvine	Religion, science and the environment;
Per Peterson	UC Berekley	nuclear technology & waste processing
David Pellow	UC Berekley	Environmental Justice; race and ethnic studies, so
Keith Pezzoli	UC San Diego	Planning, interactions in city-region sustainability.
Daniel Press	UC Santa Cruz	Environmental politics and policy
Veerabhadran Ramanathan	UC San Diego	Climate and atmospheric sciences.
Eric Rignot	UC Irvine	Glaciology & climate change
Scott Samuelsen	UC Irvine	Power generation, distribution, and utilization;
Whendee Silver	UC San Diego	Ecosystem ecology, biogeochemistry
Gina Solomon	UC San Francisco	Health and asthma effects of climate change
Richard Somerville	UC San Diego	Climate communications; atmospheric modeling;
Daniel Sperling	UC San Diego	Transportation technology & Policy
Matthew St. Clair	UC Office of the President	Sustainability; strategic energy innovations
David Victor	UC San Diego	Climate Policies and Politics
Durwood Zaelke	UC Santa Barbara (Adjunct)	Environmental law and policy;

V. Summary of Taped Lectures

Lecture	Cluster	Topics	Course Objective Addressed
		PART I: SETTING THE STAGE: CLIMATE CHANGE DRIVERS & IMPACT	
1	Science Solutions	Climate Change *V. Ramanathan (UCSD)*	1
2	All Clusters	Six Clusters & Ten Solutions for Bending the Curve *V. Ramanathan (UCSD)*	4, 6
3	Societal Transformation Solutions	Humans & Nature: How Did We Get Here? I. Climate Justice & Equitable Approaches *F. Forman (UCSD)* II. The Quest for Climate Justice *D. Pellow (UCSB)*	2, 3
4	Science Solutions	Impacts and Barriers to Solutions (Choose 2 of 3) I. Obstacles to Climate Solutions *S. Davis (UCI)* II. Climate Change: Health Impacts *G. Solomon (UCSF)* III. Sea Level Rise From Melting Ice *E. Rignot (UCI)*	3, 5
		PART II: LIVING LABORATORIES FOR BENDING THE CURVE: THE CALL TO ACTION	
5	Governance Solutions	Bending the Curve: Lessons from California *D. Press (UCSC)*	4, 6
6	All Clusters	Bending the Curve: Lessons from UC I. Carbon Neutrality Initiative of UC *M. St. Clair (UCOP)* II. Energy Efficiency Management at UCI *J. Brower (UCI)*	4
		PART III: SOLUTIONS: CLIMATE MITIGATION & SOLUTIONS	
7	Science & Technology-Based Solutions	Science & Technology Pathways for Bending the Curve I. Energy Technology Pathways *S. Samuelsen (UCI)* II. Transportation Pathways for BtC *D. Sperling (UCD)*	1, 4

V. Summary of Taped Lectures (cont'd)

8	Societal Transformation Solutions	Your Leadership: Social Movements & Social Solutions to Climate Change *H. Han (UCSB)*	7, 8
9	Societal Transformation Solutions	Behavioral Changes I. Changing Social Norms & Behavior *F. Forman (UCSD)* II. Role of Religon in BtC *J. Miles (UCI)*	7, 8
10	All Clusters	Local Solutions: Making Urban & Rural Areas Resilient (Living Laboratory: UCSD) *K. Pezzoli (UCSD)*	6, 7
11	Societal Transformation Solutions	Public Opinion & Communication I. Climate Science Communications *R. Somerville (UCSD)* II. Climate Communication *J. Christensen (UCLA)*	8, 9
12	Governance Solutions	International Governance *D. Victor (UCSD)*	9
13	Market- & Regulations-Based Solutions	Consideration of Economics for Designing Climate Policy *M. Auffhammer (UCB)*	3, 5
14	Market- & Regulations-Based Solutions	Cost Effective & Efficient Climate Policies *M. Jacobsen (UCSD)*	3, 4, 5
15	Technology-Based Solutions	Bending the Curve with Sustainable Transportation *M. Barth (UCR)*	3, 5
16	Technology-Based Solutions	New Technologies & Innovations For Carbon Neutrality I. Renewable Energy *S. Samuelsen (UCI)* II. Nuclear Energy *P. Peterson (UCB)*	5, 7
17	Technology-Based Solutions	Technologies for SLCPs Mitigation *V. Ramanathan (UCSD) & D. Zaelke (UCSB)*	4, 5
18	Natural & Managed Ecosystem Solutions	Bending the Carbon Curve by Enhancing Carbon Sinks *W. Silver (UCB)*	1

VI. Detailed Outline of Taped Lectures

Course Overview & Vision — V. Ramanathan (UCSD)

PART I: SETTING THE STAGE: CLIMATE CHANGE DRIVERS & IMPACT

Lecture 1: Climate Change — V. Ramanathan (UCSD)
- Module 1: Anthropocene & Planetary Stewardship
- Module 2: Greenhouse Effect & Global Warming
- Module 3: Why & How is Climate Changing
- Module 4: Impacts
- Module 5: Projected Warming & Summary

Lecture 2: Six Clusters & Ten Solutions — V. Ramanathan (UCSD)
- Module 1: Setting the Stage for Mitigation
- Module 2: Six Clusters as the Organizational Principle
- Module 3: The Ten Solutions
- Module 4: Living Laboratories

Lecture 3: Humans & Nature: How Did We Get Here?
Climate Justice & Equitable Approaches — F. Forman (UCSD)
- Module 1: Man + Nature
- Module 2: Climate Justice
- Module 3: Disproportionate Impacts

The Quest for Climate Justice — D. Pellow (UCSB)
- Module 1: Defining Climate Injustice & Climate Justice
- Module 2: Cases of Climate Injustice
- Module 3: Global Climate Policy Frameworks
- Module 4: What Might Climate Justice Look Like?

Lecture 4: Impacts & Barriers to Solutions
Climate Change: Health Impacts — G. Solomon (UCSF)
- Module 1: Air: Hot & Dirty
- Module 2: Water: Dry or Drown
- Module 3: Disease: The Coming Plagues?

Sea Level Rise From Melting Ice — E. Rignot (UCI)
- Module 1: How Melting Happens
- Module 2: History of Melting
- Module 3: What We Can Do

VI. Detailed Outline of Taped Lectures (cont'd)

Obstacles to Climate Solutions — S. Davis (UCI)
- Module 1: Technological & Economic Challenges
- Module 2: Political & Behavioral Challenges

PART II: LIVING LABORATORIES FOR BENDING THE CURVE: THE CALL TO ACTION

Lecture 5: Bending the Curve: Lessons from California — D. Press (UCSC)
- Module 1: 50 Years of California Policies: Air Quality
- Module 2: 50 Years of California Policies: Energy
- Module 3: California: Big State & Small Energy Demand
- Module 4: California's Climate Change Policies: AB 32 2006
- Module 5: AB 32 Policies and Implementation
- Module 6: Beyond AB 32

Lecture 6: Bending the Curve: Lessons from UC
Carbon Neutrality Initiative of UC — M. St. Clair (UCOP)
- Module 1: What Role Can Universities Play?
- Module 2: UC's Carbon Footprint and Climate Solutions
- Module 3: UC's Education Footprint

Energy Efficiency Management — J. Brouwer (UCI)
- Module 1: Energy Efficiency: Overview
- Module 2: Energy Efficiency: Campus Operations
- Module 3: Energy Efficiency: Generation of Power
- Module 4: Energy Efficiency: Utilization of Power

PART III: SOLUTIONS: CLIMATE MITIGATION & SOLUTIONS

Science Solutions Cluster (Solution #1)

Lecture 7: Science & Technology Pathways
Energy Technology Pathways — S. Samuelsen (UCI)
- Module 1: Energy Demand and GHG Intensity through 2015
- Module 2: Role of Combustion
- Module 3: Paradigm Shifts in Electricity & Transportation

Transportation Pathways for BtC — D. Sperling (UCD)
- Module 1: Vehicles
- Module 2: Fuels
- Module 3: Mobility

VI. Detailed Outline of Taped Lectures (cont'd)

Societal Transformation Cluster (Solutions #2 & #3)

Lecture 8: Social Movement Solutions — H. Han (UCSB)
- Module 1: Why Collective Action?
- Module 2: What is a Social Movement?
- Module 3: What is the Role of Leadership?
- Module 4: What Can I Do? (Part 1)
- Module 5: What Can I Do? (Part 2)

Lecture 9: Behavioral Changes
Changing Social Norms & Behavior — F. Forman (UCSD)
- Module 1: Integral Solutions
- Module 2: Go Local: Living Laboratories
- Module 3: UCSD Community Stations

Role of Religion in BtC — J. Miles (UCI)
- Module 1: Blind and Lame
- Module 2: When Washington Won't
- Module 3: Neither Blind Nor Lame

Lecture 10: Local Solutions — K. Pezzoli (UCSD)
- Module 1: Localization and the Bioregional Transition
- Module 2: Green Infrastructure, Ecosystems & Climate Action Plans
- Module 3: Trees
- Module 4: Food Forests
- Module 5: Food Waste, Energy, and Soil
- Module 6: Make Change Happen: Priorities for Action

Lecture 11: Public Communication
Climate Science Communications — R. Somerville (UCSD)
- Module 1: Preparation
- Module 2: Stories
- Module 3: Metaphors
- Module 4: Language
- Module 5: Solutions

Climate Communication — J. Christensen (UCLA)
- Module 1: Why Climate Communication Often Fails
- Module 2: How Climate Communication Works
- Module 3: Moving Beyond Doom and Gloom

VI. Detailed Outline of Taped Lectures (cont'd)

Governance Cluster (Solution #4)

Lecture 12: International Governance — D. Victor (UCSD)
- Module 1: Needed International Cooperative Institutions
- Module 2: Brief History of Climate Diplomacy
- Module 3: The Paris Agreement
- Module 4: Six Implementation Challenges

Market & Regulations Cluster (Solutions #5 & #6)

Lecture 13: Economics: Impacts and Policy — M. Auffhammer (UCB)
- Module 1: The Mitigation Challenge
- Module 2: Economic Impacts of Climate Change
- Module 3: Economic Regulation: Overcoming Market Failures

Lecture 14: Cost Effective & Efficient Climate Policies
Market-Based Climate Policy — M. Jacobsen (UCSD)
- Module 1: The Value of Market-Based Incentives
- Module 2: Current Climate Policy & Carbon Prices
- Module 3: In Depth: Incentives in the Automobile Sector

Technology Cluster (Solutions #7, #8 & #9)

Lecture 15: Energy Implications of Transportation — M. Barth (UCR)
- Module 1: Major Concerns of Transportation
- Module 2: Transportation Emissions and Energy Impacts
- Module 3: Sustainable Transportation Solutions
- Module 4: Impacts of Intelligent Transportation Systems on Energy & Emissions
- Module 5: Role of Vehicle Automation on Energy & Emissions

Lecture 16: New Technologies & Innovations for Carbon Neutrality
Renewable Energy — S. Samuelsen (UCI)
- Module 1: Alternatives to Combustion
- Module 2: Fuel Cell Technology
- Module 3: Evolution of the Electric Grid
- Module 4: Smart Grid Technology

Nuclear Energy — P. Peterson (UCB)
- Module 1: Energy From Nuclear Fission

VI. Detailed Outline of Taped Lectures (cont'd)

- Module 2: Nuclear Energy: Safety
- Module 3: Economics
- Module 4: Near-Term Reactor Technologies
- Module 5: Future Directions

Lecture 17: Tecnonlogies for SLCPs Mitigation nologies for SLCPs Mitigation — Ramanathan (UCSD), D. Zaelke (UCSB
- Module 1: SLPCs: Reduces Near-Term Warming
- Module 2: Black Carbon: Major Climate Pollutant
- Module 3: Methane Mitigation
- Module 4: Montreal Protocol
- Module 5: Kigali Amendment

Natural & Managed Ecosystems (Solution #10)

Lecture 18: Enhancing Carbon Sinks — W. Silver (UCB)
- Module 1: Introduction to Land Based Solutions
- Module 2: Soils
- Module 3: Agriculture and Forestry
- Module 4: Carbon Sequestration Case Study

Bending the Curve: Climate Change Solutions

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