CHAPTER 3.

URBAN FABRIC: THE BUILT ENVIRONMENT

On Christmas Eve a young man with long hair and luxurious clothes inlaid with jewels kneels in prayer on a deep red stone disk laid in the floor of Saint Peter's Basilica. The Pope lifts a golden crown from the altar and places it on the man's bowed head and the throng of spectators shouts, "To Charles the August, crowned by God, great and pacific emperor, long life and victory!"

With this coronation in the year 800 the Holy Roman Empire was born, and, although the young French king did not use the title, Charlemagne is considered its first Emperor. His coronation brought some political stability to Europe and some of the first significant artistic activity in Rome since its fall. In fact, some historians, such as Kenneth Clark and Richard Krautheimer, invoking the Latin name for Charles, Carolus, have termed the period that follows the "Carolingian Renaissance."

If you left St. Peter's Basilica after the coronation, say to walk to your home on the Esquiline, you would have seen a city surprisingly similar to that of the height of the empire. Of course, the city had been devastated by numerous invasions which had stripped buildings of their valuable artworks and often left them roofless, open to the elements. Nevertheless, the basic building shapes were recognizable. Leaving St. Peter's in the direction of the Colosseum you would pass the Circus Flaminius, the Pantheon, the Theatre of Pompey and then the Baths of Agrippa. Traversing the Roman Forum through the Arch of Septimius Severus, the Forum of Trajan with its sculpted column would be visible on your right. You might detour through the Suburra neighborhood, still a working class quarter as it had been at the time of Augustus, and visit the still visible ruins of the Baths of Trajan. If you needed to shop, Trajan's markets were still active as they had been in 110 AD when they opened as the world's first planned shopping center.

Indeed, an anonymous traveller gave an account of that very route in about 800 AD. The manuscript has come down to us under the name Einsiedeln Itinerary, after the Swiss monastery where it is preserved. This is one of the first of a long tradition of such itineraries, often laid out as lists of "must sees" for the

religious pilgrim seeking penitence or later for the bourgeois traveller on his or her grand tour[1]. These itineraries all describe a city whose fabric has, for the most part, been "woven," but which has fraying edges, worn spots, and a few gaping holes.

The fortified monastery of Santi Quattro Coronati, amidst the gardens of the disabitato

Good fences and the limits of growth

In *Building Thinking Dwelling*, Heideggar notes that limits are not where something ends but where something begins; "A boundary is not that at which something stops, but, as the Greeks recognized, the boundary is that from which something begins its presencing."[2]

Rome's origins are intricately tied up in this recognition of limits, ever since the legendary furrow plowed by Romulus

(over which his brother Remus impertinently leaped, evoking the wrath that would end in his murder). A Roman city anywhere in the world grew through a combination of ordering lines (the *decumanus* and *cardus* and their parallel streets) and limits. The *Pomerium* was the administrative limit (marked simply with inscribed tablets, some of which can still be seen on city streets) beyond which the city ceased to exist. Joseph Rykwert writes of Roma Quadrata, that until the end of the Republic the city would have been *quadrata* (or square) in two ways: its urban territory was divided into four districts, and its central — in constitutional, not geometric terms — areas of assembly were certainly consecrated and perhaps even geometrically regular."[3]

The notion that a boundary should carry such weight, both symbolically and functionally, is alien to us today. Sure we might take off a hat on entering a church or put on a *kippah* when entering a temple, but I tend to think of my rights as inalienable, staying with me regardless of where I go. And yet for Romans such place-based restrictions were common. A soldier ceased to be a soldier (and like everyone, had to lay down arms) upon entering the *pomerium*. Magistrates could not decree a death sentence there. A body could not be buried there.

In a similar way, time-based limits have often acted to limit absolute power, whether they be term limits, land leases, job contracts or religiously dictated periods of forgiveness. One such example in Rome is the Jubilee Year, based on the Hebrew tradition of forgiving debts every "seven times seven" years, incorporated into Christian tradition first with a fifty years repetition later shortened to twenty-five[4]. The Jubilee, like the Olympics, provides a firm temporal target which spurs productivity and innovative energy.

City Constructs or Urban Weave

Human creativity works best when pushing against physical constraints and temporal deadlines, and the built environment of Rome, what architects call "urban fabric," has emerged over the centuries within a rich and problematic set of limits indeed. In Italian "Urban Fabric" is also often translated literally as *tessuto* (or textile) to indicate a continuous weave of material that comprise a city.

The Italian noun *fabbrica* has several meanings, none of which refer precisely to textiles or cloth. When we speak of urban fabric it is not the soft malleable kind, nor is it easily portable like something you might throw in a beach bag. The verb fabricate may mean "to falsify" or "to concoct a story" but its roots lie in the manufacture of something very real and physical[5].

Fabric is what is fabricated, the result of human enterprise. Cities don't "grow" or "evolve" of their own accord, but rather are always the result of a process of fabrication, a term which does not necessarily comprise planning. And Rome, after more than 1,000 years of fabrication, has left us a big pile of physical things. If these ruined palaces, temples, basilicas and porticos were imposing, they were not indestructible.

The physical plant, and the maintenance and construction crew, of the building where Charlemagne was crowned would, in its 16th century Renaissance incarnation, all become known as the *Fabbrica di San Pietro*, a title which brings to mind smokestacks and assembly lines more than altars and cupolas.

Rossi, in his introduction to *The Architecture of the City*, speaks of "la fabbrica della città" using a word for "building" in the old Latin and Renaissance sense of man's construction as it evolves

over time[6]. For Rossi the it is essentially a collective artifact." As a young architect, reading Rossi's Architecture of the City was like exploring a Rome of the mind[7].

If we are serious about tackling climate change on an urbanizing planet we need to rethink the role of urban fabric. Instead of thinking of cities as physical artifacts– and buildings as fixed objects– we are starting to think of them as bundles of services, malleable and flexible. The buildings may be very solid themselves but the activities that take place within change with our needs, desires and technological capacity. The functions inside the Pantheon change, but its physical form persists. The fabric of our cities provides the "hardware" for what Alex Steffen, founder of Worldchanging, calls "augmented urbanism," the enrichment of our cities through shared systems, software, and additional layers of meaning.

One way of mapping this urbanism, represented by modeling and street-view, emphasizes the three dimensional constructed reality, the buildings and other walls that rise up from the land and guide our movement and frame our visual field, opening vistas and blocking other realms from view. But another, the plan view, emphasizes the city as a Roman grid or medieval web. In less urban settings, such as North American metropolis, we tend to map routes to follow and think of ourselves and our buildings as objects moving "on roads," while in older city centers, designed more for people than for vehicles, we speak of being "in roads." In America we live *on* Main Street while in England we live *in* Market Street.

Today we are used to switching back and forth between drone's eye satellite imagery and cars' eye street view, but any historic map of central Rome speaks of the combined nature of the city as fixed structure and woven fabric.

Density

In 1800 only 2.5 percent of the world's population lived in cities; the rest were in villages or rural areas. This rose to 13 percent at the start of the last century and has continued to rise ever since. We have now passed the 50 percent urban mark with predictions that by 2050 60 percent of the world's population will live in urban areas. Yet when we look closely at this urbanization, rather than being from country to city what we find is often migration from compact pedestrian-friendly mixed-use villages to the margins of sprawling metropolises. This leads us to question what we really mean by "cities," is it a question of overall population or a question of density?

In the last 50 years, as urbanized land has more than doubled, the average density of urban areas has dropped by 50 percent. Research by Peter Newman and Kenworthy shows that this low density development, which has occurred especially in US cities, is proportional to energy use; the lower the density, the higher the fuel consumption.

The critique of low-density sprawl is familiar to anyone who has read the works of Paolo Soleri, the Italian architect who left his home in Piedmont in the 1940s to work in the American Southwest and spent most of his life designing and promoting his version of compact urbanism. According to Soleri, "they literally transform the earth, turn farms into parking lots and waste enormous amounts of time and energy transporting people, goods and services over their expanses. My solution is urban implosion rather than explosion."[8]

Another Italian-born architect, Richard Rogers, has also dedicated much of his career to advocacy of compact cites. "a dense and socially diverse city where economic and social activities

overlap and where communities are focused around neighborhoods." Compare the sprawl cities described by Soleri with the compact ones described by Rogers; apart from the efficiencies of the latter made possible by proximity, there are social and economic costs of sprawl. As long as the qualities of mixed-use and overlap are met, compact urbanism may refer to webs of semi-autonomous settlements with farmland between (the rural Italian model) or to a cluster of neighborhoods (the Roman model).

In Rome, density seems a given but it has radically decreased in recent decades as residents have fled the historic center. According to Stefano Boeri, one in seven homes in central Rome are uninhabited, left empty as investments. Meanwhile, rents have increased 91 percent in recent decades. The historic center of Rome was home to 370,000 people in 1951; this is now down to 100,000. Like Venice, the central district has been hollowed out and left to temporary residents or tourists, while the outlying districts, lacking in history and the complications that come with it, is booming out of control.

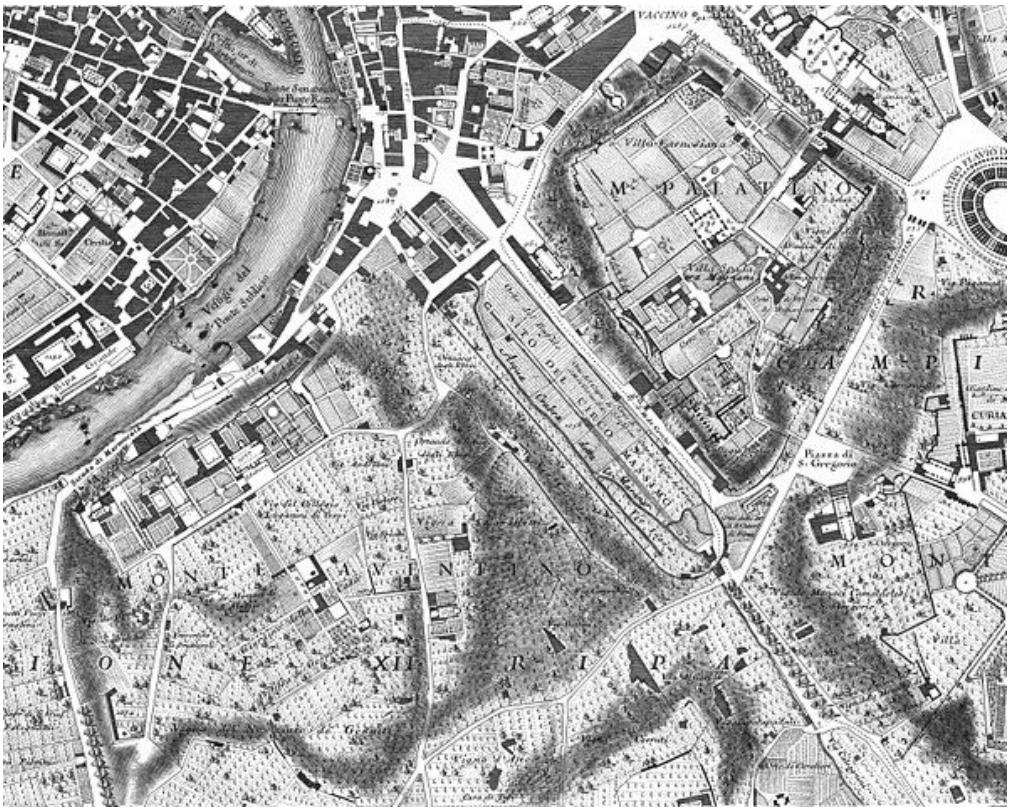
Mapping Eternity

No city has been mapped so obsessively and extensively as Rome, and no one knows Rome's maps as well as Allan Ceen. A cartographer, architect and life-long Romanophile, Allan has been collecting (and continues to collect and produce) maps and other prints which he safeguards and exhibits in the great room of Studium Urbis, not far from Piazza Farnese. Countless students of architecture and urban studies have had the privilege of hearing Allan expound on the evolution of graphic representation of the city from its origins to the digital present.

Any discussion of the mapping of Rome's urban fabric must begin with the Marble Plan. Etched (or rather gouged, given

the huge scale and clunky medium) in the Severan period of the Roman Empire, this plan represents the entire inhabited area of Rome at a scale of 1:248. It was affixed to the wall of the Forum of Peace (the pock marks left upon its later removal are still perceptible to the left of the church of San Cosma e Damiano) visible to passersby. Documented are the public and private buildings, monuments and shops, but also the open spaces in between. Some clues suggest that the marble plan documents not just a single point in time but multiple moments, the coexistence of monuments destroyed (by fire) with contemporary structures from the Severan period. Was this due to the lag in the production of the map and difficulty in editing information carved in stone, or was there an intentionality behind representing the persistence of built form?

Maps of Rome from the fall of Rome to the dawn of the Renaissance favor the episodic and narrative over the logical or realistic. In addition to itineraries such as the Einsiedeln, there are stylized depictions of key monuments but without any buildings or public spaces in between. It is not until Leonardo Buffalini in 1551 that we will again see the city in plan view. Two centuries later GiovanBattista Nolli will make the definitive map of Rome, one that will set standards of map making for centuries. Nolli's 1748 plan systematically describes the city fabric in black and white, distinguishing the built city (black) from the spaces in between (white). Nolli makes the simple decision to represent publicly accessible spaces, whether city streets or courtyards or churches, differently from inaccessible volumes (whether structural walls and columns or entire private homes).



Detail of the 1748 Nolli plan

Palimpsest

Rome's historic center still today has the qualities that Nolli mapped in 1748, with the persistent palimpsests of now defunct ancient structures, such as the Stadium of Domitian, the Odeum or Pompey's Theatre. These traces are easily discernible in aerial photography, like the silhouettes of buried structures visible in photographs of desert landscapes. But rather than being buried by nature, they have been engulfed by the city, constructed over centuries but always on the same basic foundation lines. Aaron Betsky, in his article Uneternal City[9], goes so far as to say that "Rome can no longer be planned anymore than any other aspect of global sprawl can be. It can only be tracked and traced, with local interventions being about all that is possible." The many maps of Rome, he says, "represent a kind of mythic palimpsest, a place that might already be there, we have just not seen it,

a Rome of our imagination that is as ephemeral as the view through the rearview mirror."

As Richard Sennett notes in "The Open City," an environment rigid in form, static in function is doomed to fail. Mankind is permanently threatened by two disasters: order and disorder and cities need a solution to both, an ordering plan and an insurgency against excessive order.

Cities provide for this kind of complexity naturally, through radical adjacencies and proximity. Now what Soleri called the "urban effect" can be fabricated digitally, counterfeited in a place where no city exists. Thus technology does not always have an urbanizing effect; in fact often it isolates in the name of connecting. Even in cities we have become a culture of individuals plugged into devices, tuned into a distant network but ignoring the reality around us. Like the tourist with her face in the guidebook oblivious to the work of art in front of her, we experience reality through a screen. We neglect to "live in the present," one of Douglas Rushkoff's commands for the digital age. Technology, or more precisely Web 2.0 part and parcel with various platforms of social networking, now allows us to carry out much of what previously required proximity: socializing, information-gathering, debate, commerce, entertainment, recreation.

Twelve centuries after Charlemagne, you can still duck into a little church built in his reign: Santa Prassede on the Esquiline Hill. A few blocks from Termini Station in a neighborhood now a melting pot of Asians, Africans and other recent immigrants, you are transmitted back into the 9th century. In the dimly lit basilica you gaze up at the apse mosaics glittering with gold and other rich colors. There, alongside St. Peter, Paul, and the patron saint of this church, Prassede, you will see Pasquale I, the Pope who commissioned this building so many centuries ago,

carrying the model of his church. The city that Charlemagne arrived at in ‘800 was already ancient, but it was at the same time brand new. Pop a euro in the box to turn on the lights in the chapel the Pope built for his mother, Saint Teodora, and, if you want to learn more, the airwaves passing through the ancient walls carry more information to your smartphone than contained in all the libraries of the 9th century world.

The torn *tessuto* of Rome invites continued fabrication, but most of the opportunities today demand not starting from scratch but fixing and fitting, not planning but mapping, not remaking the physical but rethinking the flows of data and energy that pass unstoppable through the walls of our cities.

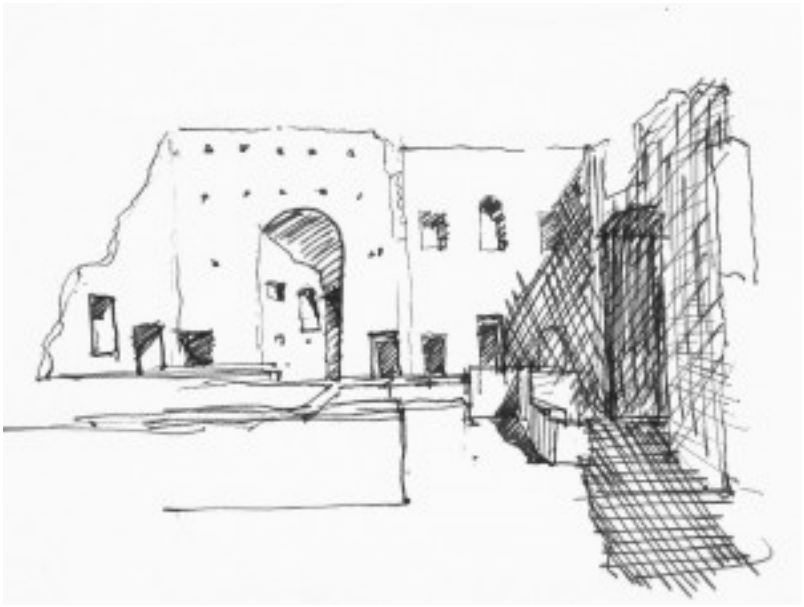
Via Giulia and San Giovanni dei Fiorentini

Notes

1. Other important such documents include the *Mirabilia*, originally composed by Benedetto Canonico, cantor of the basilica of S. Pietro, between 1140 and 1143.
2. Martin Heideggar, *Building, Dwelling, Thinking* (New York: Harper Colophon Books, 1971)
3. Joseph Rykwert, The Idea of a Town: The Anthropology of Urban Form in Rome, Italy and the Ancient World (London: Faber and Faber, 2011), 62.
4. Occasionally, as Francis did for 2016, a Pope will declare a special Jubilee in between the planned ones.
5. In Italian the word "fabbrica" most commonly refers to factory (a word whose ostensible translation as "fattoria" causes no small confusion, as this actually means "farm").
6. Aldo Rossi, *Architecture of the City*. Cambridge, MA: MIT Press, 1982. 18
7. I had the privilege to meet and talk with Rossi at a Harvard GSD event in around 1990. Our conversation is a bit of a haze—clouded by many glasses of red wine and my own nervousness at speaking (in Italian, no less) with the most influential architect of that generation. We spoke of Rome and of the permanence of buildings and I thanked him for helping me to understand the richness of history, separating buildings from their functional roles to see them as part of cycles of change.
8. Paolo Soleri, interview in "The Evolution of the City" in *The Urban Ideal*, (Albany, CA: Berkeley Hill Books, 2004)
9. Betsky, Aaron, ed. *Uneternal City: Urbanism Beyond Rome*. Catalogue of exhibit of 2008 Biennale di Architettura.

CHAPTER 4.

ENERGY: THE POWER OF ROME



The sun in Rome in the Summer is an intense, direct, persistent and memorable source of light and heat. It is Mediterranean, almost African. Buildings become defined with sharp lines and deep shadows. The hot sun lends added significance to pine trees and colonnades and brings huge respect for catacombs, crypto-porticos, stone churches and any structure built into the earth, the contrasting coolness of which becomes an asset. As you pass from the glaring midday sun of the Piazza della Rotonda to stand, dwarfed, amidst the massive granite monoliths which

support the roof of the Pantheon, the temperature drops dramatically, the tile roof filters out the rays, and the 20-foot thick concrete walls and well-preserved ancient marble floor absorb the heat from your body. Enter the building now through the bronze doors and your eye returns to the sunlight entering through a precise circular "oculus" at the top of the perfectly hemispherical concrete dome. The contrast between the hot and chaotic city and the cool geometric interior surprises you as it has visitors for over 2,000 years. Whereas out in the piazza the sunlight encompassed you, now it is precisely focused in a spotlight on the floor, a circle of light which moves slowly but perceptibly from hour to hour and season to season. Return later in the day and it will slide across the trapezoidal coffer pattern of the dome until sunset, when it flickers and is gone.

Rome's ancient buildings embody an awareness of the sun's apparent movement across the skies. The sunlight penetrating the oculus of the Pantheon marks the passage of hours and seasons, passing from the upper hemisphere through the semicircular arch above the portal to descend again into the lower hemisphere at precisely midday on the spring equinox. On this date at the end of the winter season, the sun penetrates the grille above the door and begins to illuminate the floor of the portico from the inside. A month later, on April 21st (Rome's traditional founding day) the full disk illuminates the floor outside the door. The ancient Roman historian Cassius Dio tells us that the Pantheon was dedicated to all the gods "because of its vaulted roof, it actually resembles the heavens." (53.27.2).

A few hundred yards away, the point of the 60 foot tall obelisk called the *orologeum* (from the Latin word for hour) casts its shadow in a precise rhythm on the modern pavement outside Italy's Houses of Parliament. I recently climbed with a small

group of travelers down to see the one small section visible of the original surface onto which it projected its shadow. The white stone contains mathematical markings in Greek and symbols of the signs of the zodiac, a veritable solar calendar.

Rome's urban layout, its building designs and their details, can teach us and inspire us as we again begin to recognize the importance of adapting our built environment to climate (after several decades of eluding ourselves that our technology made such adaptation unnecessary). Another example: the great cloth canopy topping the Colosseum, called "velarium" after the *vela* or sails on which the technology was based, provided comfort for its occupants in the summer months. According to Seutonius, the emperor Caligula saw in the hot summer sun an opportunity to inflict pain and "would sometimes draw back the awnings when the sun was hottest and give orders that no one be allowed to leave," a captivating illustration of the power of the sun, and the cruelty of this emperor.

These same buildings were supposed to inspire us because they embody meaning and cultural knowledge. We are beginning to see that they can inspire us for another reason: their common sense approaches to climate. From the radiant-heating ducts below Ostia Antica to the cutting-edge photovoltaic installations on the rooftops of central Rome, most of the energy a thriving modern city needs is already there for the taking.

Firmitas and Thermal Delight

Reyner Banham was one of the first authors to focus on this other, less photogenic aspect of building in his 1969 book, *The Architecture of the Well-tempered Environment*, which provides an encyclopedic introduction to the topic of thermal systems. The following year Lisa Hershong's *Thermal Delights in Archi-*

tecture addressed the more sensual aspects of the same. But two millennia earlier the architect Vitruvius was already preaching the importance of thermal performance in design choices. "The method of building which is suited to Egypt would be very improper in Spain, and that in use in Pontus would be absurd at Rome: so in other parts of the world a style suitable to one climate, would be very unsuitable to another: for one part of the world is under the sun's course, another is distant from it, and another, between the two, is temperate.[1]" Roman homes, whether the single-family *domus* that we find in sites like Pompeii or the multi-story *insula,* tenement houses prominent in working class neighborhoods of Ostia Antica, were built with thermal qualities in mind.

At 42 degrees latitude and close to the Mediterranean, which acts as a heat sink, Rome has a temperate climate. It is hot and dry in the summer and chilly and damp in the winter, free from the extremes of cold of northern Europe and the parching droughts of the equator. Even in winter, the sun at midday often provides enough radiant heat to warm a massive masonry wall which, in turn, radiates this warmth to its inhabitants into the night. Similarly, in the summer, the walls discharge the midday heat at night and in the morning are ready to start absorbing energy again, resulting in remarkably cool interiors (as we experienced in the Pantheon). For millennia Rome was designed around a precise awareness of the changing presence of the sun throughout the day and the seasons.

Roman baths such as the Forum Baths of Ostia had hot rooms, called *caldaria*, opening to the south to receive low winter sunlight which would be absorbed by dark colored stone walls and floors, while the cooler *frigidaria* baths ensured shading from the high summer sun and breezes which would produce an evap-

orative cooling effect when passing over the pools of cool water. Siting and smart design alone was not enough to provide thermal comfort. In the winter it was supplemented by wood burning fires, whose scalding water would fill the tubs and hot fumes would pass through hollow walls to radiate warmth directly to bathers before venting out into the air.

Drawing a Bath

It is another "hotter than normal" September day and a group of sweaty and suntanned students from one of Boston's prominent university architecture programs are sprawled out on the ground in an elite bathing club. There is no water, and the hot Mediterranean sun is beating down on them relentlessly, but the students are thrilled nevertheless. They are spending a week at ancient Rome's port city of Ostia Antica, producing precise measured drawings of the ruined Baths of Mitra. One of a half-a-dozen bath complexes in the teeming seaside town, these baths were part of the social amenities surrounding the Mythrean religion, a mysterious cult that emerged at the height of the Empire and was eclipsed as Christianity moved to the forefront in the 4th century. The drawings will enrich the collective archives of archaeological data about this still-emerging site and the students' work, in addition to providing them with an unforgettable learning experience, will award them academic credits toward their professional degree in architecture.

The word "thermal" corresponds to the Roman word for bath: *terme*. Rome's original Termini station was built above the remains of the Baths of Diocletian, thus its name (not, as many assume, because the trains terminate there). On chilly winter days thermal baths were the only places that were heated, and an hour or so relaxing in the warmth of the *caldarium* (or, at Hadrian's Villa, in the *Heliocaminus* or solar sauna) would make

the rest of one's day more bearable. In the baths of Mitras at Ostia, as in the Forum Baths nearby, remains of each of these are visible. The heated spaces are easily recognizable by the crawl spaces under the floor and hollow tile walls through which smoke and hot air from the fires below passed, radiating heat to the bathers within. Seeking respite from the hot sun, our students explored the cisterns and surface ducts below ground, where the temperatures stay constantly cool. This simple "geothermal" fact — below ground temperatures remain nearly constant — informed many baths and palaces of the ancient world. It has been nearly forgotten today.

Measuring and drawing at Ostia Antica

Performative Antiquities

Earlier in the semester we analyzed the energy performance of the Domus of the Fortuna Annonaria based on hypothetical reconstructions of its roofs and porticos, demonstrating it to be a successful exemplar of passive solar heating and natural ventilation. The workshop then proposed a contemporary transforma-

tion of the ancient house into a museum, augmenting the ancient energy strategies with today's best practice and technologies to achieve a carbon zero ecological footprint. The results are beautiful, and confirm our hypothesis that the bulk of energy performance depends, not on the latest German or Japanese high-tech gizmos, but on basic, common sense design. A south-facing portico shades the hot summer sun but welcomes the desirable low winter rays. Thick masonry walls provide thermal mass to mitigate day-night temperature swings, capturing the sun's energy during the day to radiate it at night when the temperature drops. Gushing fountains trigger the evaporative cooling effect, absorbing heat in the process of converting water to vapor.

Calling this traditional Roman house carbon neutral would be going too far. The ruins the students are documenting may seem comprised of only durable, recyclable materials such as concrete, brick and stone, but look closer and you see the square holes where wood scaffolding, floor beams and roof rafters once sat. Large quantities of wood were also squandered to built the ships that brought the slabs of polished marble facing from quarries as far afield as North Africa and Asia Minor. Wood was burned in the production of the bricks which formed an integral part of the concrete structural system, now revealed where facing stone and stucco has been lost. During the course of the Roman Empire the forests of Tuscany were not-so-gradually transformed into the naked rolling hills travelers love today. This "imbedded energy" load that the students calculated was offset to some degree by longevity: instead of the 20-year life span of 20th century buildings, the materials in this Roman house were re-used again and again, a practice that has, thankfully, once again become the norm today.

The Beauty of Contrasts

One of the lessons of Rome lies in the beauty of contrasts, including thermal contrasts. The ancient builder's command of means to achieve thermal comfort didn't mean that anyone, even the most affluent, expected a constant, standard temperature. Far from it. The ritual of the Roman bath is a case in point: a plunge in cold water followed by a rub down, a hot sponge bath, a steam bath and, again, cold water. Certainly in the winter, when central Italy is chilly and humid, an hour or so spent in a hot, dry sauna, combined with vigorous exercise and warm layers of wool made for an acceptable, if not entirely comfortable, routine, especially when activities were concentrated in the warmer midday and afternoon hours. By contrast, in the summer only a fool would be anywhere but resting in the shade in the hot midday hours; productive activities took place (and to a lesser degree still do today) in the early morning hours and well into the evening when the city cools down noticeably.

For years I've watched public spaces in Rome– and people's use of them– change as the seasons change. In the winter the sunny side is where people gather, where sidewalk cafes prosper, street furniture materializes on warm days and people emerge from cool stone *palazzi* into the warmth of sun-drenched public space. The opposite occurs during the summer. It is now the shade and shadows which draw all but the most thoughtless tourists; where shade is not already provided by buildings or trees, umbrellas appear or shutters are drawn during daylight hours (only to be reopened, when the sun goes down, to maximize cool evening breezes and vent out any heat absorbed during the day).

Watching the dress patterns is indicative as well. As soon as temperatures drop slightly, even as tourists are still in t-shirts, fur coats and down parkas appear. But even on the hottest summer

day it is rare to see a Roman man in shorts. It may be that Italians have a higher tolerance for heat than for the lack of it, or a lower tolerance for male anatomy than for female (skimpy dresses yes, men's shorts no). The spaces one occupies in most American cities are either indoors, fully-conditioned year-round, or outdoors whereas in European cities there are more intermediate spaces, inside but not sealed from the elements. These spaces, whether the stairwells or entrance halls of apartment buildings or the galleria shopping arcades, act as buffers between the interior and the elements.

In Boston I was used to spending time in overheated interiors and putting on a heavy coat only for the short jaunts between destinations, or not at all when a short walk across campus in a t-shirt was a refreshing contrast. In Rome where big stone interiors tend to stay chilly the attitude is to heat the body, not the building. Radiant heat works along these principles, whether provided by in-floor heating coils, wood-burning fireplaces or simply well-placed windows. The explanation for the summer dress code is more complicated; instead of cooling the body in the face of heat (for which the solutions are more invasive) Romans avoid the heat by shifting their daily routines. Thus they tend to dress for the cooler hours, especially the evenings, while the tourist dresses for the hottest hours and suffers anyway, only to feel out of place and often downright chilly once the sun goes down.

Another example of cultural approaches to energy that I have always found enlightening is the drying of clothes. Since moving to Rome I have never had a dryer, though our washing machines have always been the most sophisticated high-performance devices which leave clothes immaculately clean with a minimum of water and energy. And then we hang the clothes to

dry on a line or a rack. One of the most common observations I've heard from North American travellers has always been about this lack of dryers, with clothes-lines often associated with poverty of the trailer park variety. The clothes drying paradox: in the US we burn petroleum or coal ("ancient sunlight" as Thomas Hartmann calls it) to produce electrical current, then transmit that electricity (wastefully) over long distances, and finally transform it back into heat and power to turn a drum to dry our clothes. Or we can simply hang them out to dry in the sun and air. Italians prefer the latter, (although a good advertising campaign might convince them to change their ways as it has convinced them to parrot other wasteful American foibles, buying ever larger cars and homes.)

Personally I find the ritual of hanging laundry, like that of tending a garden or taking a walk, a great way of ensuring contact with the outside air. I agree, however, with those who balk at hanging clean clothes over polluted city streets. Like the argument against urban gardens, this is all the more reason to address the core problems. The solution is not to limit our exposure to air pollution; it is to eliminate the causes of pollution (especially Rome's automobile addiction, as we will discuss later.)

Let There Be Light

"Show me the apartment that lets you sleep! In this city sleep costs millions, and that's the root of the trouble. The wagons thundering past through those narrow twisting streets, the oaths of draymen caught in a traffic-jam, would rouse a dozing seal—or an emperor." So Juvenal describes Rome of the late first and early second centuries AD. One had to choose to either shut out the noise by closing wooden shutters and risking suffocation, or leave them open and stay awake all night.

Until relatively recently, the choice to let in light most often meant a sacrifice in thermal insulation, which had to be compensated for by high fuel consumption. The single-glazed curtain walls of the post-war office buildings are as distant from the high-performance glazing we have today as they were from ancient Roman shuttered window walls. While good solar designers have been exploring the potential of the "positive greenhouse effect" for decades, taking advantage of the unique properties of glass, like certain gases in our planet's atmosphere, to allow light to penetrate but prevent heat transfer. As our technological evolution would have it, our ability to profit from this effect only came at the moment when our exploitation of (seemingly) cheap fossil fuels made it (seemingly) un-necessary. Recently this situation has changed and the technology of glazing, now no less energy efficient than masonry, has received the attention and the application it deserves.

It has been confusing to laypeople and to many architects themselves to see the use of glass walls shift, in one generation, from environmental heresy to high-performance energy savers. In cities from Bilbao to Berlin it is common to see new glass walls clipped in front of old masonry ones, second skins which mediate between outside and in, or simply double glass envelopes which let in light and heat when desired but reflect or vent it away when unwanted. This "garment architecture" approach, to use Paolo Soleri's term, would make as much sense in Rome's variable climate and a few examples can be found. The retrofitting of the Lazio Region's offices by Aldo Aymonino, the Dutch Embassy, or a recent (unpublished) proposal by A+V Architetti to offset the power load of Rome's MAXXI Museum by applying a photovoltaic greenhouse to one of the adjacent masonry buildings are just a few examples. Renzo Piano's glazed porticos surrounding the Parco della

Musica incorporate operable textile shades, intended to allow light and warmth in the winter while keeping the hot summer sun from hitting the building's walls. Even Massimiliano Fuksas's muscular megastructure called *La Nuvola* (the "cloud") attempts to mitigate the impact of suspending Rome's new convention center inside a big glass box by giving the box a double skin. One inspiring example of a performative facade in Rome remains Luigi Moretti's Casa Girasole (sunflower house), dating to the late 1940s. Its windows peel off the screen-like facade like flower petals to catch light and views while sliding shutters, operated by the building's users, result in a constantly changing appearance. Like sunflowers turning to face their energy source, or crawling ivy providing Rome's *palazzi* a variable second skin, biomimicry has been providing obvious solutions as long as humans have been building.

Natural lighting has long been supplemented, if not displaced, by artificial lighting. Limited use of artificial lighting didn't have to wait until the gas lamps of the streets of Victorian cities, later replaced by electricity. One of the most common finds in Roman archaeological digs is the small oil-burning lamp, often affixed to walls of darker corridors or carried by hand through the rooms after hours. Not only a functional necessity — it was far more practical to simply carry on activities during the day and sleep at night —sometimes artificial lighting was used to literally highlight artifacts, to see the city under a different light.[2]

Casa Girasole, architect Luigi Moretti 1949

Green is the New Gold

When asked about what makes architecture "sustainable" most people will mention energy conservation and renewable sources of power before bringing up the other six themes of sustainable urbanism. Between buildings and transportation cities consume close to 80 percent of all energy. Most of central Rome, though, was built prior to the harnessing of fossil fuels for heating, cooling, lighting and transport; it worked pretty well and there is a lot we can learn from it. In his presentation of the 2030 challenge architect Edward Mazria notes that, before resorting to the purchase of energy from (costly) renewable sources or the application of (costly) technological solutions such as photovoltaics,

wind generators, automated sun shading devices and the like, buildings can already cut their energy consumption dramatically by doing what we designers do, that is designing responsively to local conditions.

Thanks to its temperate climate and mostly well-planned historical building stock, Rome has what it takes to become a demonstration project for the net zero energy city without a huge investment, through smart retrofits and design.

Sometime in the late 2000s renewable energy passed from the terrain of the radical green counter culture to corporate mainstream, a fact I first realized at the Zero Emissions Rome trade fair a few years ago.

Two huge pavilions were dedicated to "sun" and "sun/earth" —the latter seemed to result from the fact that there were so many exhibitors in the solar energy field that one pavilion was not enough, but they shared space with green chemical companies and the like. Another was dedicated to wind, and a fourth that I didn't make it to was supposed to address carbon neutrality.

I spent most of my morning looking at photovoltaic panels, by far the biggest sector of the growing market. Italy ranks fifth as producer of electricity through photovoltaic cells, after Germany, Japan, Spain and the United States. To date almost 400 megawatts of production capacity has been installed here; in Europe as a whole the number is about 90 gigawatts (thanks mostly to Germany). This may still sound small compared to the multi terawatt capacity of nuclear and hydroelectric plants in Europe, but it is growing rapidly. Italy has been slow to jump on the bandwagon but thanks to a combination of high government incentives, the most costly electricity in Europe, and

its sunny climate, the boot is finally showing some interest in photovoltaics. Strangely, the region where it is most productive is Lombardia, not among the sunniest, but sunny and southern Puglia is in second place. The reason has to do with confused regulations, differing from region to region, in place of a much needed national guideline.

Lacking was any serious attention to the design of photovoltaic panels: just the standard rigid panel composed of 50-100 cells. It seems like the days that computers were big grey boxes and monitors flickered with green text. Design was evident in the marketing materials (some great graphics and nice stand design) but not in the products or their representatives who from their looks could have just as easily been selling tractors or pharmaceuticals. While some stands showed sophisticated fastening systems and transparent glass panels without the ubiquitous aluminum frame, there was no real cutting edge application of the technology on display. And worse, none of it was put to use despite the sunny day. As far as I could tell there were megawatts worth of panels on display but the entire fair was being powered by the national grid. Did anyone even think of putting all these panels to use to demonstrate their functionality? I suppose that would be like suggesting that an automotive show actually had cars with their engines on; a logistic nightmare not to mention health hazard as well.

On a similar note, the *Fiera di Roma* (the convention center where the show was held) is — from an urban standpoint — one of the worst buildings that could have been built in the current age of environmental crisis. Located far on the edge of town, near the airport, it was made for cars and in fact is surrounded by a sea of parking like any suburban shopping mall. Instead of being built adjacent to the Rome-airport train line it was placed

just far enough away to require a shuttle bus to make the rounds, a degrading, polluting and time-consuming experience.

Interior of Pantheon dome

Net-Zero Cities

By 2030 3/4 of the world's energy will be consumed in urbanized areas; it is in cities that the greatest opportunity exists to wean us off our dependence on fossil fuels like oil which we consume thousands of times faster than its rate of production. The alternatives exist, most evidently the sun. One hour of sunlight at high noon contains the energy used by the entire planet in a year. To benefit from this wealth of energy, buildings must be rethought, no longer considered consumers of energy but potential power plants.

Rome is well-situated to become one of Europe's first net-zero

energy cities. In Rome's temperate climate, leveraging emerging photovoltaic technologies and good, common-sense design, the area occupied by an urban building can provide for all that building's energy needs and even produce a surplus to feed into the power grid. The energy efficiency of the city's building stock must be recognized, appreciated and augmented where possible, an investment that has no downside.

In cold weather Rome has a great opportunity to exploit adjacencies for co-generation. My condominium complex went through several cold winters when the central heating wasn't activated due to bickering about policy, but meanwhile the industrial bakery on the ground floor continued to vent hot air to the atmosphere, air which channeled intelligently could have heated most of the building. For true cold-weather performance a good deal of retrofitting is needed, especially the application of thermal insulation, air-tight glazing and weather seals but this can be done gradually as new products and techniques become available. It doesn't have to be a big investment and it doesn't necessarily require sophisticated technology.

In the past, keeping your building comfortable often allowed (or required) active participation on the part of the users. Is this really a bad thing? Pulling the shutters closed as the afternoon sun strikes a facade and opening them as the evening breezes kick in, these are some of Roman life's greatest rituals, on a par with the late morning espresso. Would we really prefer the monotony of regulated air conditioning, even if it had no environmental impact?

Every aspect of sustainable city living carries an energy cost. It takes energy to transport and process water, and even when electricity is produced through hydroelectric generators the net gain is often outweighed, as with nuclear power, by losses in

transmission from distant sources. About half of the energy consumed in cities is due to our buildings, the urban fabric addressed in Chapter 3. Vegetation as discussed in Chapter 2 not only provides an efficient natural buffer to reduce building's energy load and the surrounding heat-island effect; local agriculture preserves huge quantities of fossil fuels that would be spent on transport and fertilizers. Over 30 percent of the energy used in cities is due to our transportation choices which will be addressed in Chapter 6. I have discussed here how shared public spaces act as thermally attractive buffers, boosting both energy savings and community ties. But it is the connection to waste that is perhaps the most direct; we discard materials that contain embodied energy and, rather than exploiting their energy content, we often bury them, leaving a hazard for future generations. This is the subject of the next chapter: waste.

Notes

1. Vitruvius, The Ten Books of Architecture, translated by Morris Hickey Morgan (New York: Dover, 1960)
2. Goethe described a torchlight visit to the Vatican or Capitoline museums as a visit desired alike by all strangers, artists and connoisseurs.