How Blockchains can Help Smart Cities

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All images from Wikipedia unless otherwise noted

MANY PROBLEMS FACING CITIES TODAY

Health and substance abuse

Changing demographics

Lack of affordable housing and homelessness

Crime

Infrastructure management

Environmental degradation (soil, water, air)

Energy use and carbon footprint

Resilience to climate change

Source: Survey of American mayors, 2017

SOME CAN BE SOLVED BY 'SMARTNESS'

Health and substance abuse

Changing demographics

Lack of affordable housing and homelessness

Crime

Infrastructure management

Environmental degradation (soil, water, air)

Energy use and carbon footprint

Resilience to climate change

DIGGING DOWN…

Crime

Infrastructure management/environmental degradation
- transportation networks
- water supply
- stormwater and sewage
- waste management and recycling
- leaf and snow clearance
- tree cover and parks
- parking

Energy use and carbon footprint

Resilience to climate change

AT A HIGH LEVEL…

Moving

- Energy
- People
- Water
- Waste (including leaves and snow)

Spending

- Money
- Energy
- Carbon

With susceptibility to shocks

- due to climate change

CAN WE TREAT THE CITY AS AN ORGANISM?

Study the movement of energy, materials, people, waste
- to help understand and solve problems

Examples
- studying flow of vehicles can identify congestion points and parking needs
- studying flow of water can identify water losses and reservoir capacity
- study of snow fall and movement can identify snow clearance routes
- …

The Metabolism of Cities

by Abel Wolman

The metabolic requirements of a city can be defined as all the materials and commodities needed to sustain the city's inhabitants at home, at work and at play. Over a period of time these requirements include even the construction materials needed to build and rebuild the city itself. The metabolic cycle is not completed until the wastes and residues of daily life have been removed and disposed of with a minimum of nuisance and haz-
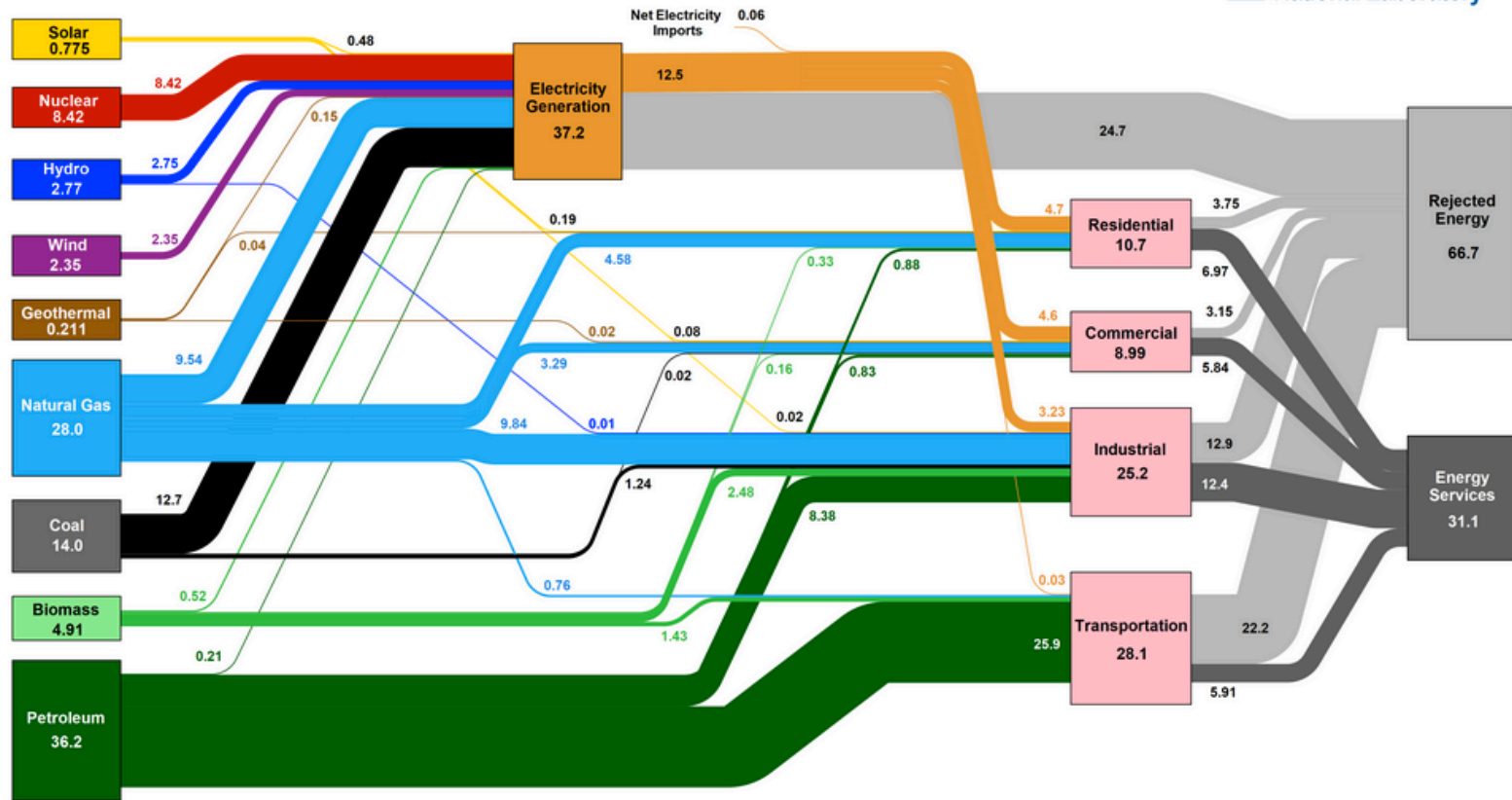
Wolman, A. (1965). The metabolism of cities. *Scientific American, 213*, 179–190.
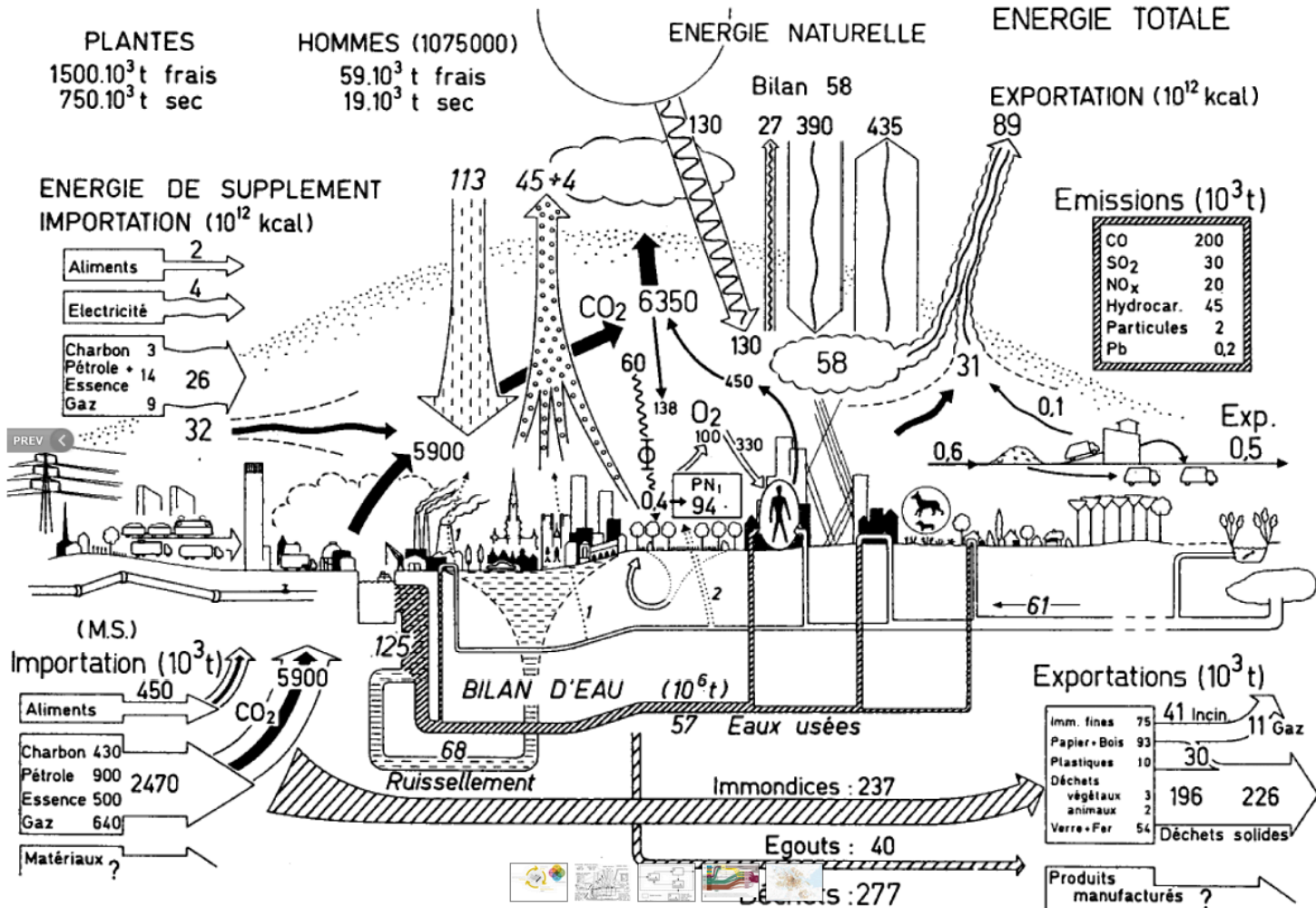
Figure 2: Study of the urban metabolism of Brussels by Duvigneaud and Denaeyer-De Smet, 1977 (http://mfadiagrams.blogspot.nl)

Estimated U.S. Energy Consumption in 2017: 97.7 Quads

Lawrence Livermore National Laboratory

Source: LLNL April, 2018. Data is based on DOE/EIA MER (2017). If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. This chart was revised in 2017 to reflect changes made in mid-2016 to the Energy Information Administration's analysis methodology and reporting. The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential sector, 65% for the commercial sector, 21% for the transportation sector, and 49% for the industrial sector which was updated in 2017 to reflect DOE's analysis of manufacturing. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

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Figure 1: Sankey diagram of Quebec's energy system in 2012
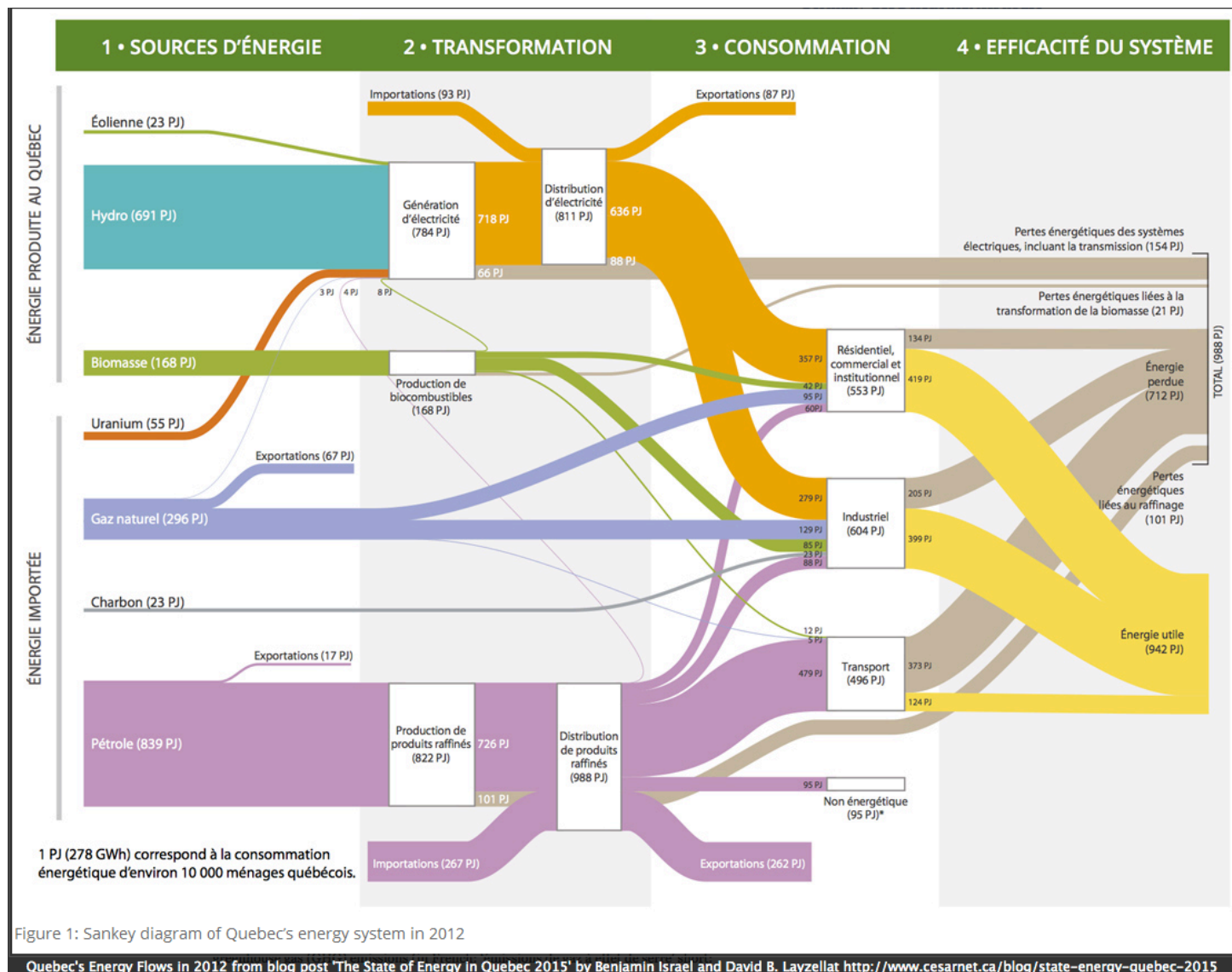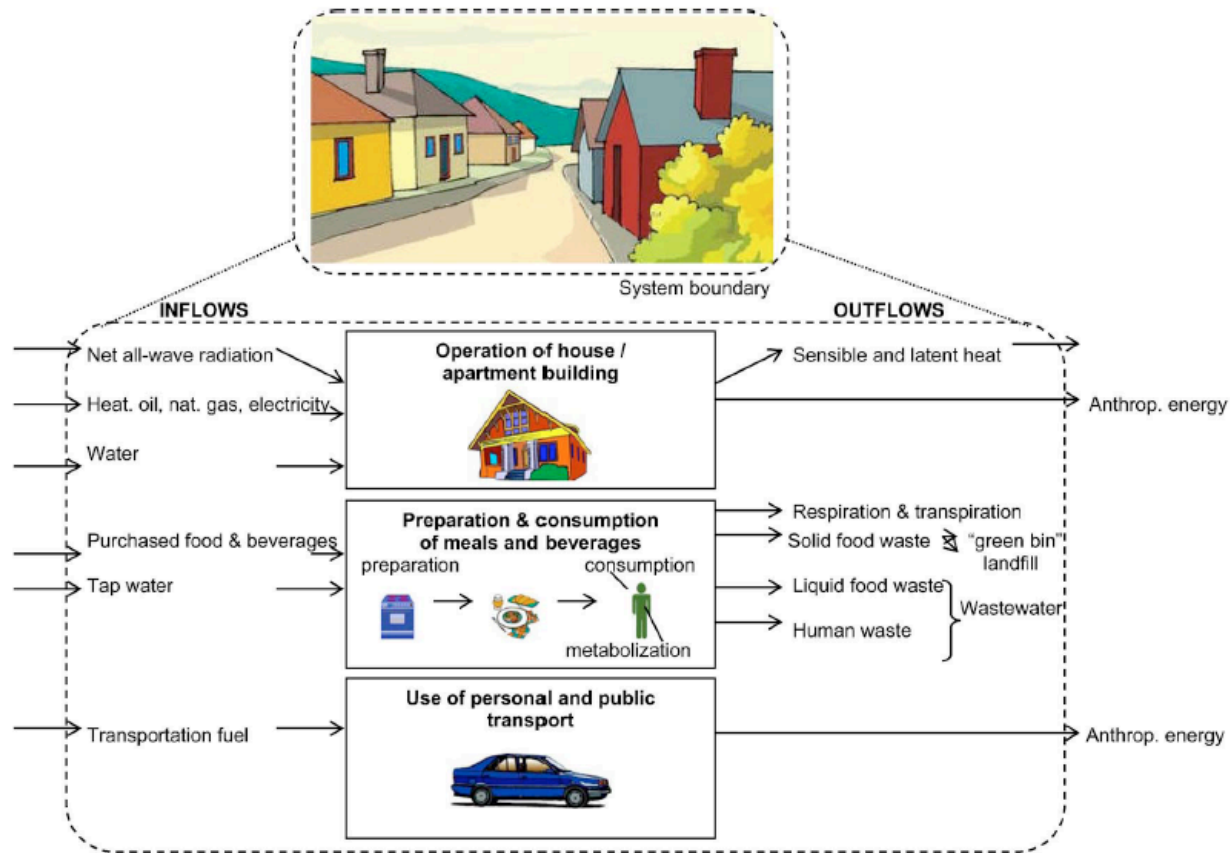
Fig. 2. Key metabolic processes of study system of Toronto neighborhoods

Codoban, N., & Kennedy, C. (2008). Metabolism of neighborhoods. *Journal of Urban Planning and Development, 134*, 21.

sustainable urban futures will require a
fundamental transformation of existing production and consumption patterns in cities, and
that looking into how these patterns are organized into flows—of materials, energy, people,
meanings, and power—is a fruitful avenue to investigate such transformation.

Castán Broto, V., Allen, A., Rapoport, E., 2012. Interdisciplinary perspectives on
urban metabolism. J. Ind. Ecol. 16, 851–861, http://dx.doi.org/10.1111/j.1530-
9290.2012.00556.x.

BUT…

Data Acquisition

The biggest challenge of this study was to find reliable data. Some of the current information on consumption of water, food, and energy at the neighborhood level is scarce and therefore the metabolism of neighborhoods is established with the data available. For the system defined above, data are collected from vari-

available data. For MFA to develop, however— and it should conceivably be conducted every year or at the very least every five years for effective environmental policies to be implemented— it will be necessary for government to improve data production, collection, and availability.

(1) *Lack of data*: Despite the acknowledged importance of cities for the overall volume of socio-economic material and energy use, periodically available and harmonized datasets are provided by statistical offices almost exclusively for the national level. Therefore any attempt to generalize patterns and trends of urban specific resources use from the literature struggles with incomplete or incommensurable data.

comes. Data gaps, omitted/hidden upstream flows, uncertainty regarding the appropriate scale of analysis, and segregated information sources continue to constrain fine accounting of the urban metabolism of cities. No studies have yet been able to describe flows into a city and the waste sinks in a way that correlates those flows with the specific residents and their activities, let alone a cradle to grave accounting of the inputs. For example, few cities have data about trash generation by fine-grained geographic scale or by land use type.

that the current resolution of UM investigation, on city level and per year, is of insufficient detail to provide the information that is needed to inform resource-conscious urban planning and design decision-making. Moreover, the spatiotemporal resolution of exist-

THIS IS CHANGING …

Open data initiatives from all levels of government

BUT THERE IS MORE…

Internet of things
- Allows pervasive measurement, communication, monitoring, and control

MICRO SENSORS
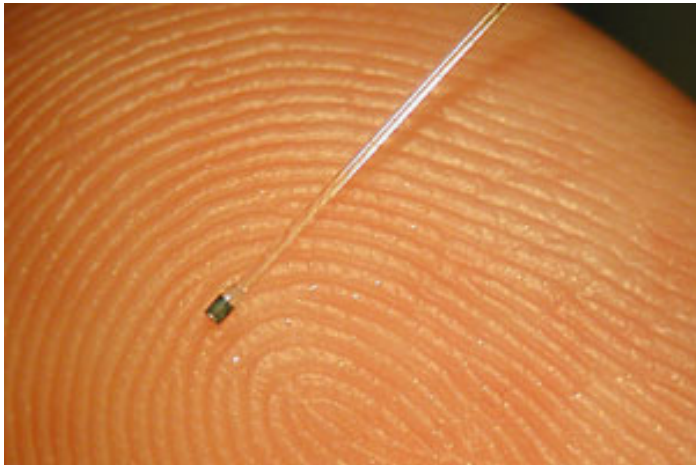
PERVASIVE COMMUNICATION
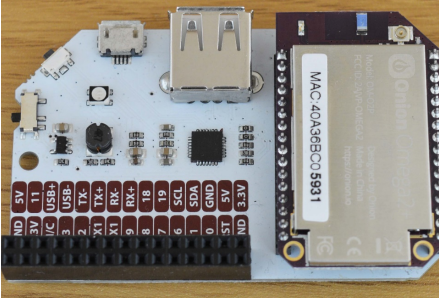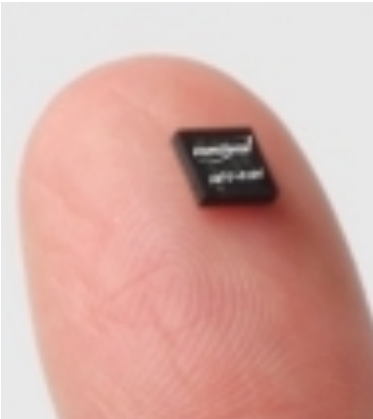
PERVASIVE CONTROL

Source: European Technology Platform Vision Document

BUT ALSO…

https://www.globalsmartcitysolutions.ca/products

BUT THERE IS MORE…

Internet of things

Data science

Data -> models

Image Source: http://www.kiwidatascience.com/

BUT THERE IS MORE…

Internet of things

Data science

Blockchains

WHAT IS A BLOCKCHAIN?

A globally visible ledger that is owned by no one but can be trusted by everyone
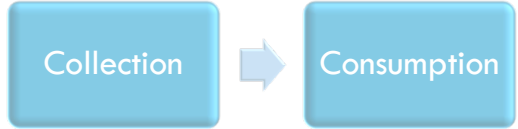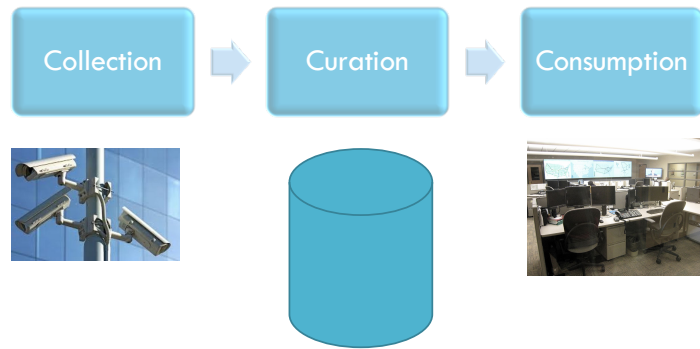
BLOCKCHAINS FOR SMART CITY DATA

Blockchains can hold consent for data use

Proves that data access is valid

Fills the privacy gap

Collection → Consumption

Collection → Curation → Consumption

Collection → Cleaning → Curation → Consumption

Collection → Cleaning → Curation → Classification → Consent? → Consumption

PII

No PII

PII

Collection → Cleaning → Curation → Classification → Consent? → Consumption By a 'role'
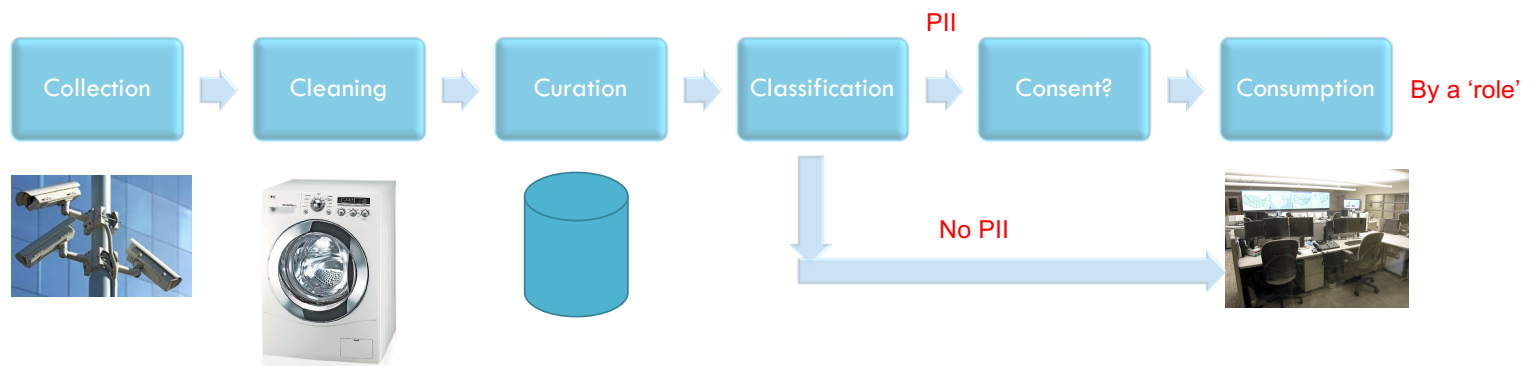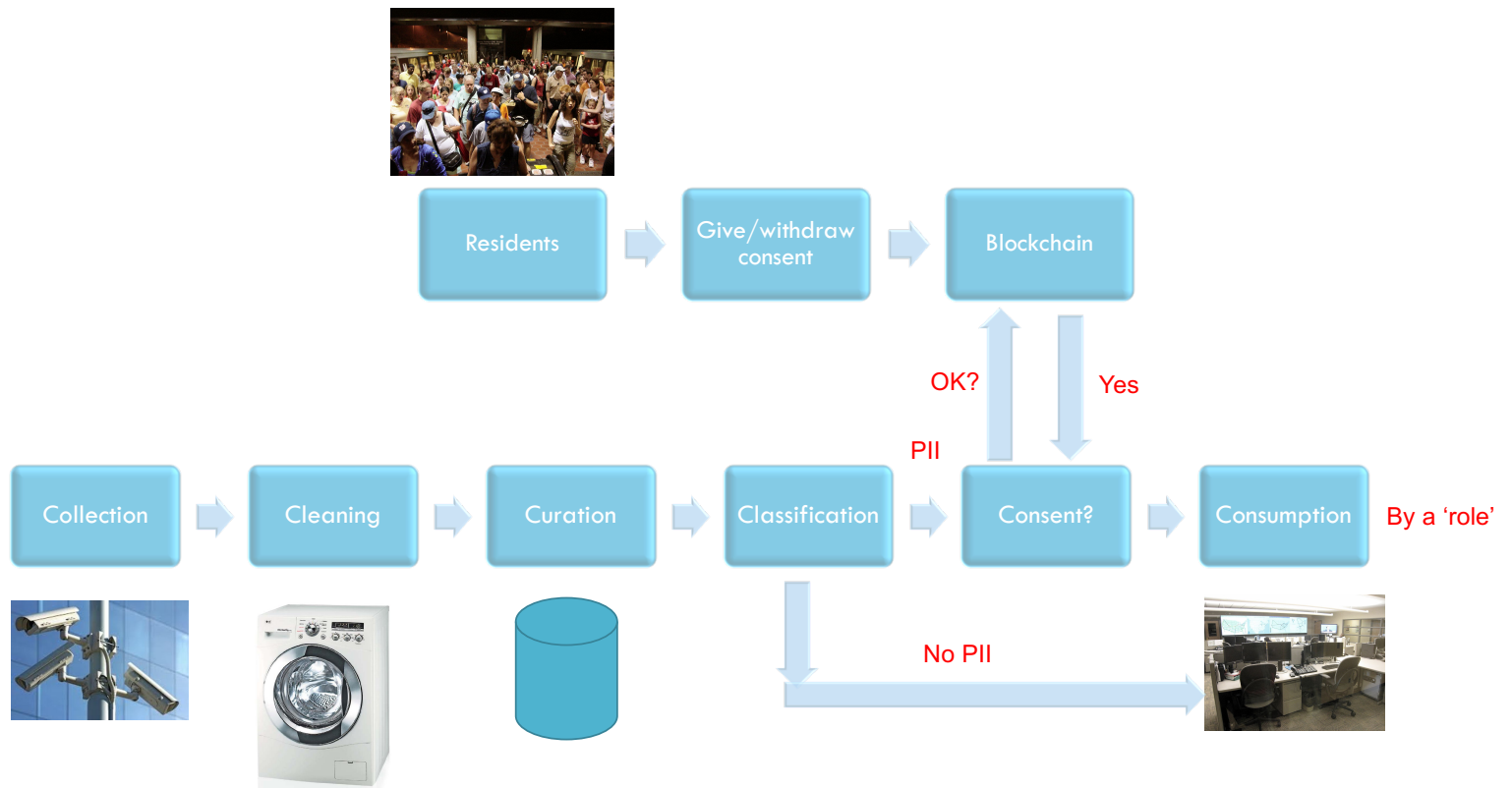
No PII
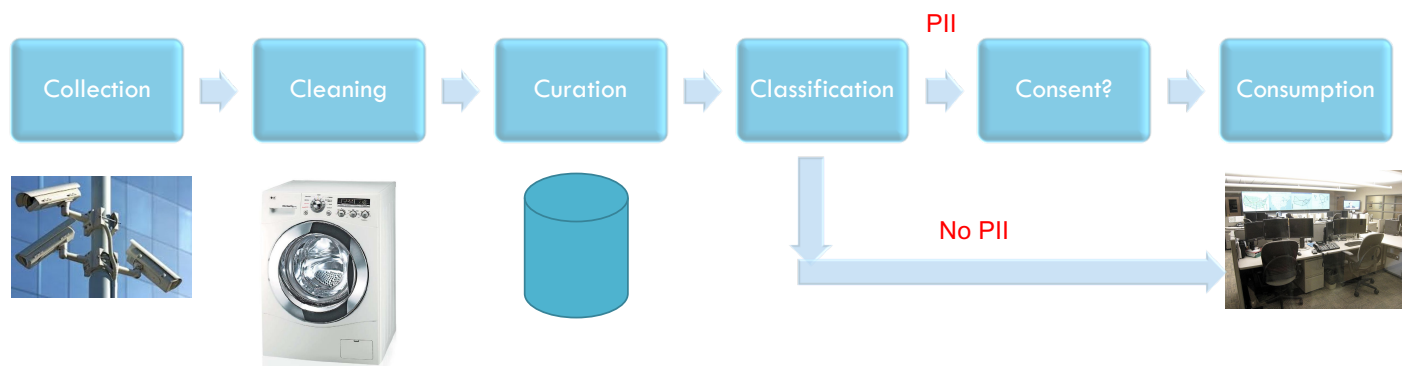
CONSENT

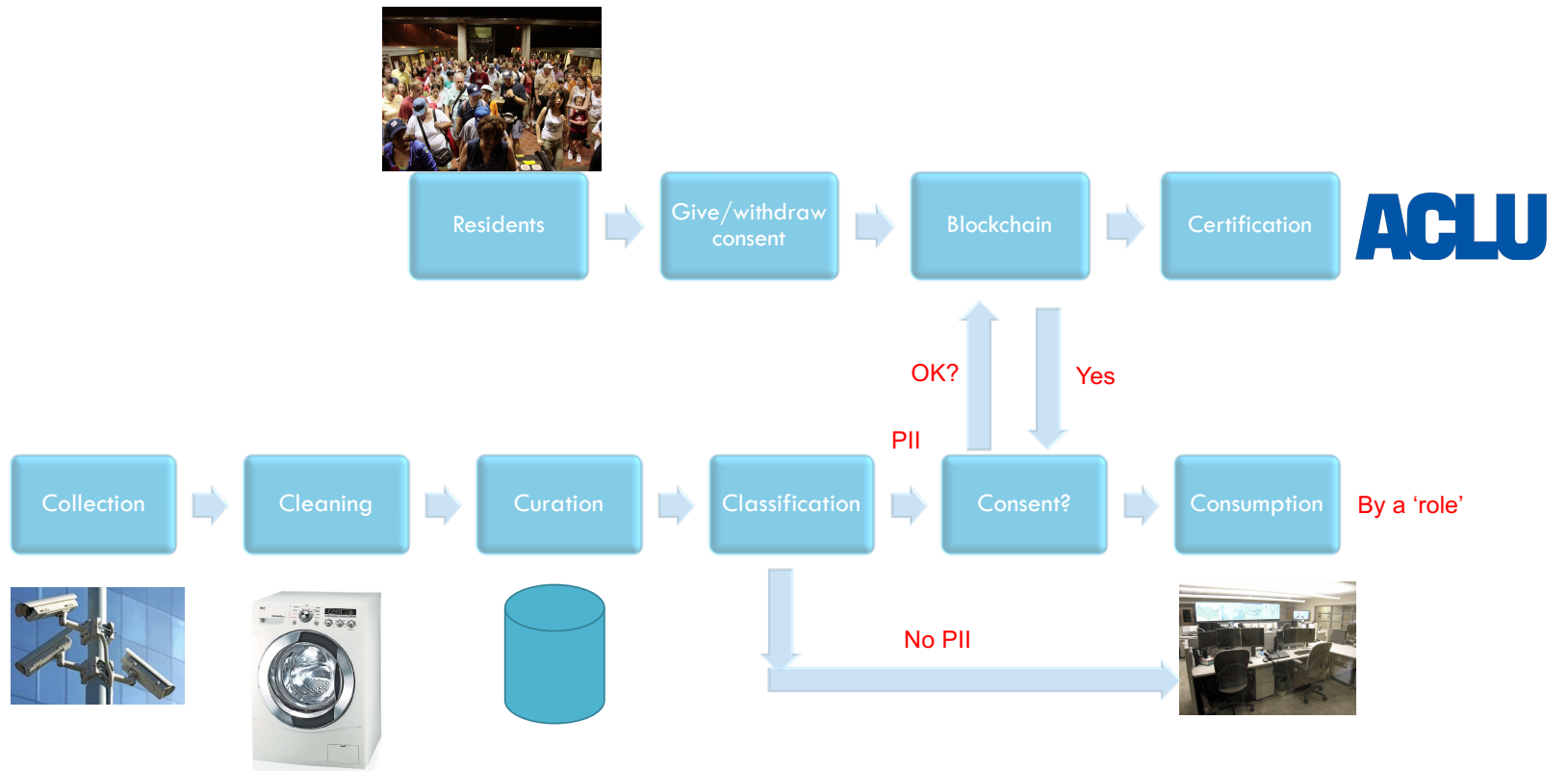I {grant/withdraw} my consent

to {my} PII data subset

to {consumer/role}

 {from time x to time y}

Can be delegated
- I {grant/withdraw} my consent
- to {my/my delegator's} PII data subset
- to {consumer/role}
- {from time x to time y}

Residents → Give/withdraw consent → Blockchain

OK?   Yes

PII

Collection → Cleaning → Curation → Classification → Consent? → Consumption   By a 'role'

No PII

Residents → Give/withdraw consent → Blockchain → Certification **ACLU**

OK?   Yes

PII

Collection → Cleaning → Curation → Classification → Consent? → Consumption   By a 'role'

No PII

Residents → Give/withdraw consent → Blockchain → OK? → Certification

Collection → Cleaning → Curation → Classification → Consent? → Consumption   By a 'role'

PII   OK?   Yes

No PII

TO SUM UP

Cities can be viewed in metabolic terms

and to manage them, we need to understand the flow of energy, materials, and people

So far, a lack of data and analytical capabilities

This will change with IoT and Data Science

But there is a danger with unrestricted sensing

So we will also need blockchain to protect privacy by storing consent