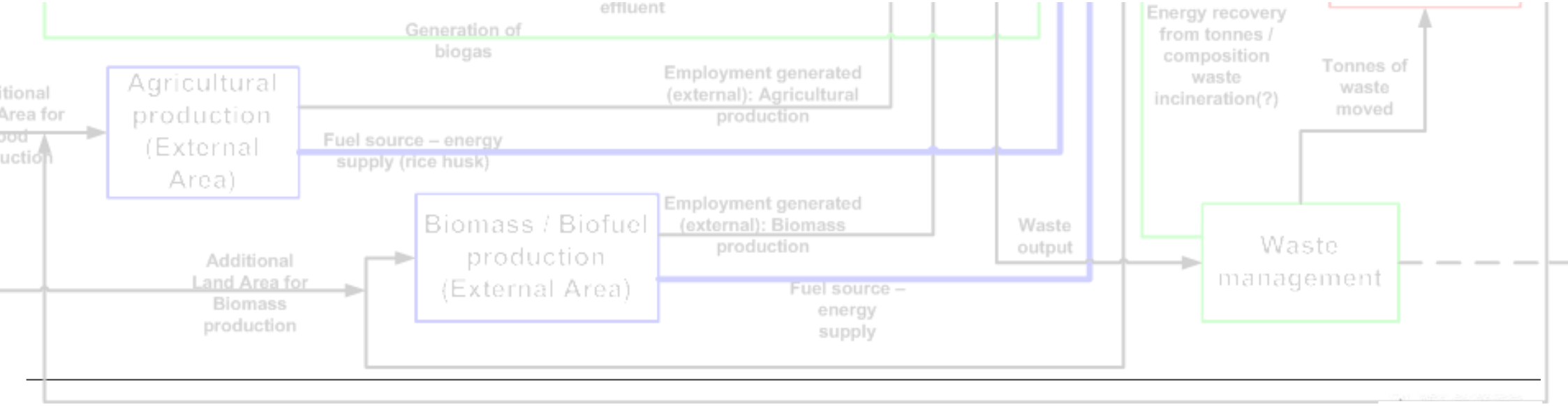
Spatially-linked Integrated Resource Management (IRM)
A tool to inform sustainable city planning

ARUP

Cole Roberts, PE, LEED AP

New Partners for Smart Growth 2010 | Seattle, WA | February 4, 2010



Outline

Arup

Arup Background

global | integrated | employee-owned | multidisciplinary

Principal Fields of Activity

Building Engineering

Sustainability & GHG Consulting

LEED Consulting

Civil Engineering

Energy & Resources Engineering

Integrated Resource Planning

Infrastructure

Transportation Planning

Information Technology

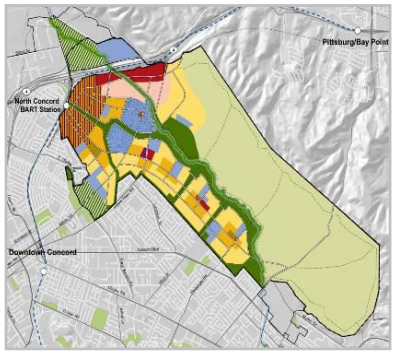
Smart Grid & Information Architecture

Acoustics / Vibration Consulting

Advanced Technology

Risk Assessment

Environmental Consulting



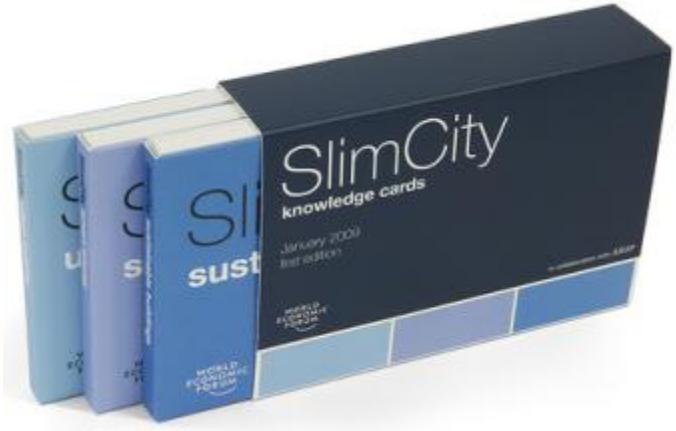
Total Planning = Sustainability

the integration process and the interdependence of all the professions involved, the creative nature of planning and engineering, the value of innovation and the social purpose of design.

Collaborations

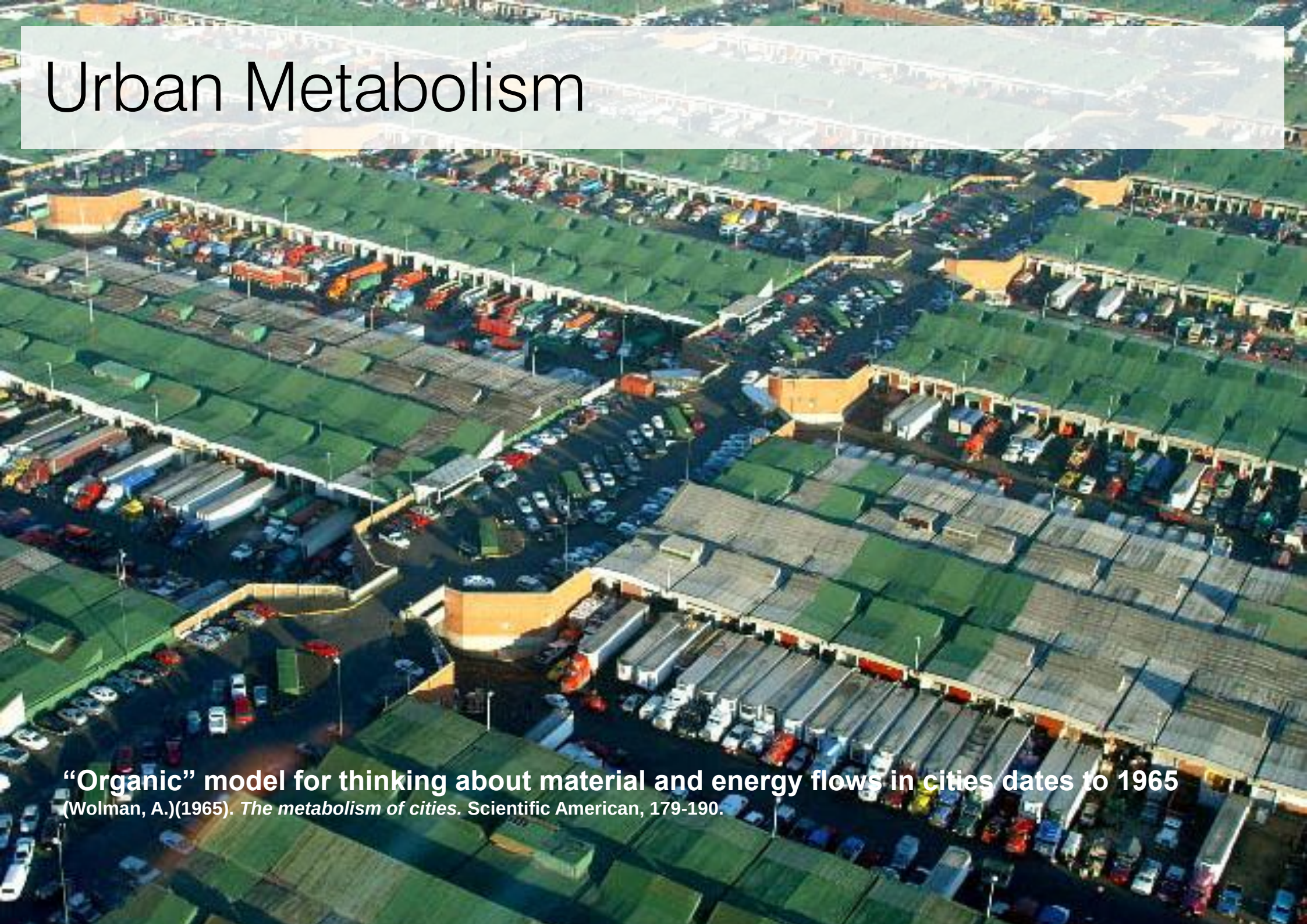
- Clinton Climate Positive Projects
- C40 Memorandum of Understanding
- World Economic Forum

C40 CITIES
CLIMATE LEADERSHIP GROUP



Arup
IRM
Approach

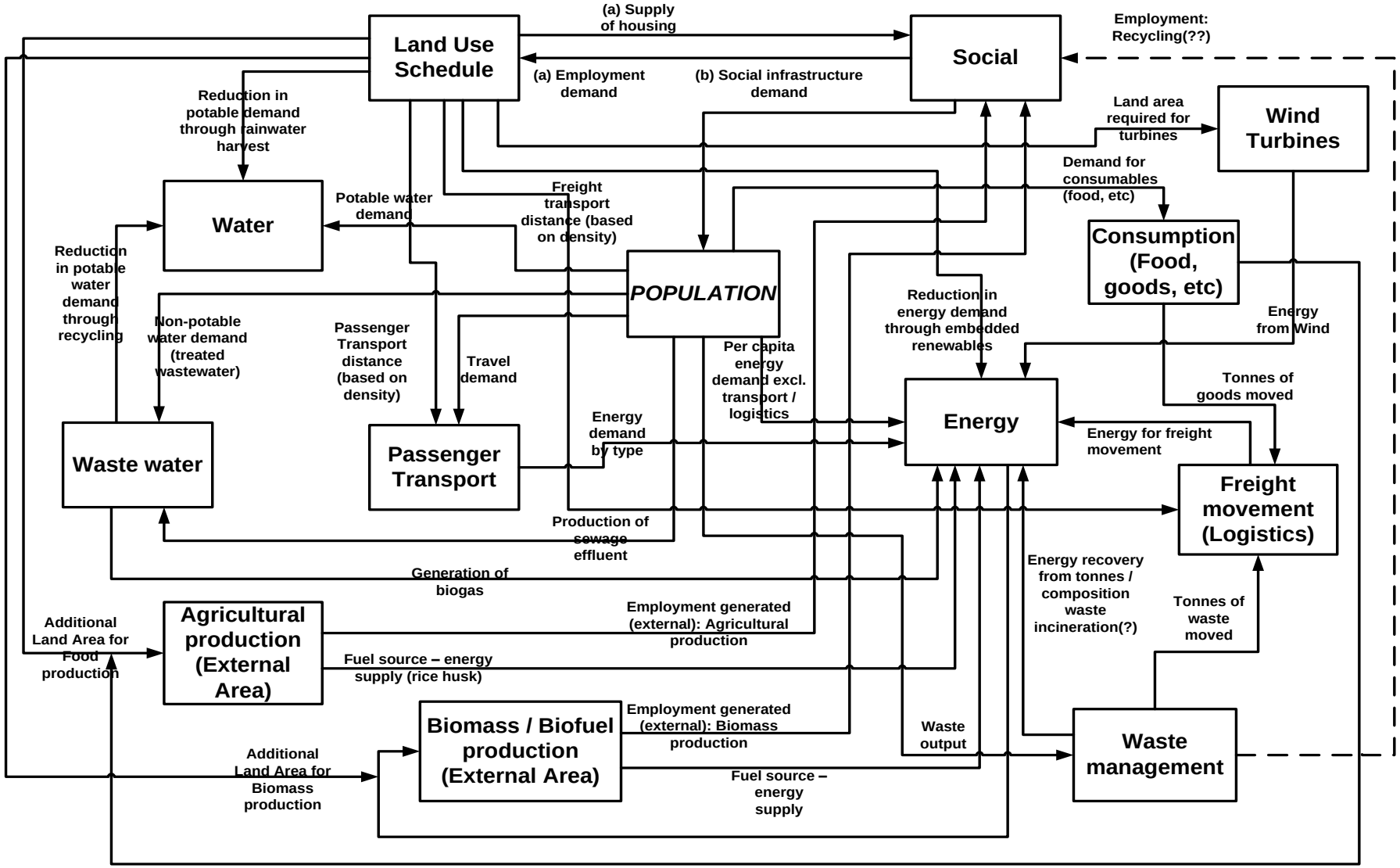
Urban Metabolism



“Organic” model for thinking about material and energy flows in cities dates to 1965

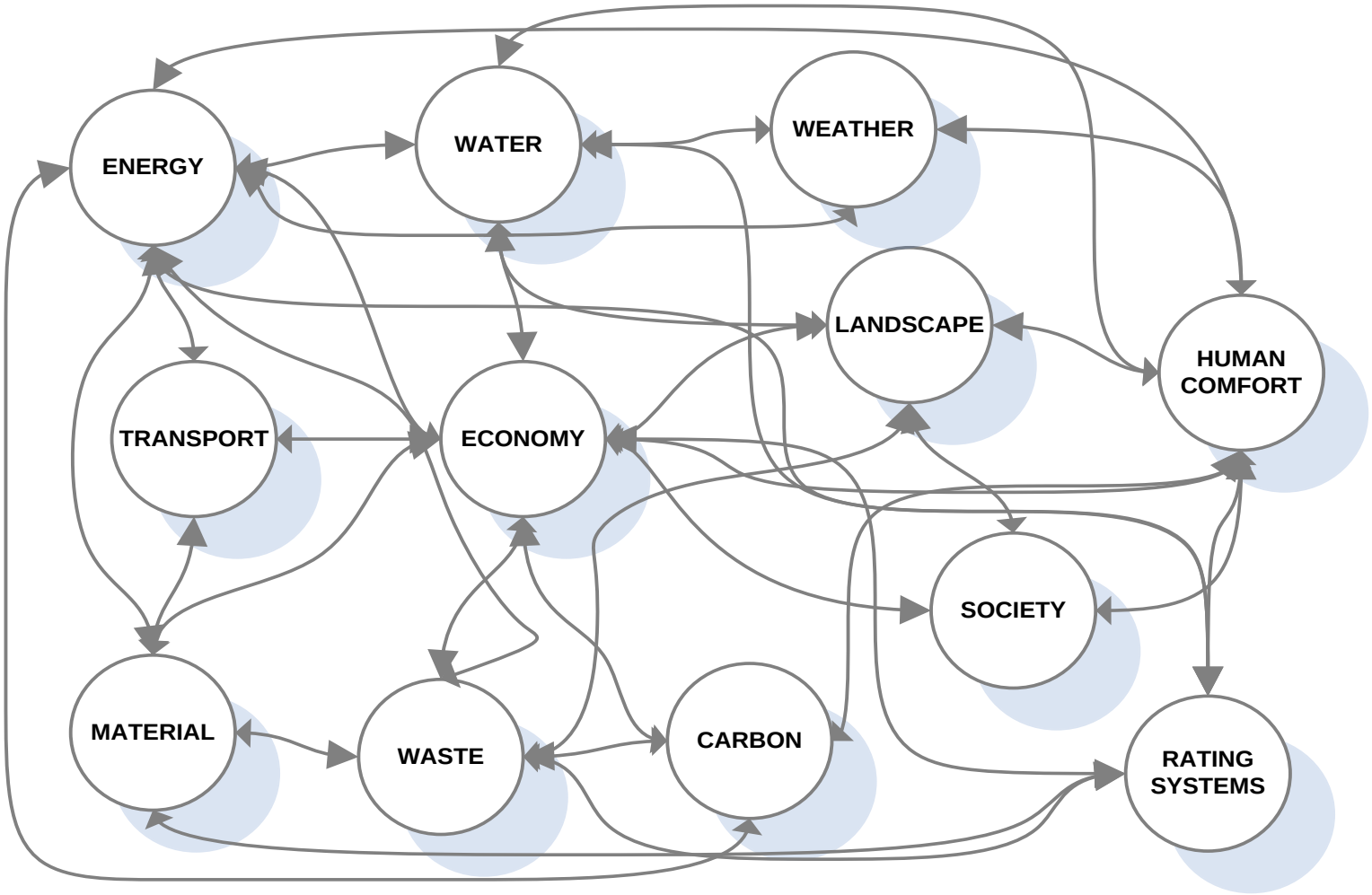
(Wolman, A.)(1965). *The metabolism of cities.* Scientific American, 179-190.

Urban Metabolism



ARUP

Integrated Resource Management (IRM)



Beyond VMT in Land Use

In One Project:

VMT related GHG reductions: 46%

Building energy related GHG reductions: 54% (i.e. greater than the VMT related emissions reductions).

Beyond VMT in Land Use

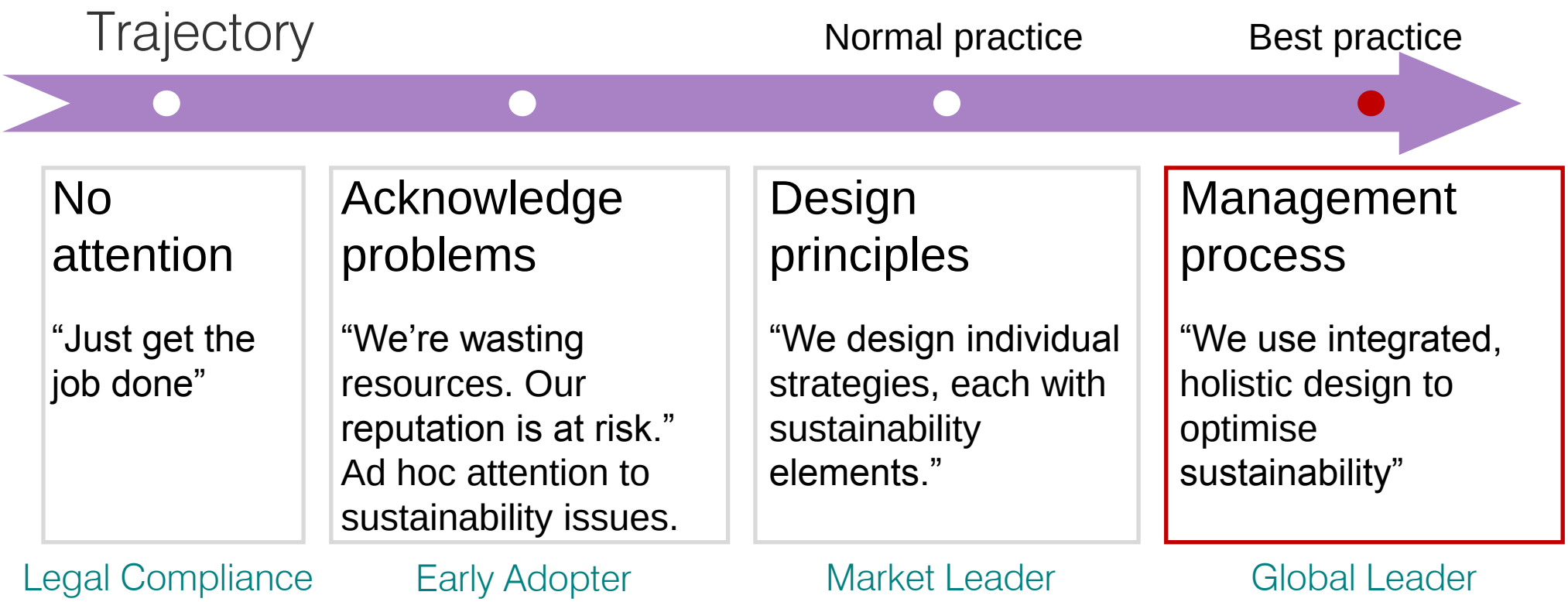
In One Project:

VMT related GHG reductions: 46%

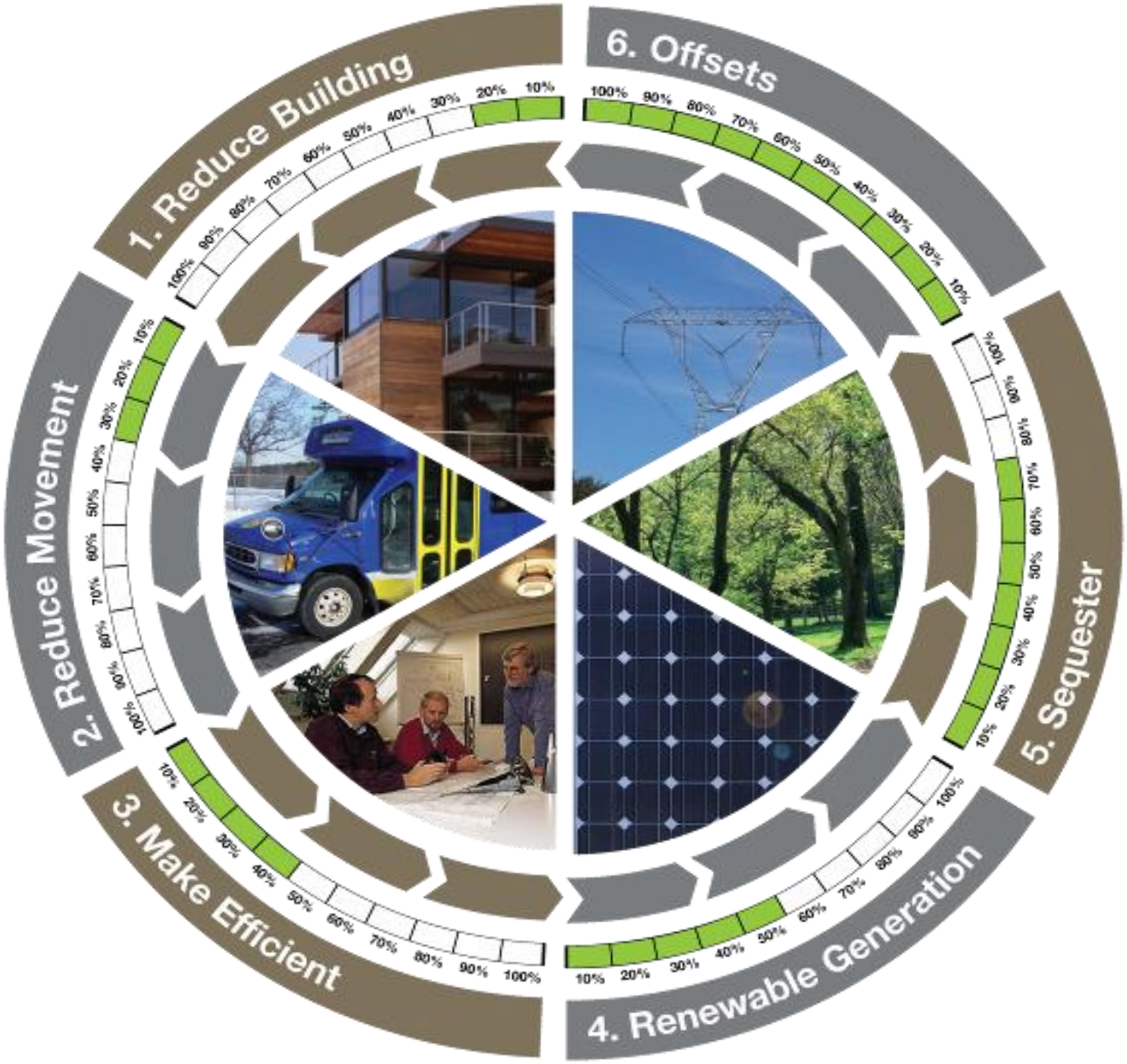
Building energy related GHG reductions: 54% (i.e. greater than the VMT related emissions reductions).

…and this did not include further benefits from embodied GHG in the improved water and waste systems (often better in infill locations) or the protected bio-mass sequestered in undeveloped alternative sites such as prime ag land and watersheds.

Progress towards best practice sustainability



Rational & Complete



Reduce Building
- Built Size
- Material Selection

Reduce Movement
- Reduce Trips
- Optimize Distances

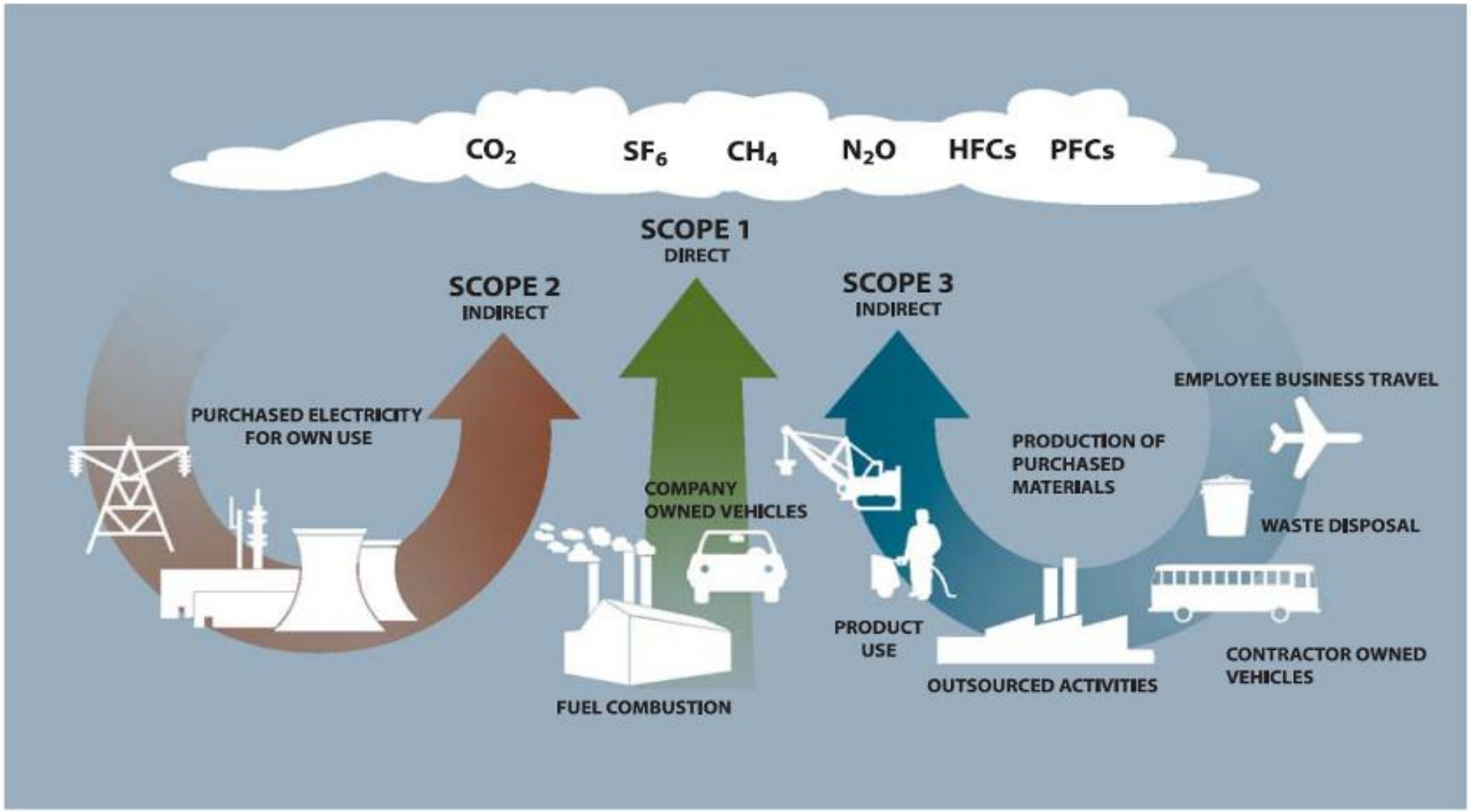
Make Efficient
- Building Systems
- Vehicles
- Operations

Renewable Generation
- Solar
- Wind
- Bio-Fuel Transit

Sequester
- Green Space
- Infill Benefit
- Gas Injection

Offsets
- Carbon Credits
- Support for Green Causes

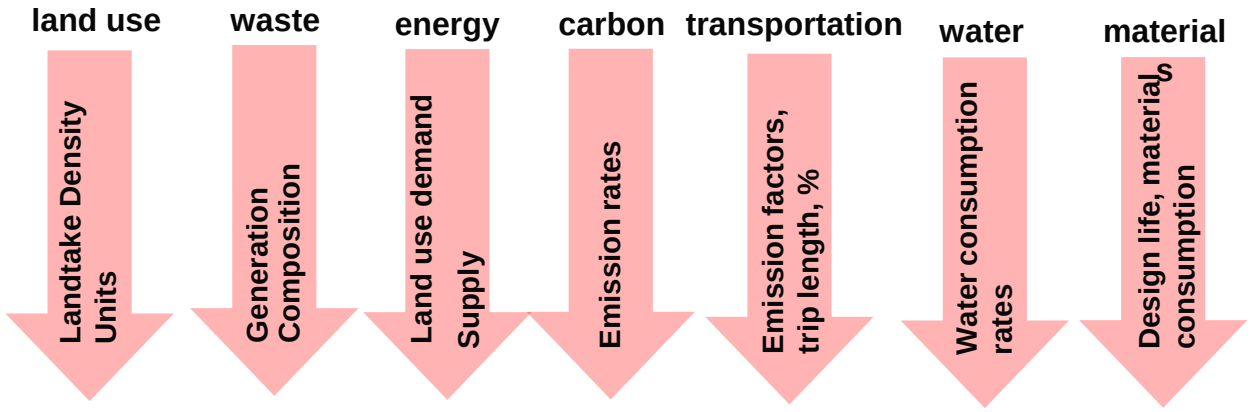
Significance and *Control*



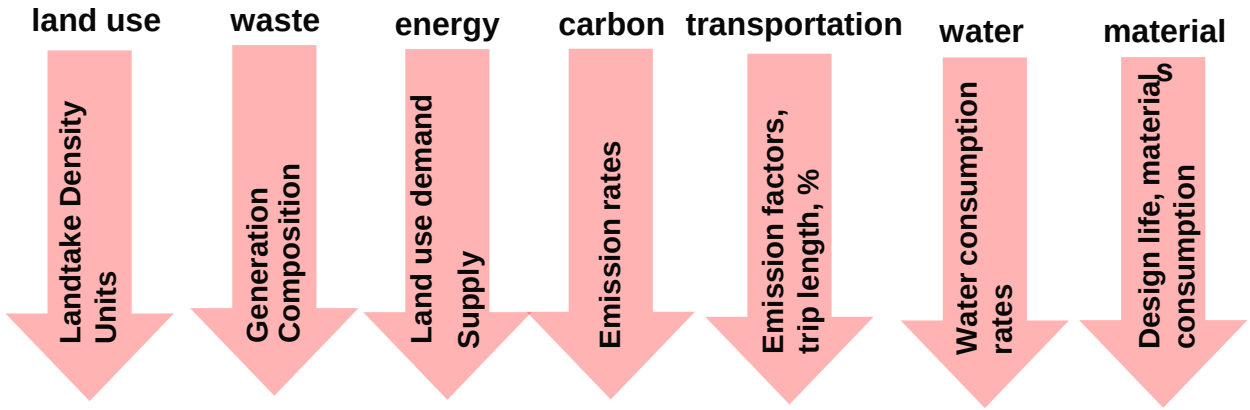
Quantitative Support – IRM: *Modeling*

A **holistic quantitative** model for improved **understanding** of urban systems and the **impact of planning decisions**

The IRM Model

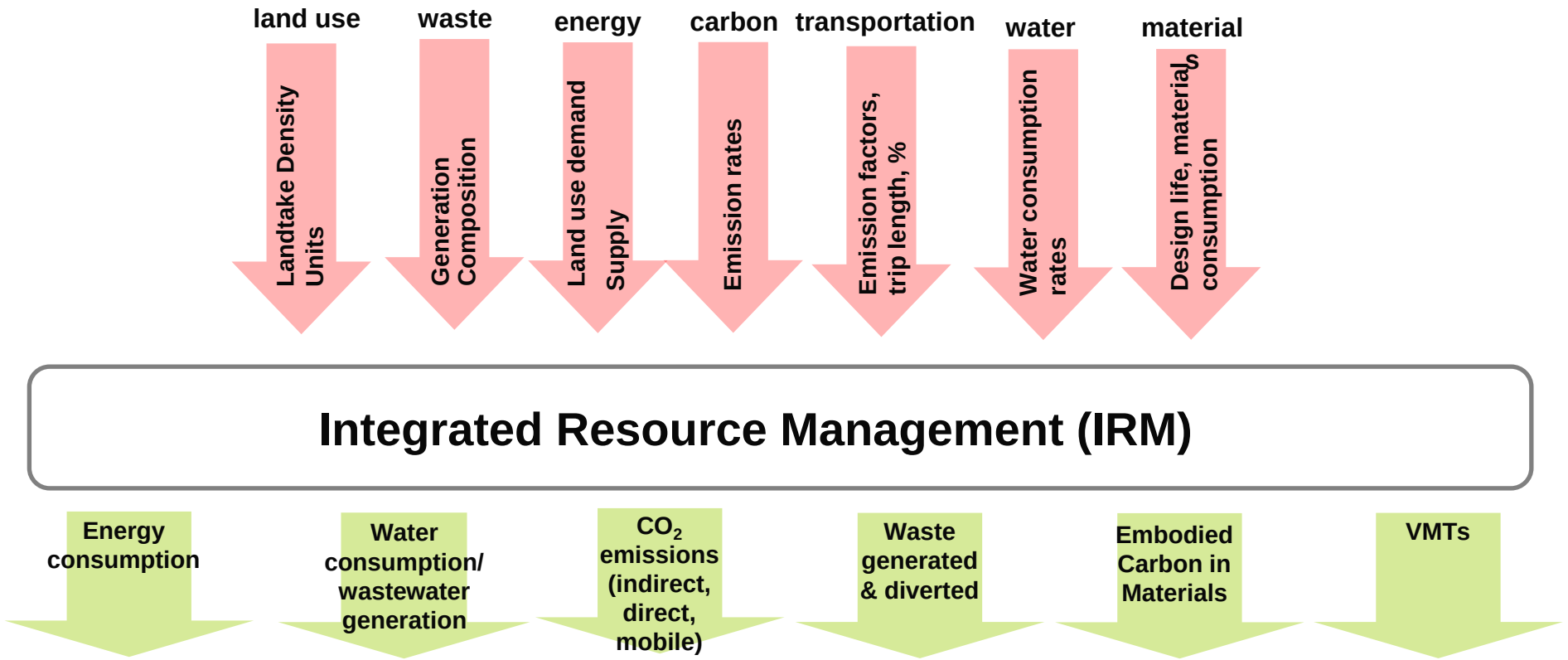


The IRM Model

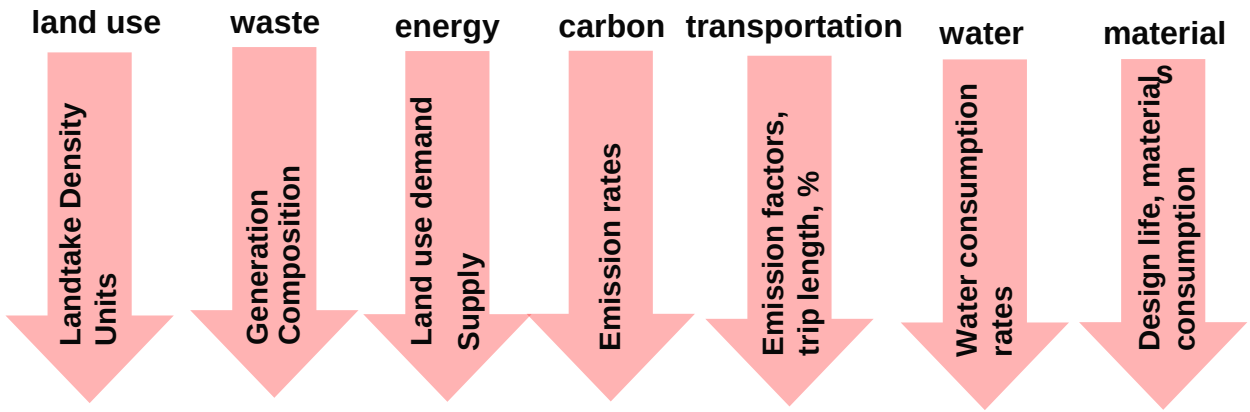


Integrated Resource Management (IRM)

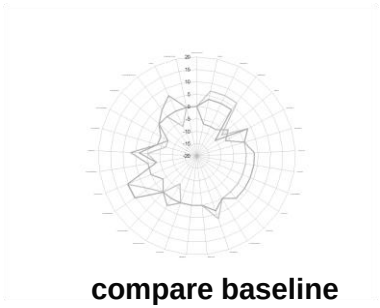
The IRM Model



The IRM Model

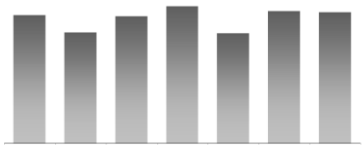


Integrated Resource Management (IRM)



compare baseline and design across multiple indicators

compare baseline with design

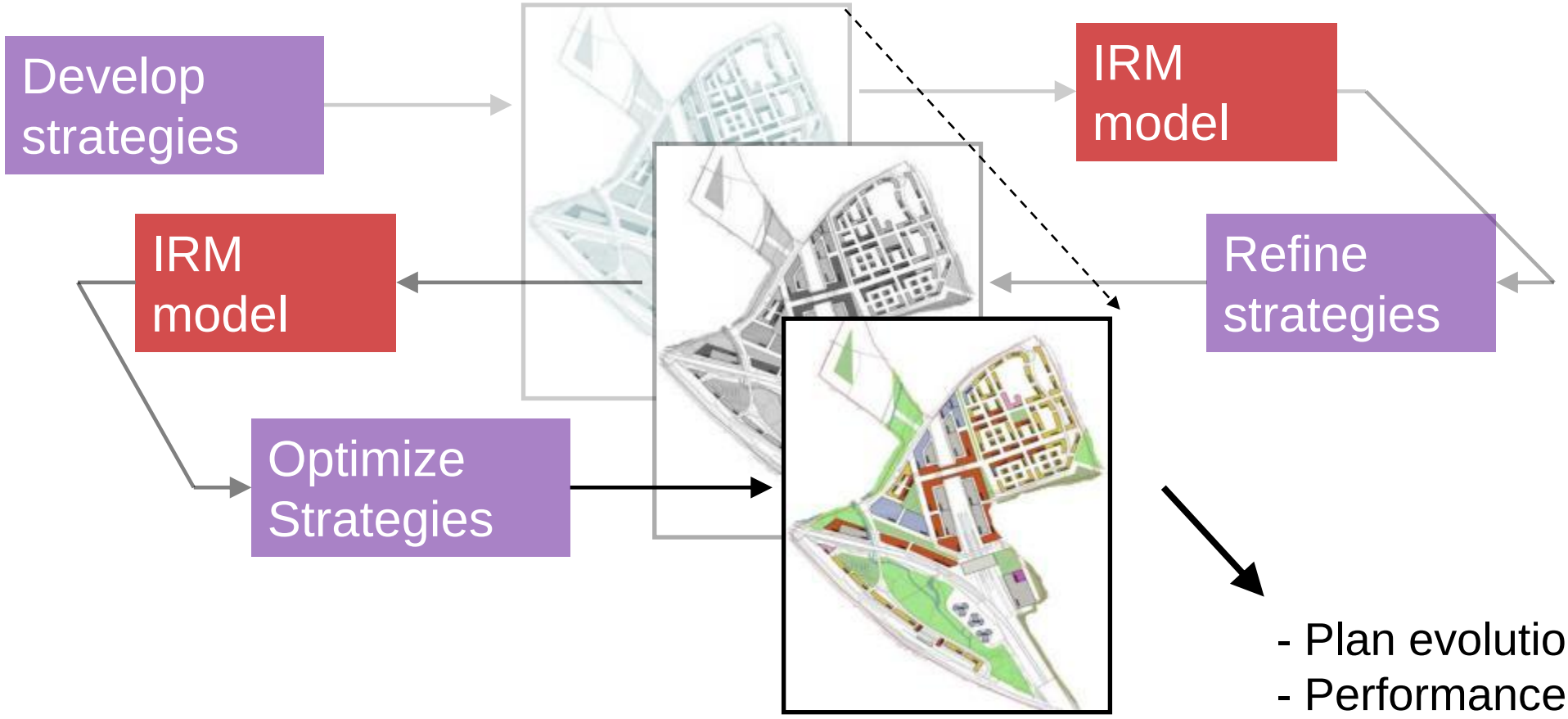


compare alternatives

compare with comparable everyday items (e.g. waste generation measured in # of garbage bins)

detect “hotspots” of resource consumption across the plan

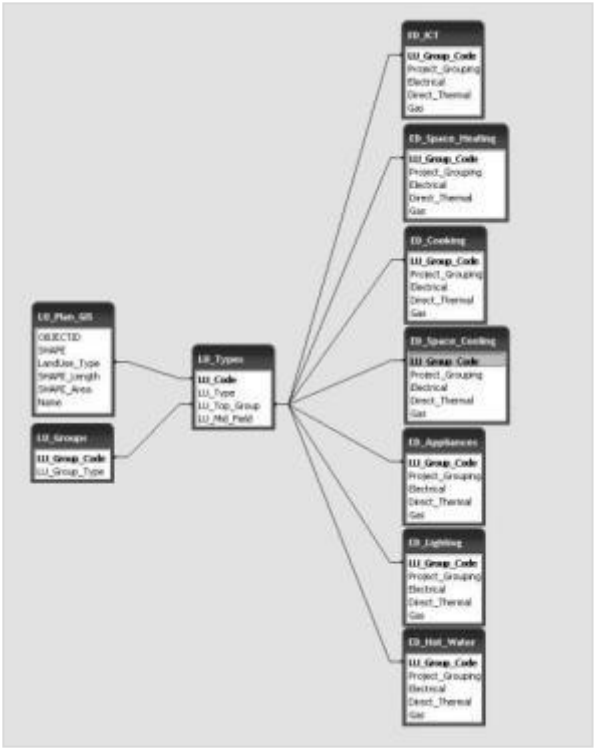
Optimized and Informed Planning

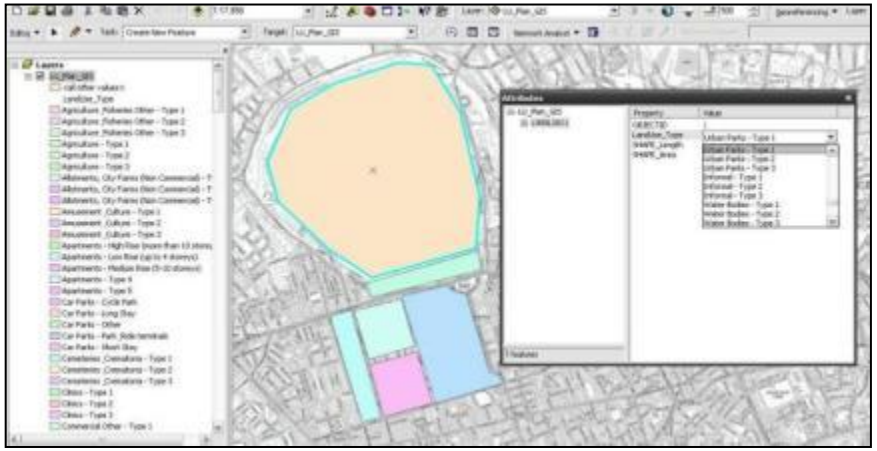


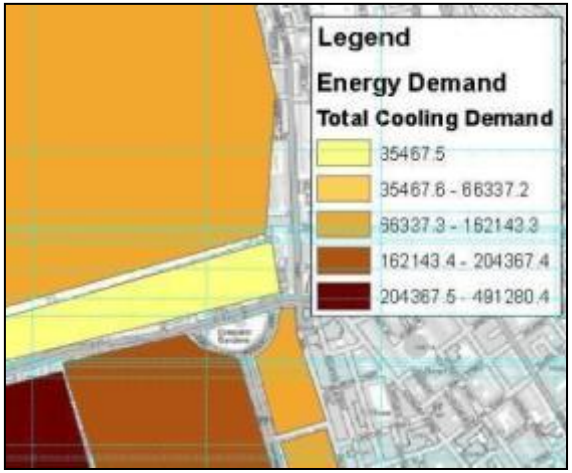
GIS Integration

Contents | Preview | Metadata

Name	Type
ED_Appliances	Personal Geodatabase Table
ED_Cooking	Personal Geodatabase Table
ED_Hot_Water	Personal Geodatabase Table
ED_ICT	Personal Geodatabase Table
ED_Lighting	Personal Geodatabase Table
ED_Space_Cooling	Personal Geodatabase Table
ED_Space_Heating	Personal Geodatabase Table
LU_Groups	Personal Geodatabase Table
LU_Plan_GIS	Personal Geodatabase Feature Class
LU_Types	Personal Geodatabase Table
PT_Bicycle	Personal Geodatabase Table
PT_Bus	Personal Geodatabase Table
PT_Car_out_of_city	Personal Geodatabase Table
PT_Car_within_City	Personal Geodatabase Table
PT_Ferry	Personal Geodatabase Table



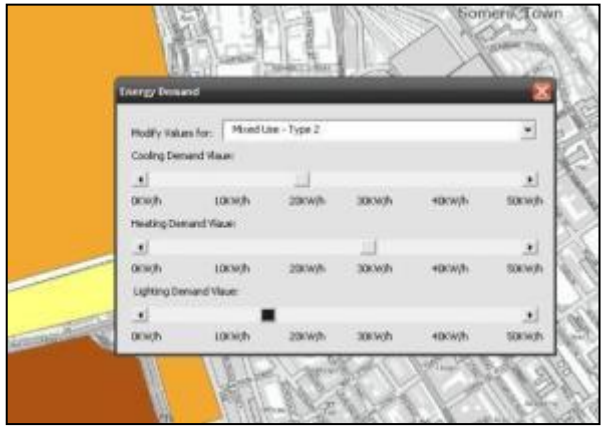




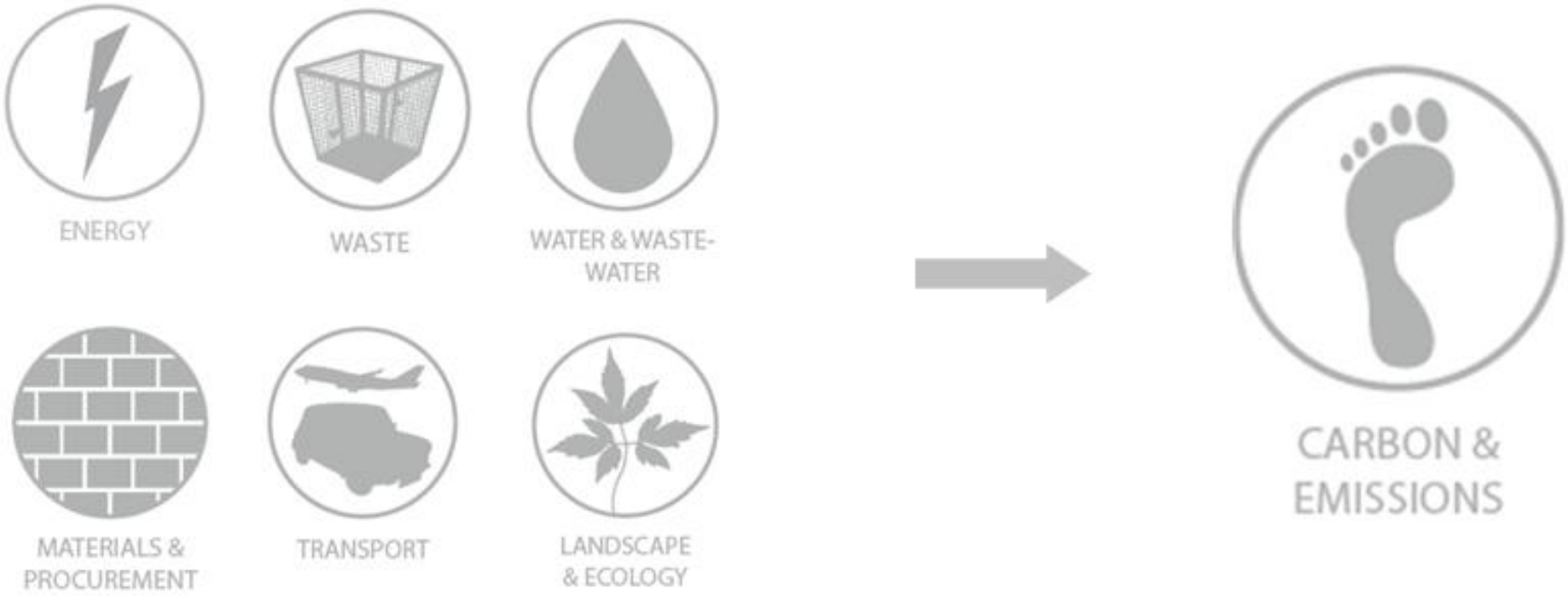
IRM_TEST : Database (Access 2000 file format)

qry_ED_Office_ICT : Select Query

LU_Group_Type	Electrical	Total_Area	Total_ElecUse
Offices	40	2349.0500571	93962.002283
Residential	10	4463.1422374	44631.422374



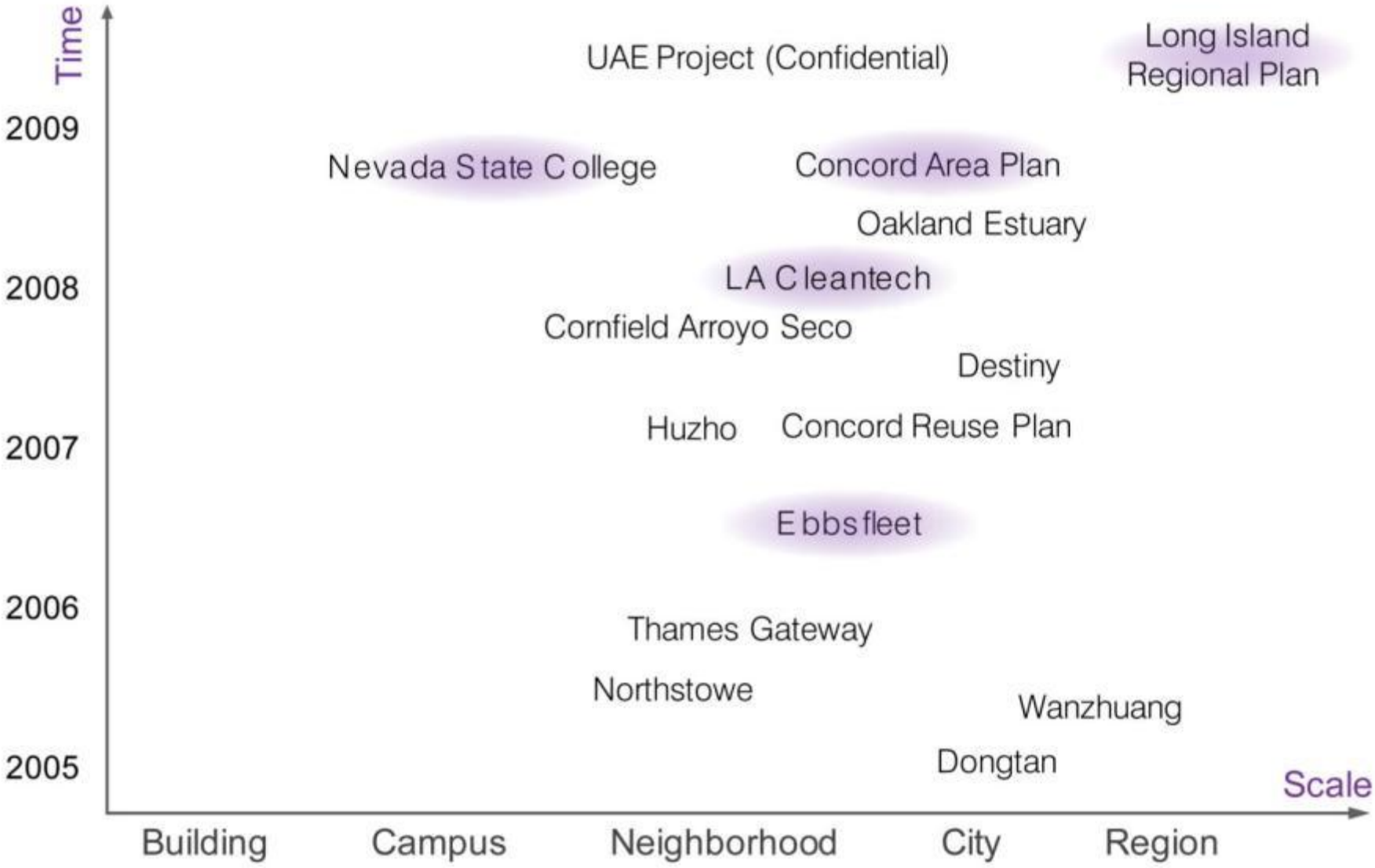
Greenhouse Gases and Emissions



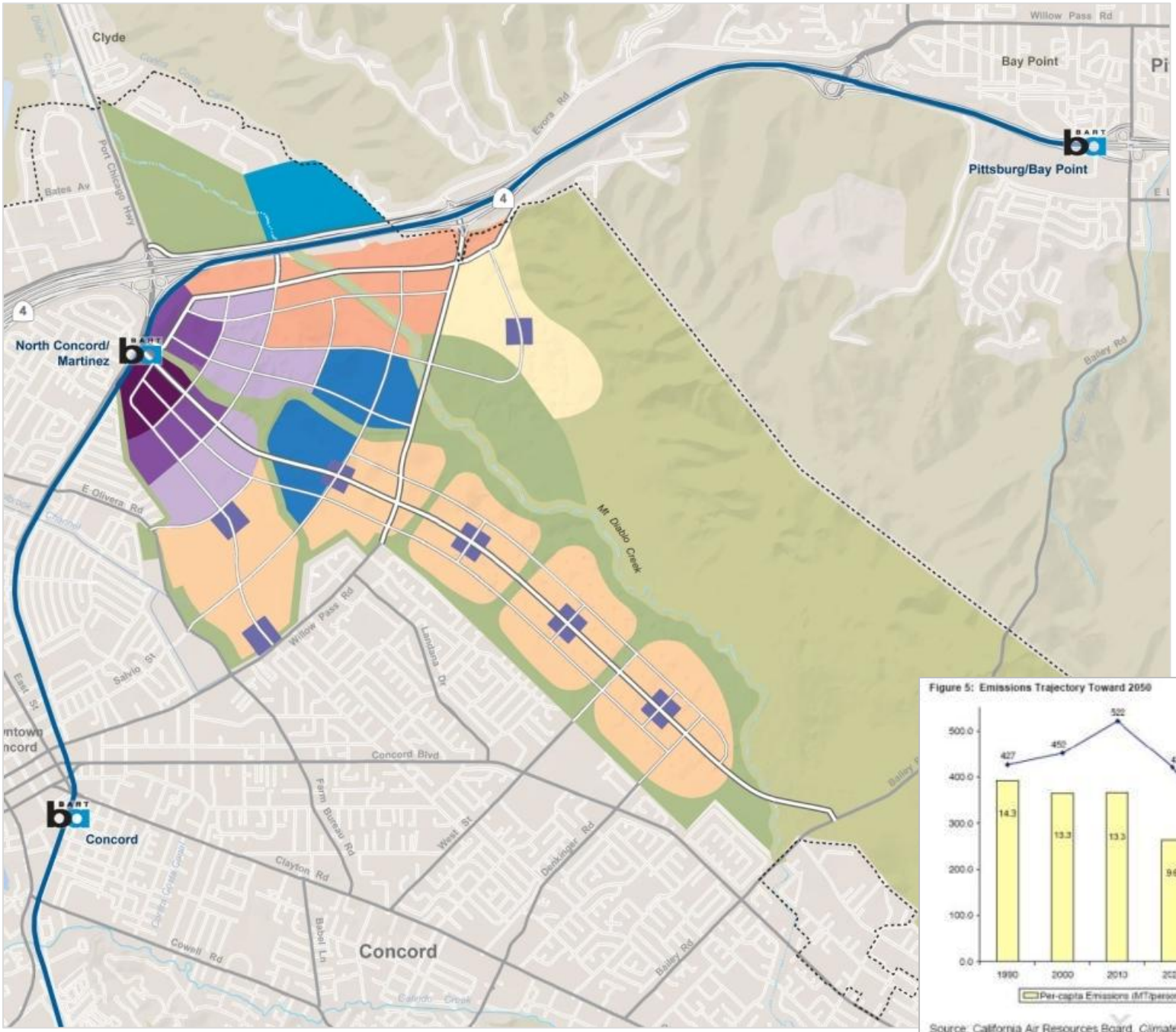
Arup
IRM Approach
IRM Tool

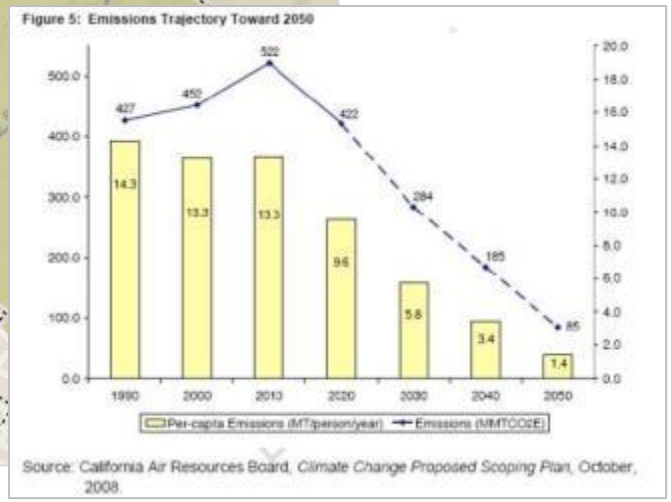
Projects

IRM masterplan projects

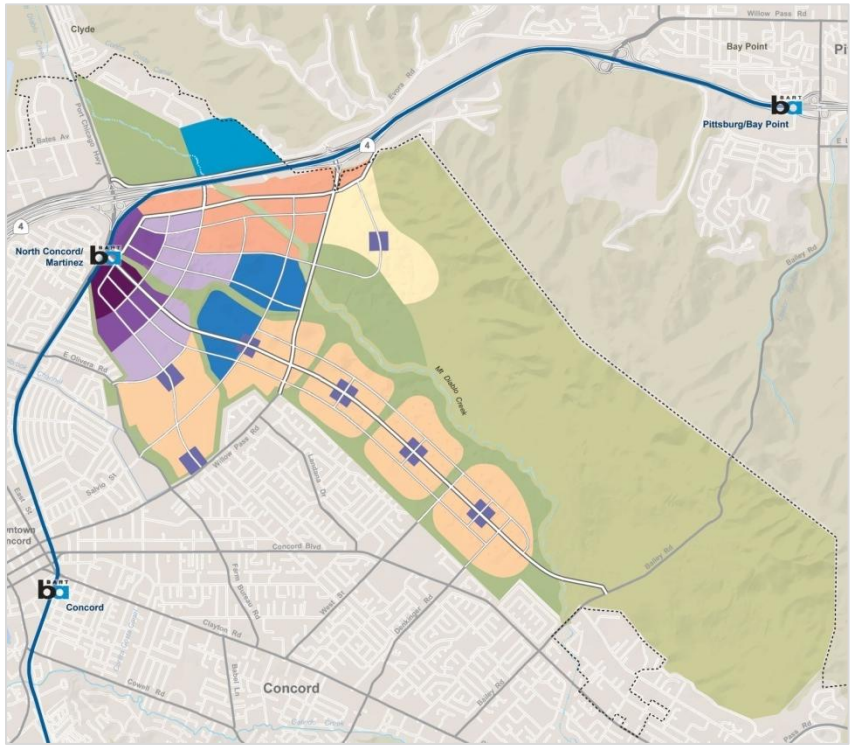


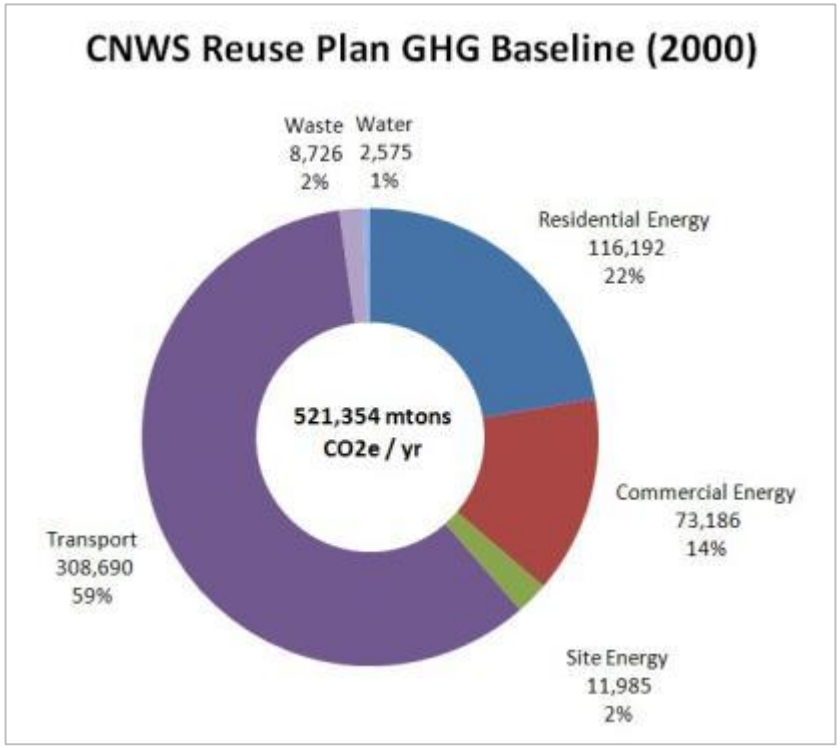
Concord Naval Weapon Station

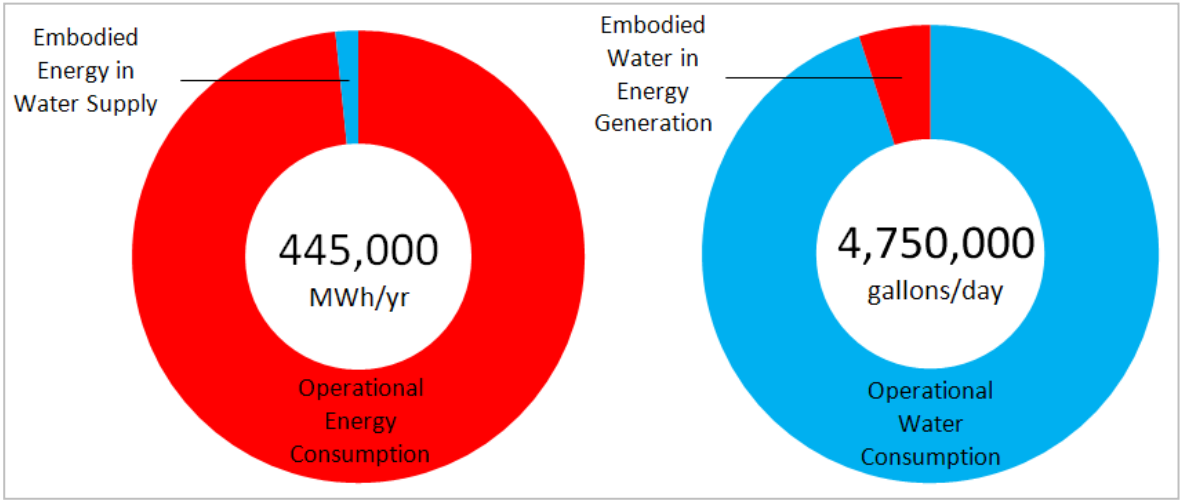




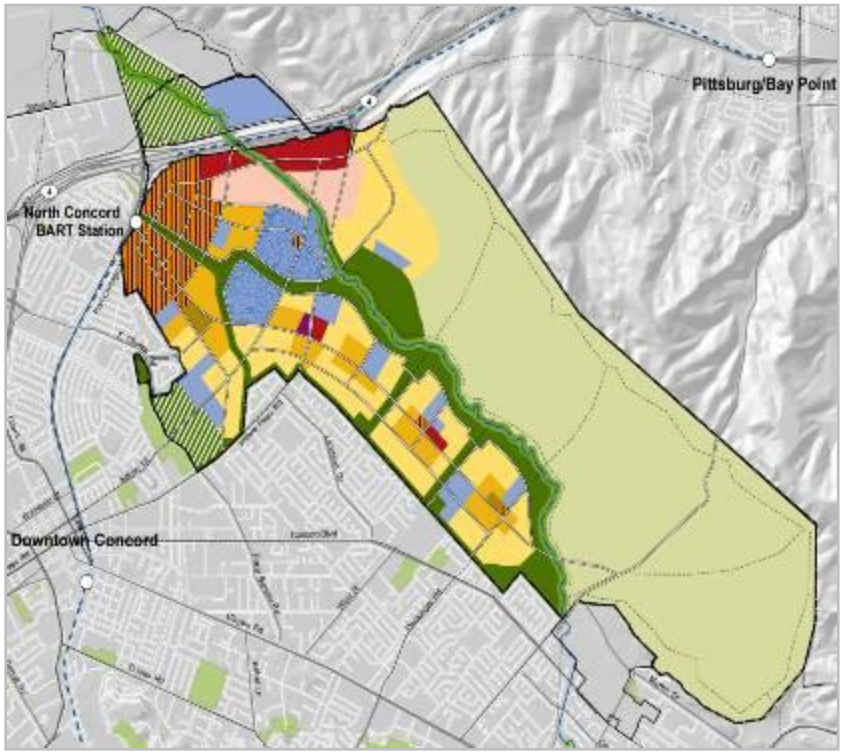
Concord Naval Weapon Station

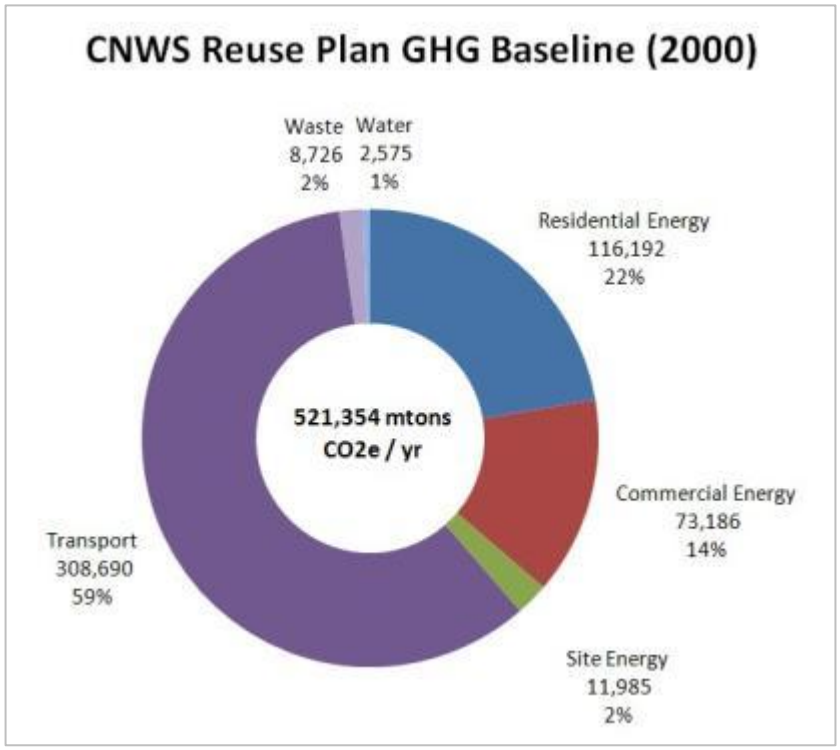


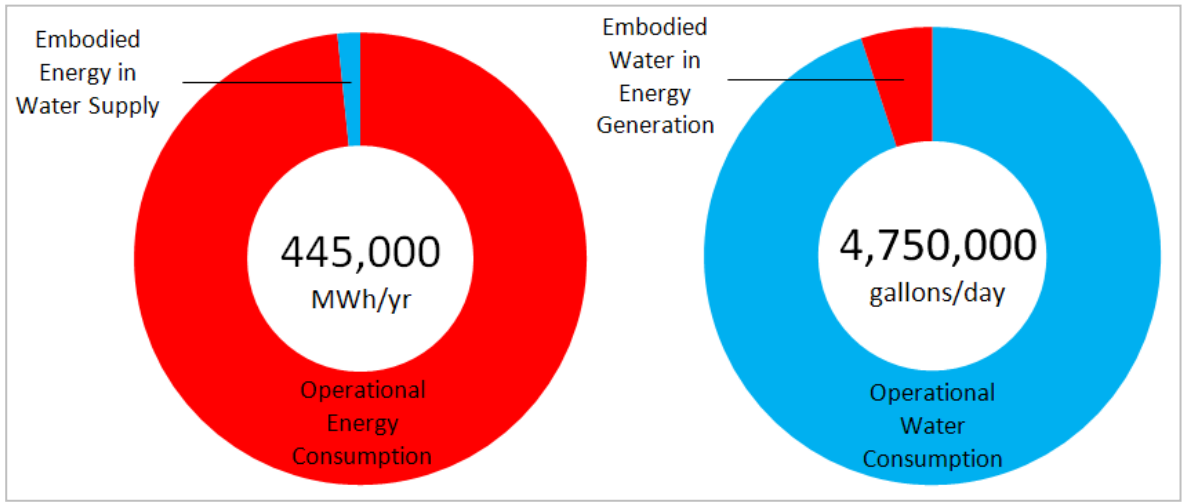




Concord Naval Weapon Station

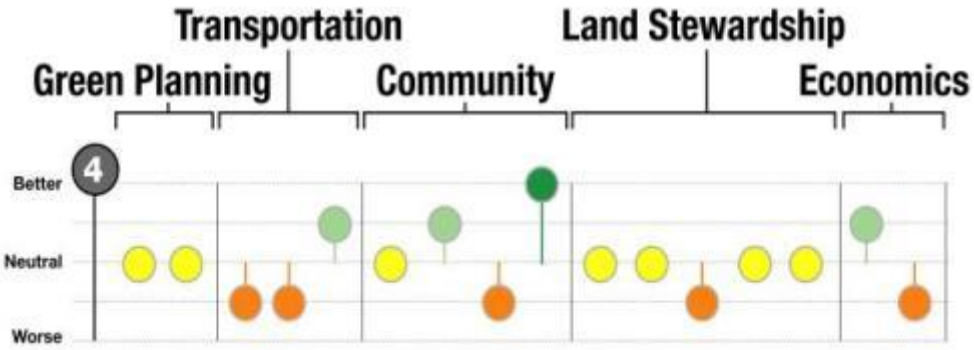






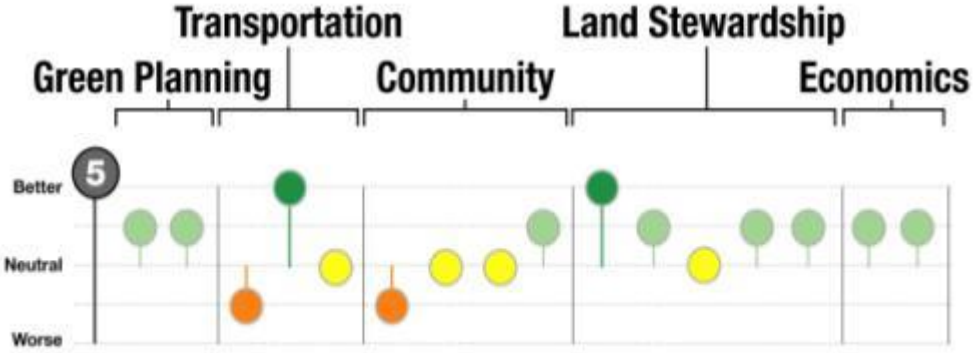
4 "Concord Parks"

- Population: 21,964
- Housing: 8,900 units
- Jobs: 21,000
- Parks & Recreation: 630 acres
- Open Space: 2,100 acres



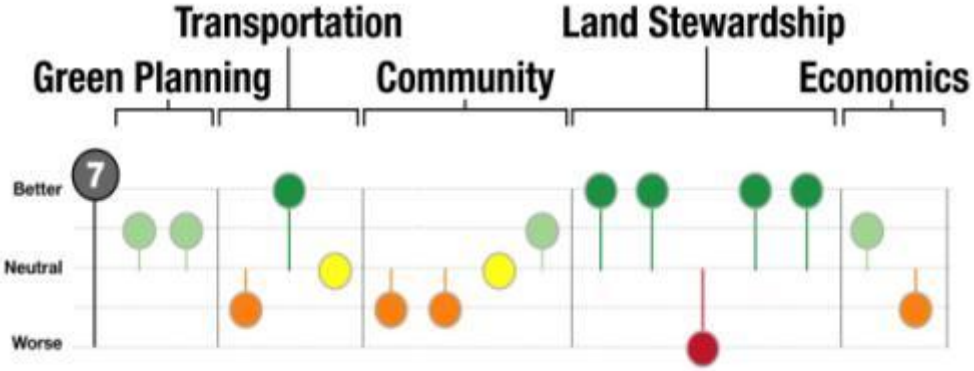
5 "Concentration + Conservation"

- Population: 22,327
- Housing: 10,000 units
- Jobs: 23,500
- Parks & Recreation: 450 acres
- Open Space: 3,000 acres



7 "Conservation First"

- Population: 14,724
- Housing: 6,250 units
- Jobs: 18,100
- Parks & Recreation: 400 acres
- Open Space: 3,500 acres

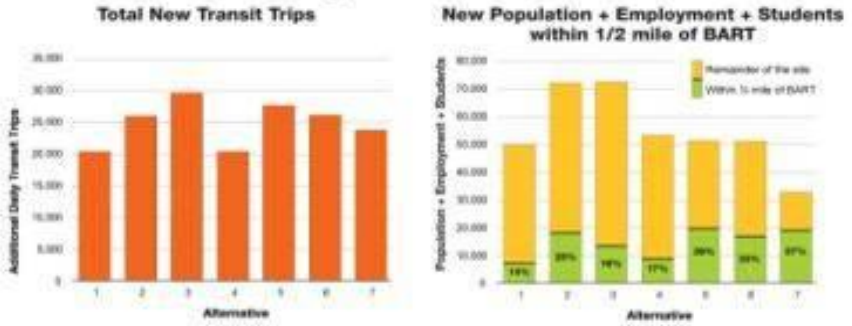


Transportation

Development patterns and transportation networks can provide opportunities to travel by walking, bicycling, and public transit.

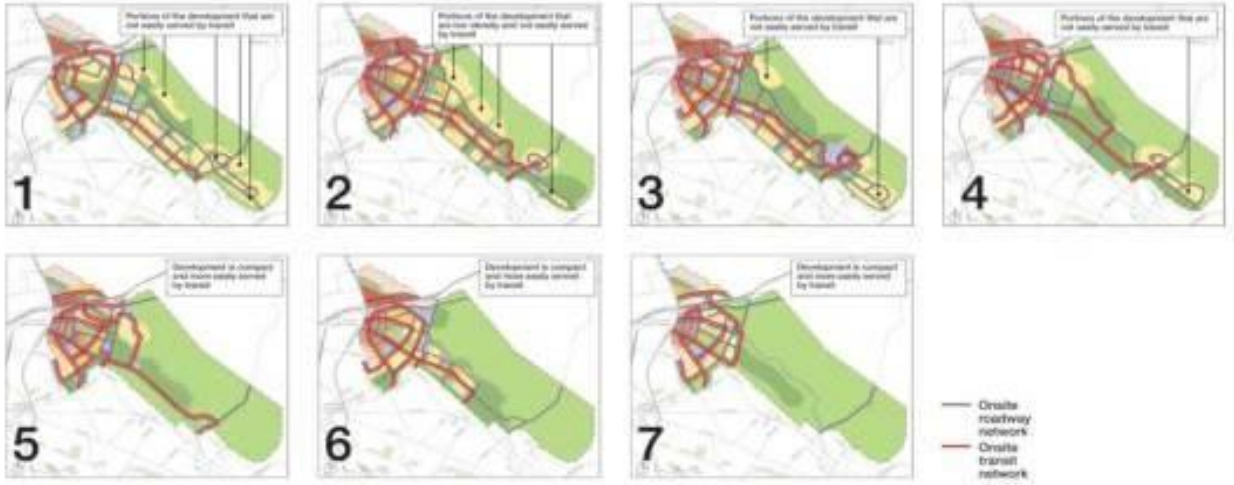
Alternatives with larger areas of low-density development are less supportive of public transit, walking, and bicycling.

Transit Ridership + Land Use Near BART

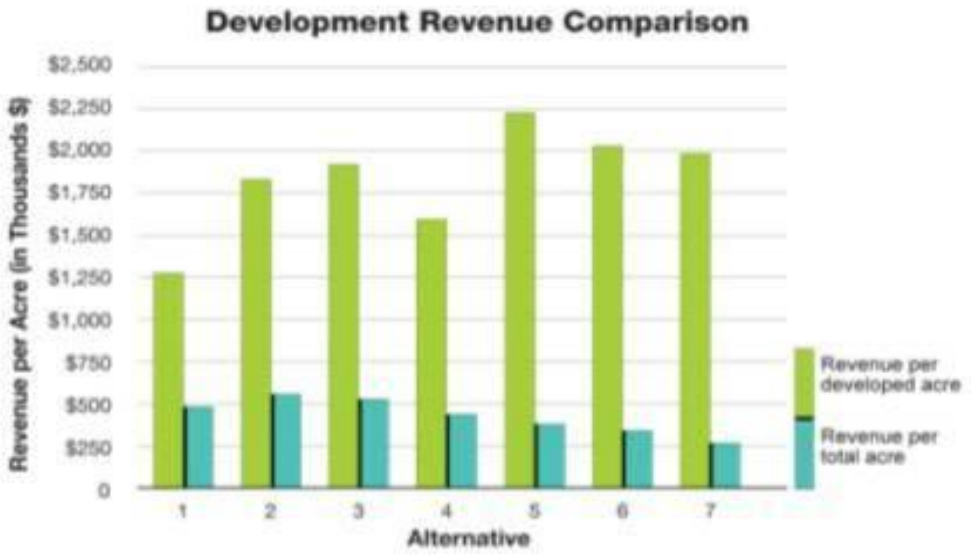


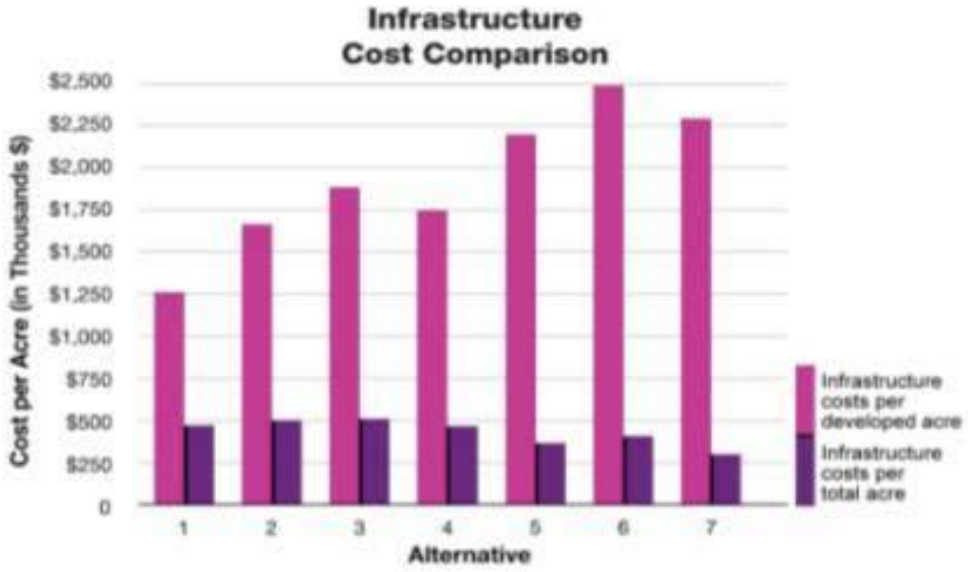
Development Pattern

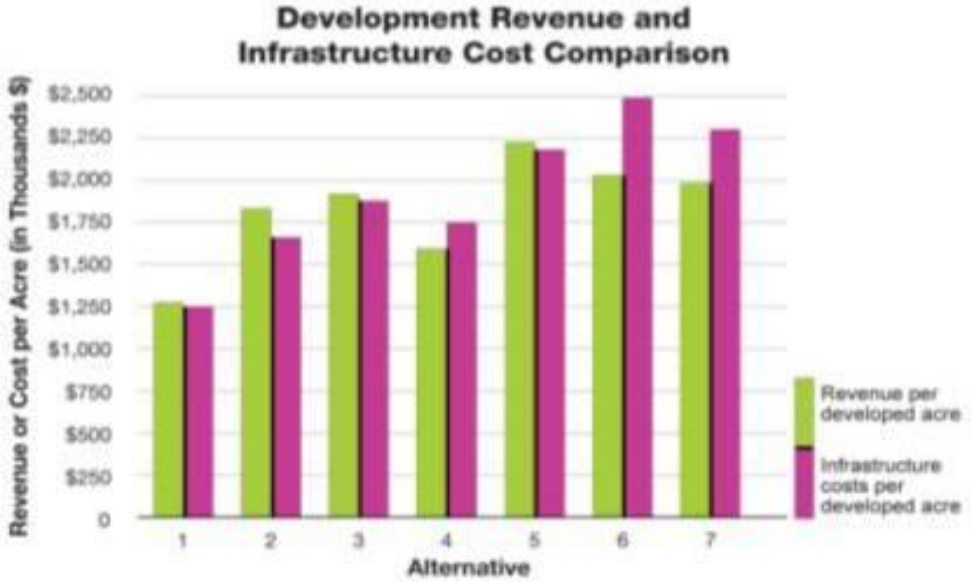
Transit Service Coverage + Low-density Areas

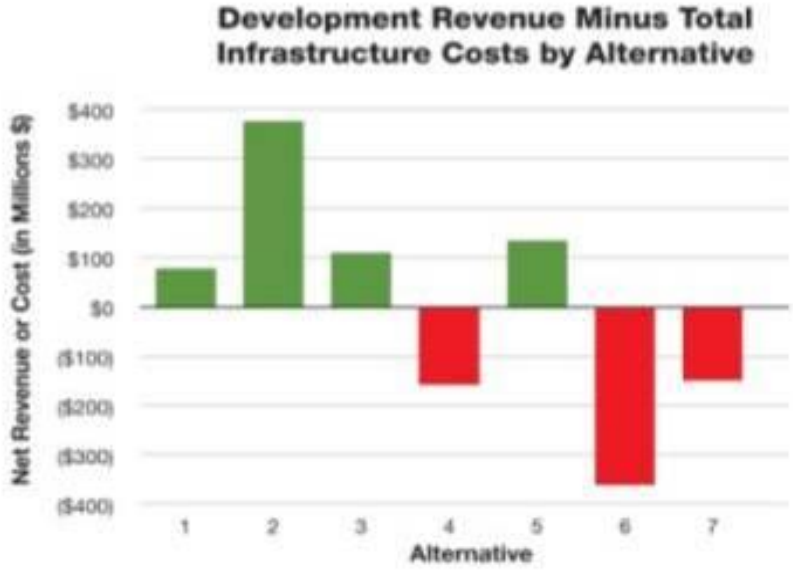


Economics


Development Revenue Comparison
Revenue per Acre (in Thousands $)
$2,500
$2,250
$2,000
$1,750
$1,500
$1,250
$1,000
$750
$500
$250
0
1
2
3
4
5
6
7
Alternative
Revenue per developed acre
Revenue per total acre

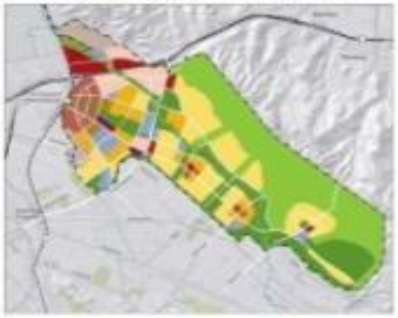

Infrastructure Cost Comparison
Cost per Acre (in Thousands $)
$2,500
$2,250
$2,000
$1,750
$1,500
$1,250
$1,000
$750
$500
$250
0
1
2
3
4
5
6
7
Alternative
Infrastructure costs per developed acre
Infrastructure costs per total acre

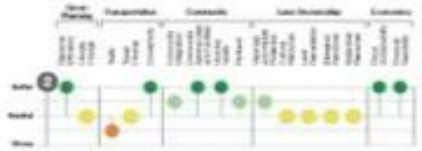

Development Revenue and Infrastructure Cost Comparison
Revenue or Cost per Acre (in Thousands $)
$2,500
$2,250
$2,000
$1,750
$1,500
$1,250
$1,000
$750
$500
$250
0
1
2
3
4
5
6
7
Alternative
Revenue per developed acre
Infrastructure costs per developed acre


Development Revenue Minus Total Infrastructure Costs by Alternative
Net Revenue or Cost (in Millions $)
$400
$300
$200
$100
$0
($100)
($200)
($300)
($400)
1
2
3
4
5
6
7
Alternative

Clustered Villages

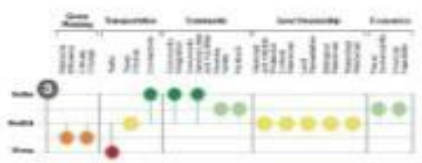
2 "Connected Villages"



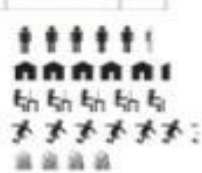


- Population: 30,573
- Housing: 13,000 units
- Jobs: 29,000
- Parks & Recreation: 500 acres
- Open Space: 2,000 acres

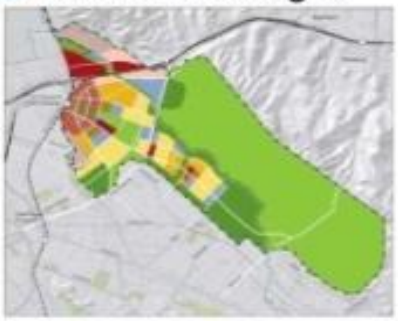
3 "Creek Park Villages"

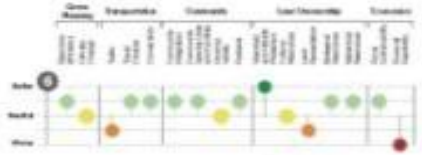


- Population: 26,950
- Housing: 11,300 units
- Jobs: 23,000
- Parks & Recreation: 630 acres
- Open Space: 2,000 acres



6 "West-side Villages"

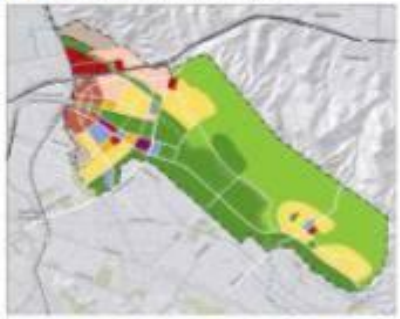


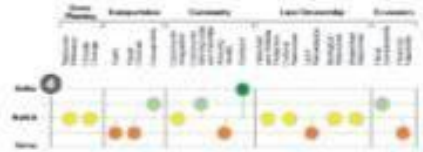


- Population: 18,100
- Housing: 8,000 units
- Jobs: 20,900
- Parks & Recreation: 500 acres
- Open Space: 3,000 acres

Concentration+Conservation

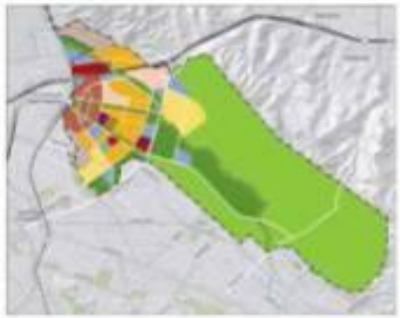
4 "Concord Parks"

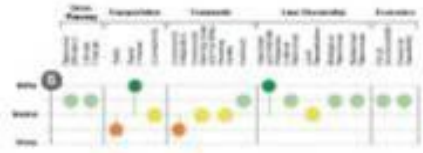




- Population: 21,964
- Housing: 8,900 units
- Jobs: 21,000
- Parks & Recreation: 630 acres
- Open Space: 2,100 acres

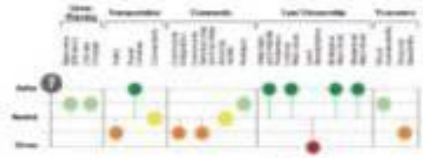
5 "Concentration + Conservation"





- Population: 22,327
- Housing: 10,000 units
- Jobs: 23,500
- Parks & Recreation: 450 acres
- Open Space: 3,000 acres

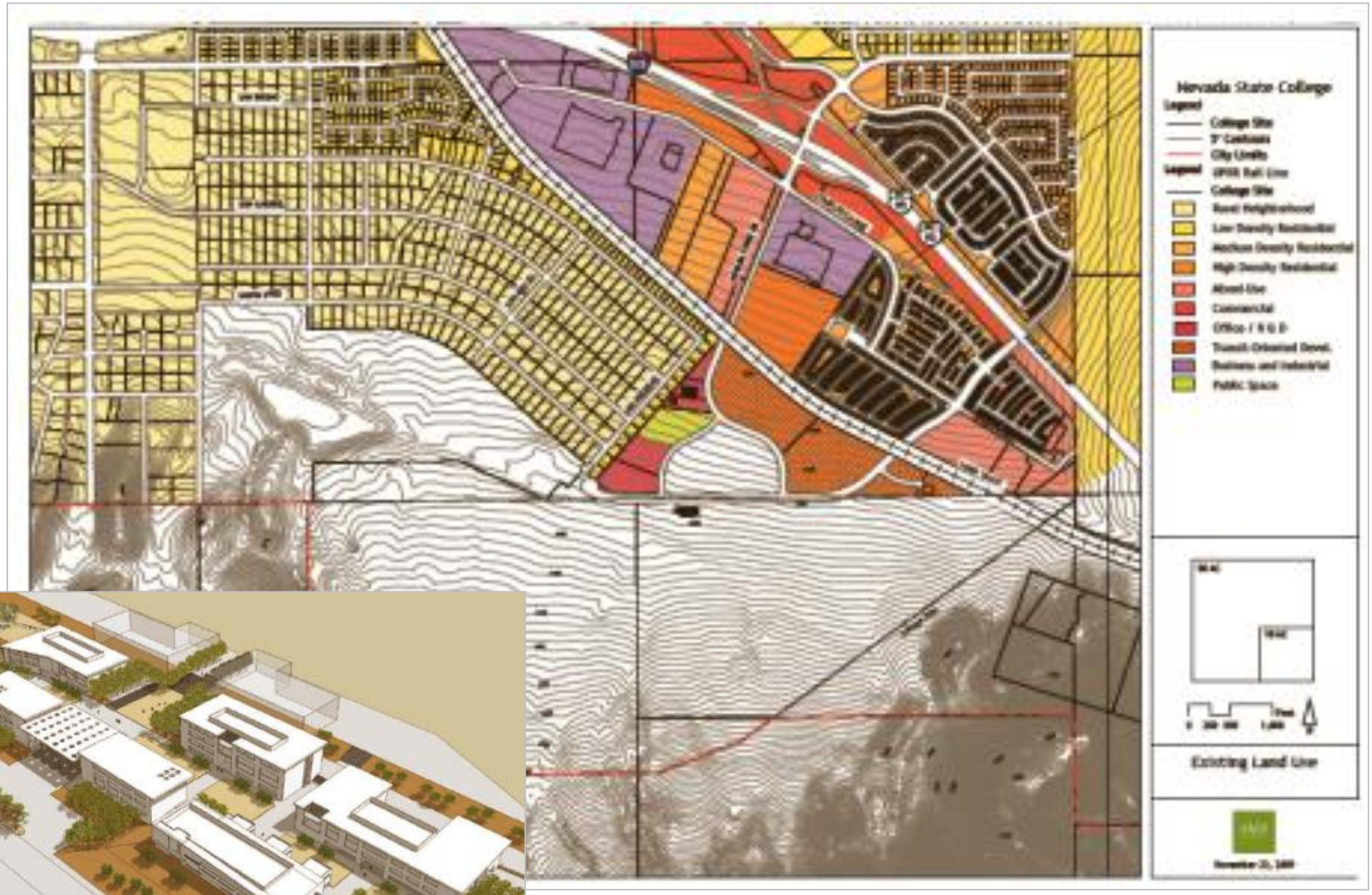
7 "Conservation First"



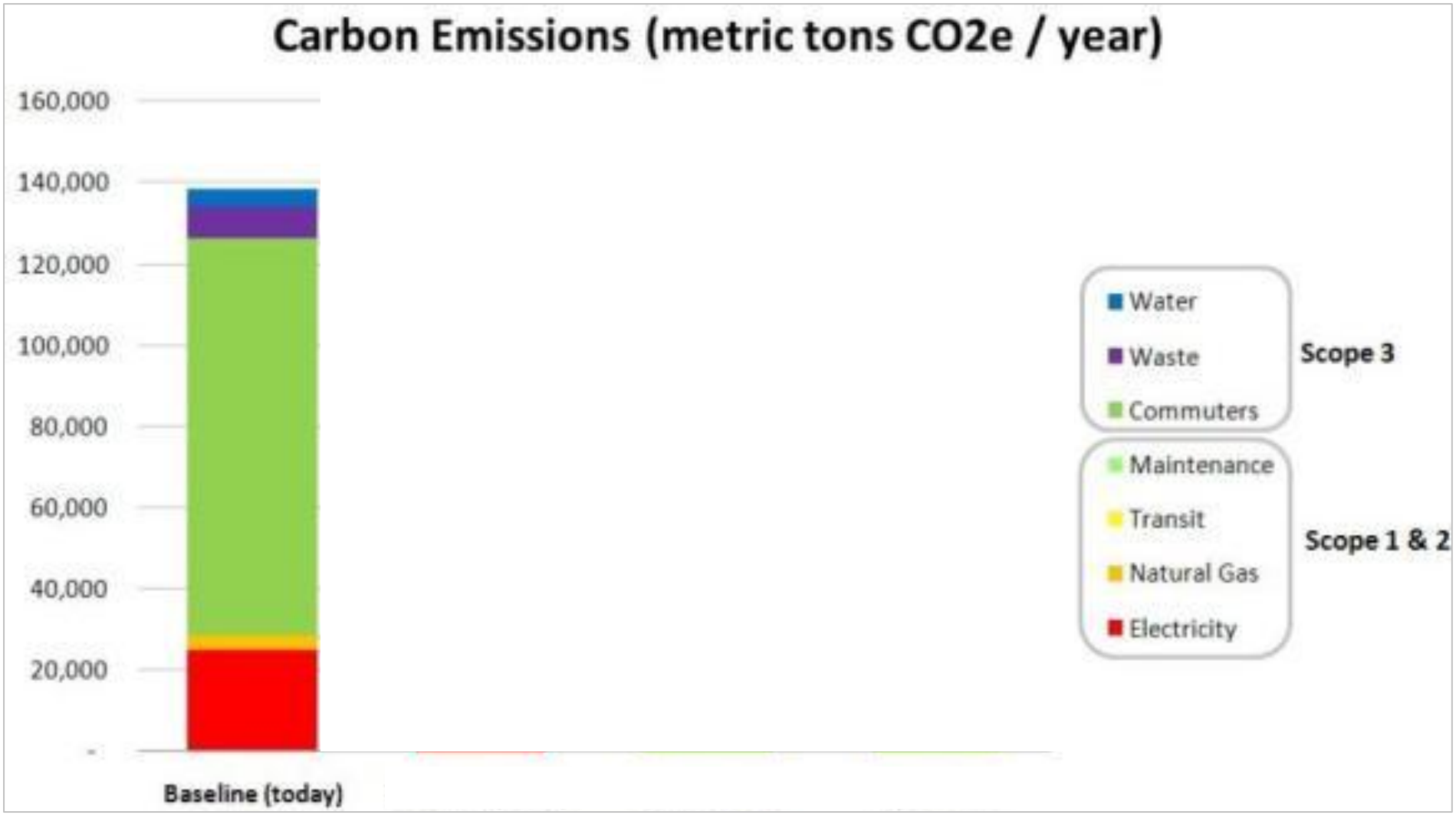
- Population: 14,724
- Housing: 6,250 units
- Jobs: 18,100
- Parks & Recreation: 400 acres
- Open Space: 3,500 acres

Community
Community Integration
Community
Community Serving Uses + Facilities
Community
Housing Variety
Community
Parkland Background Information
Community
Parkland
Community
Parkland

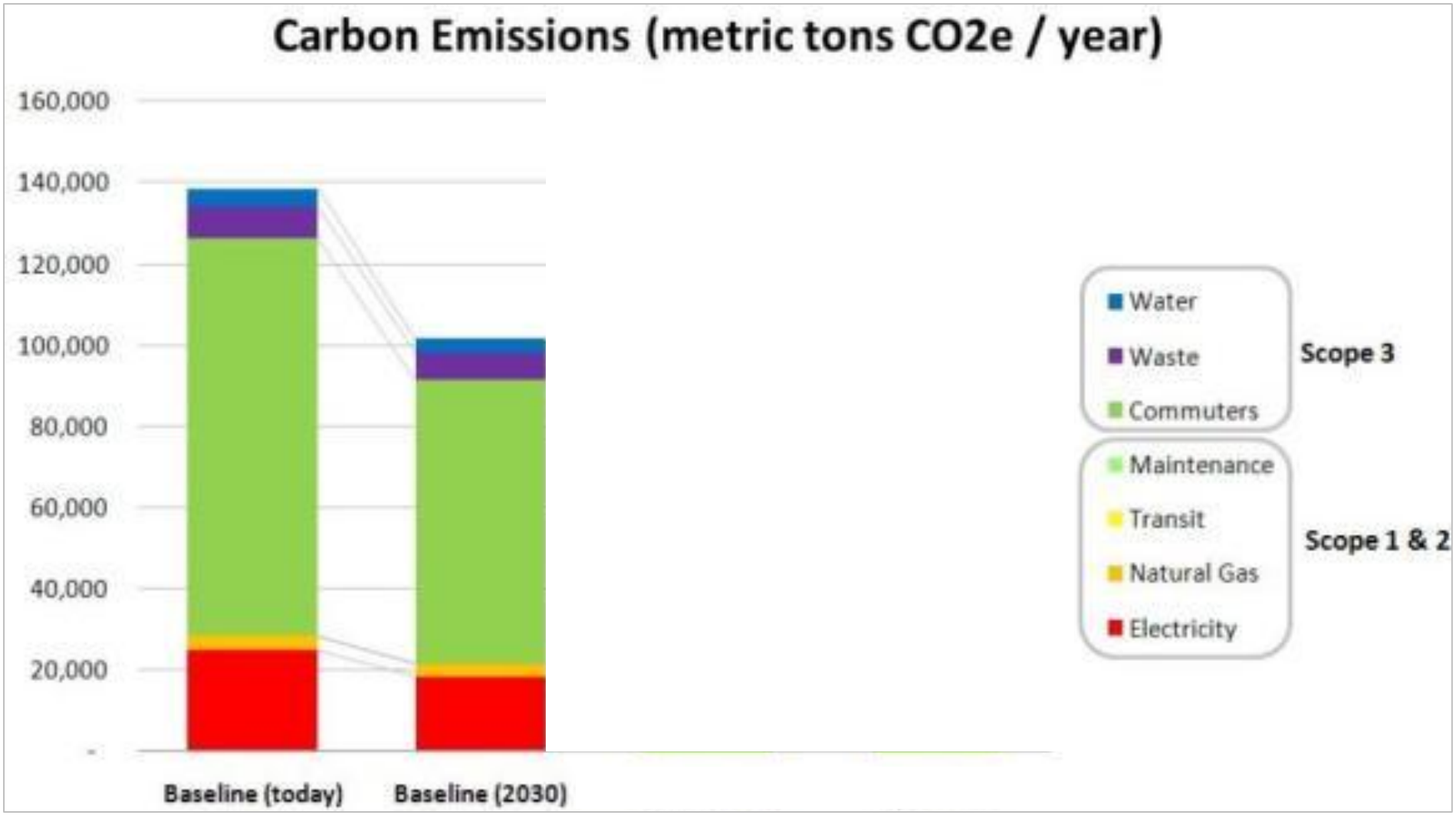
Nevada Institution



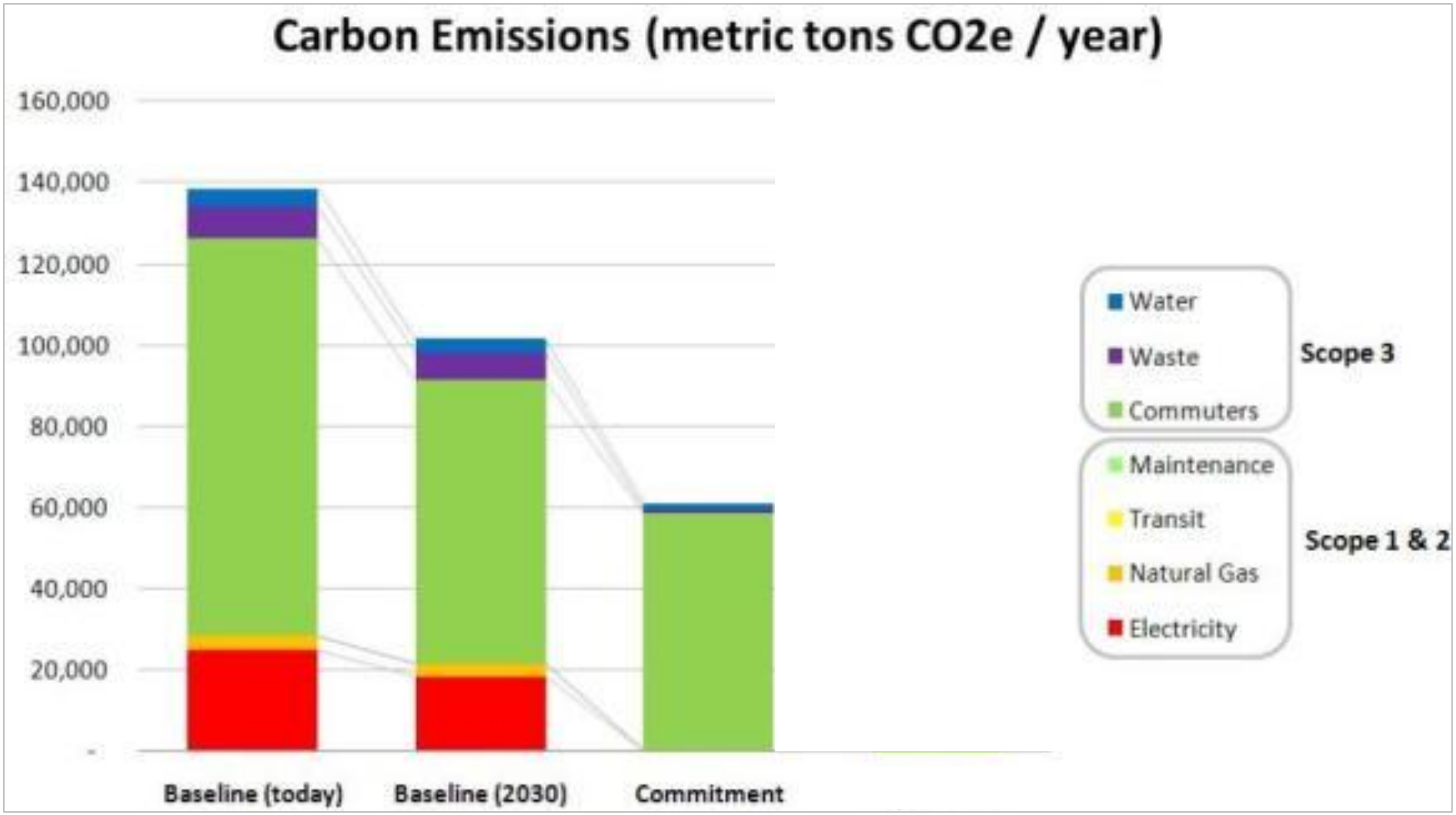
Nevada Institution



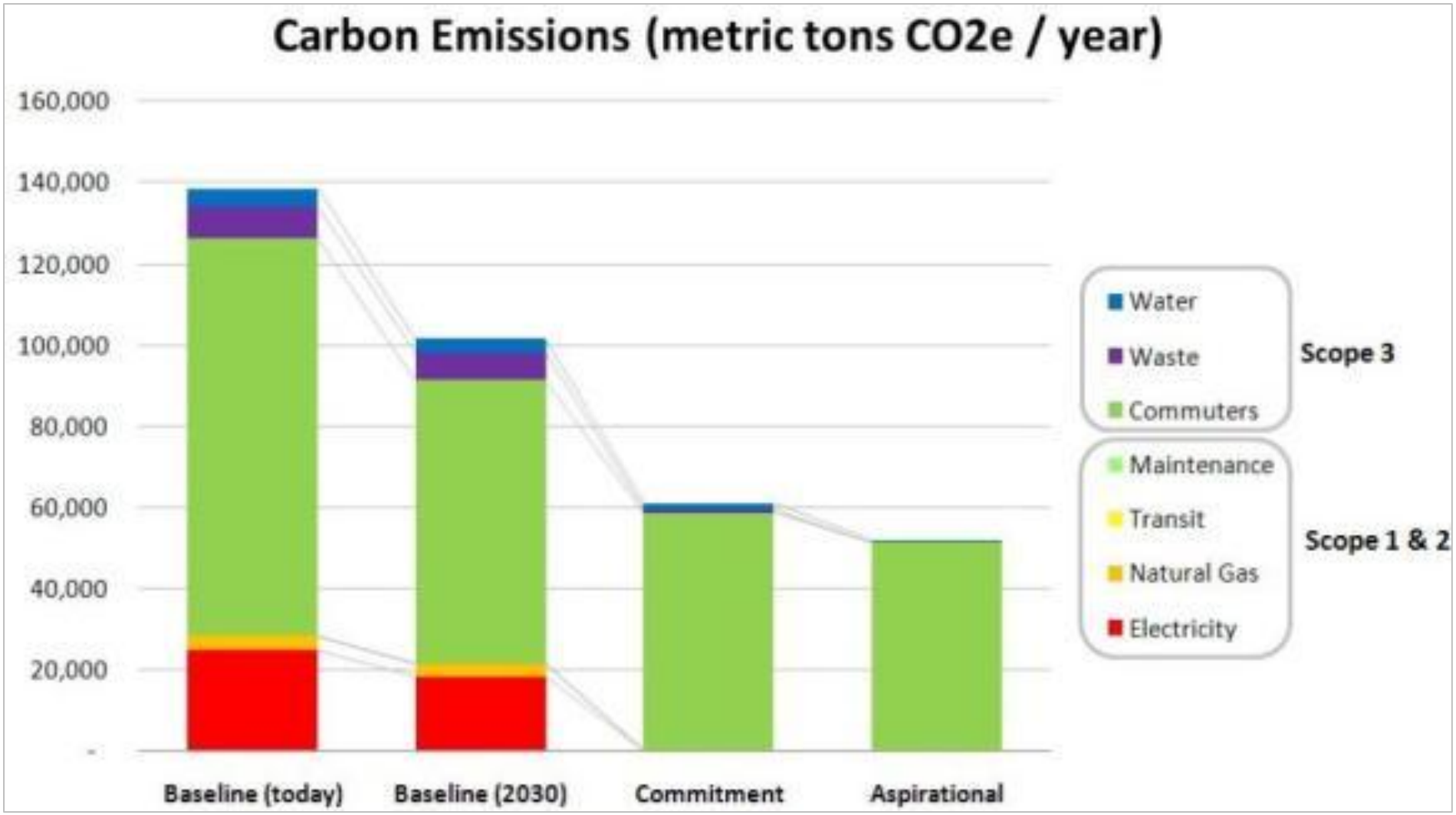
Nevada Institution



Nevada Institution



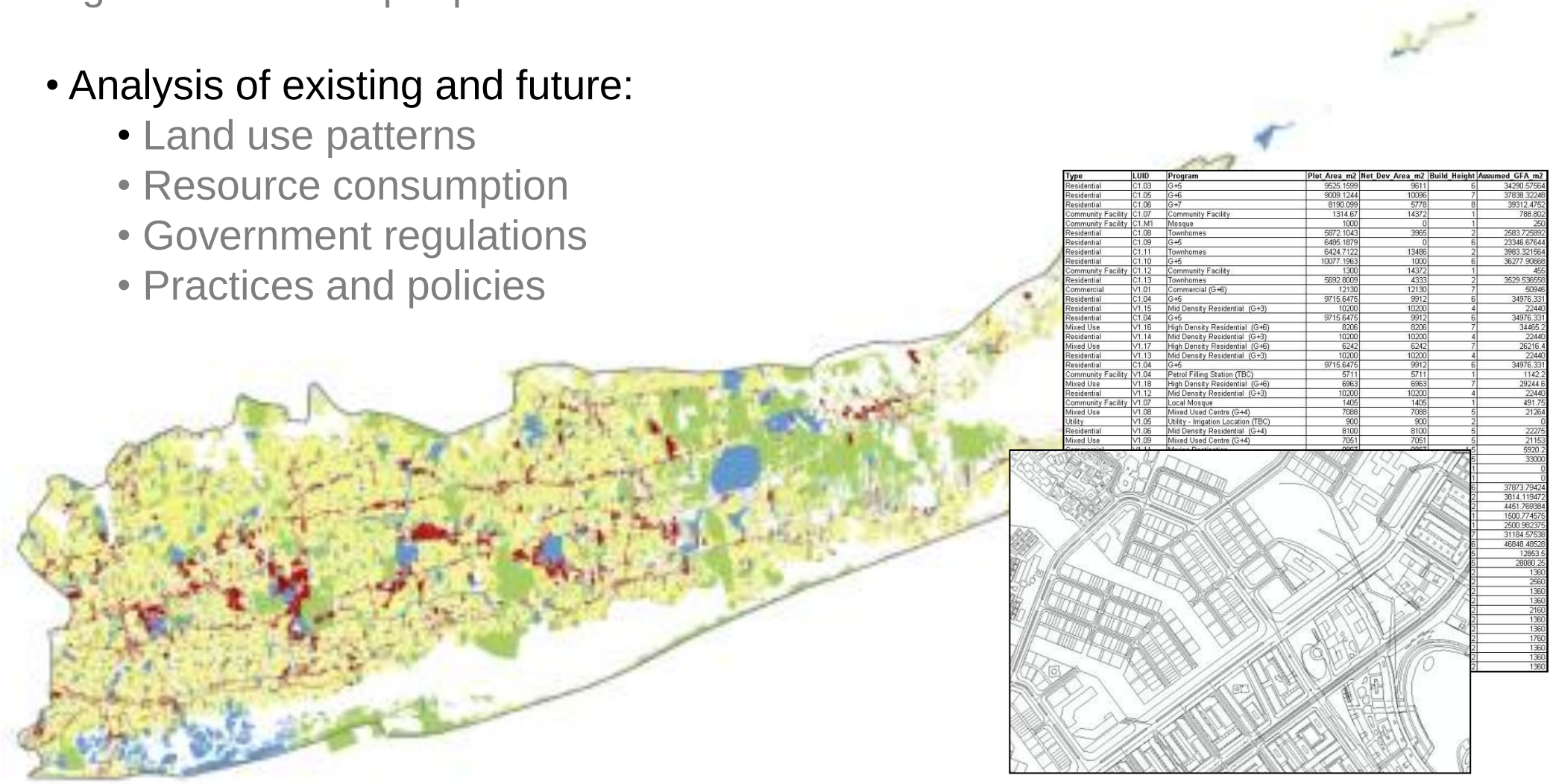
Nevada Institution



Long Island 2035 Sustainability Plan

- Evaluation of “alternative futures” for a region of 3 million people

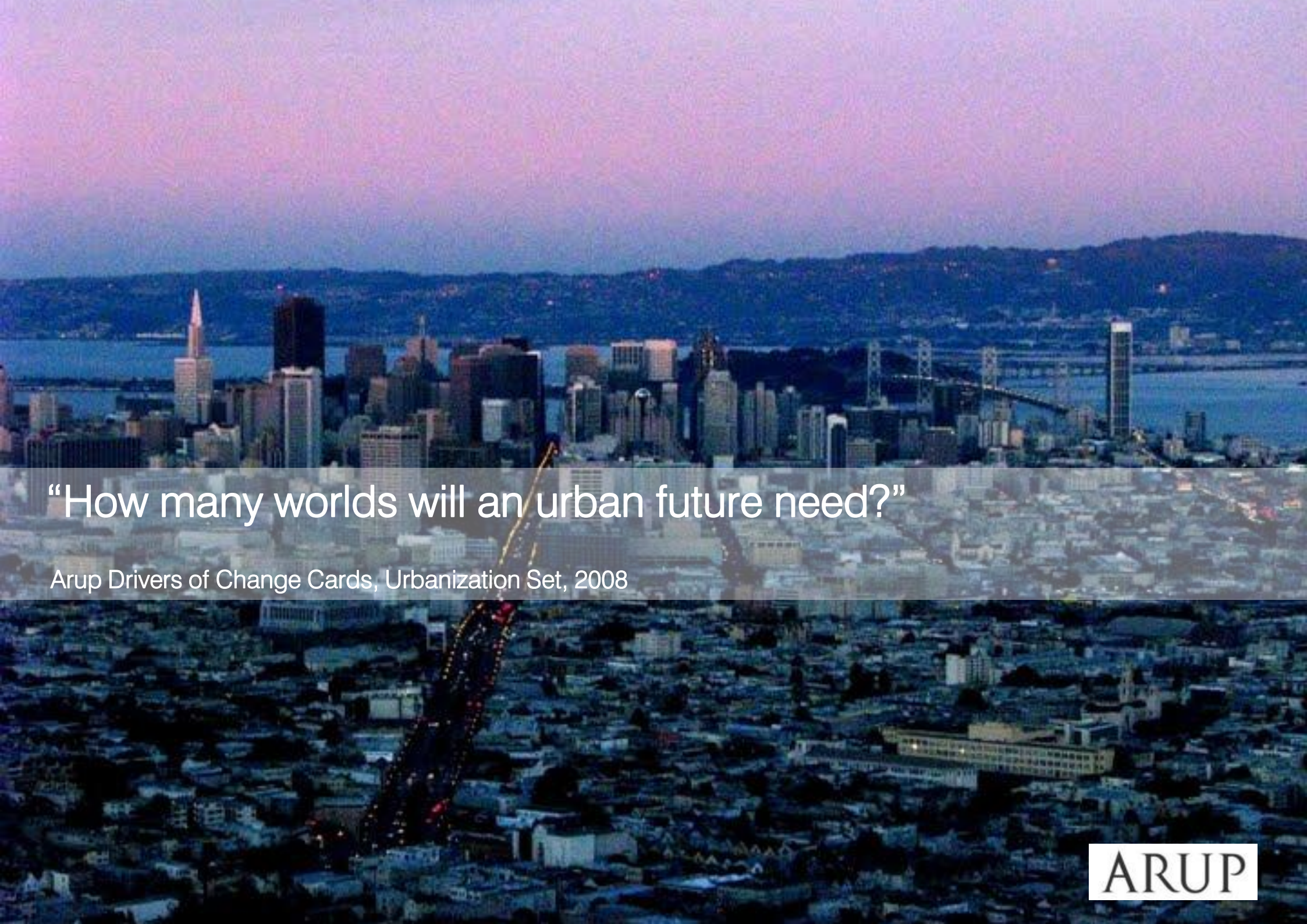
- Analysis of existing and future:
  - Land use patterns
  - Resource consumption
  - Government regulations
  - Practices and policies



Type	LUID	Program	Plot_Area_m2	Net_Dev_Area_m2	Build_Height	Assumed_GFA_m2
Residential	C1.03	G+5	9525.1599	9611	6	34290.57564
Residential	C1.05	G+6	9009.1244	10096	7	37838.32246
Residential	C1.06	G+7	8190.099	5778	8	39312.4752
Community Facility	C1.07	Community Facility	1314.67	14372	1	788.802
Community Facility	C1.M1	Mosque	1000	0	1	250
Residential	C1.08	Townhomes	5872.1043	3965	2	2583.725892
Residential	C1.09	G+5	6485.1879	0	6	23346.67644
Residential	C1.11	Townhomes	6424.7122	13486	2	3983.321564
Residential	C1.10	G+5	10077.1963	1000	6	36277.90668
Community Facility	C1.12	Community Facility	1300	14372	1	455
Residential	C1.13	Townhomes	5692.8009	4333	2	3529.536556
Commercial	V1.01	Commercial (G+6)	12130	12130	7	50946
Residential	C1.04	G+5	9715.6475	9912	6	34976.331
Residential	V1.15	Mid Density Residential (G+3)	10200	10200	4	22440
Residential	C1.04	G+5	9715.6475	9912	6	34976.331
Mixed Use	V1.16	High Density Residential (G+6)	8206	8206	7	34465.2
Residential	V1.14	Mid Density Residential (G+3)	10200	10200	4	22440
Mixed Use	V1.17	High Density Residential (G+6)	6242	6242	7	26216.4
Residential	V1.13	Mid Density Residential (G+3)	10200	10200	4	22440
Residential	C1.04	G+6	9715.6475	9912	6	34976.331
Community Facility	V1.04	Petrol Filling Station (TBC)	5711	5711	1	1142.2
Mixed Use	V1.18	High Density Residential (G+6)	6963	6963	7	29244.6
Residential	V1.12	Mid Density Residential (G+3)	10200	10200	4	22440
Community Facility	V1.07	Local Mosque	1405	1405	1	491.75
Mixed Use	V1.08	Mixed Used Centre (G+4)	7088	7088	5	21264
Utility	V1.05	Utility - Irrigation Location (TBC)	900	900	2	0
Residential	V1.06	Mid Density Residential (G+4)	8100	8100	5	22275
Mixed Use	V1.09	Mixed Used Centre (G+4)	7051	7051	5	21153
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5	5920.2
					5	33000
					1	0
					1	0
					6	37873.79424
					2	3814.119472
					2	4451.769384
					1	1500.774575
					1	2500.982375
					7	31184.57538
					8	46848.48528
					5	12853.5
					5	28080.25
					2	1360
					2	2560
					2	1360
					2	1360
					2	2160
					2	1360
					2	1360
					2	1760
					2	1360
					2	1360
					2	1360

Summary

- Quantitative and integrated approach to sustainable development and design
- Outputs for Scope 1, 2 and 3 Carbon emissions classified by WRI protocol
- Outputs for density, waste, energy, water & wastewater
- Provides output in non-technical language (marketability)


“How many worlds will an urban future need?”
Arup Drivers of Change Cards, Urbanization Set, 2008
ARUP

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