Smart City Design Differences: Insights from Decision-Makers in Germany and the Middle East/North-Africa Region

Marc Ringel

Annex

Overview Supplemental Material

A.1 Codebook literature review

I. Framing data

1. **Country/region**
   i. Algeria
   ii. Egypt
   iii. Germany/German
   iv. Morocco
   v. Oman
   vi. United Arabian Emirates/UAE
   vii. Arab*
   viii. MENA

2. **Cities**
   i. Berlin
   ii. Bremen
   iii. Cairo
   iv. Cologne
   v. Hamburg
   vi. Kuwait
   vii. Maskat
   viii. Munich
   ix. Masdar City
   x. Ras-Al-Khaima

3. **City profile**
   i. smart AND sustainable
   ii. sustainable

II. Topics

1. **Governance**
   i. Bottom up
   ii. Top down
   iii. Coordination
   iv. Public private partnership
   v. Citizen consultation
   vi. Stakeholder

2. **Energy**
   i. Renewable energ*

ii. Heating and cooling networks
iii. Building energy efficiency (private)
iv. Building energy efficiency (office and public buildings)
v. Efficient appliances
vi. Prosumer
vii. Demand side management, DSM
viii. Smart meter*
ix. Consumption feedback
x. Smart grid*
xi. Smart infrastructure
xii. Information communication technology, ICT
xiii. Internet of things, IoT
xiv. Wireless networks

3. Mobility

i. Electric vehicles, E-vehicles, E-mobility
ii. Public transport
iii. Cycling
iv. Walking
v. Traffic management

III. Motivation, drivers and barriers

1. Motivation and drivers

1.1 Economics

i. Cost effectiveness
ii. Competitiveness
iii. Green growth
iv. New business models
v. Increase attractiveness for investors
vi. Economic advantages by improved infrastructure
vii. Enable ICT-entrepreneurship
viii. Deploy ICT/IoT
ix. Modernize infrastructure

1.2 Environment & energy

i. Lower energy consumption
ii. Climate policy
iii. CO2 mitigation, CO2 abatement
iv. Climate adaptation
v. Reduce CO2 emissions
vi. Resource efficiency
vii. Deploy RES and save fossil fuels
viii. Sustainab*, sustainable, sustainability

1.3 Social

i. Living conditions
ii. Improvement of services for citizens
iii. Allow participation for citizens
iv. Population growth
v. Traffic problems
vi. Increase living conditions
vii. Build up knowledge society
viii. Living laboratory

2. Barriers

2.1 Qualifications

i. Lack of qualified workforce
ii. Lack of technical expertise

2.2 Economics

i. Lack of economic expertise
ii. Investors hesitate to provide finance (risk investment)
iii. Economic feasibility of project is not guaranteed (negative cost/benefits)
iv. Value added is not clear

2.3 Management and organization

i. Principal-agent problem with external construction partner
ii. Specialists focus too strongly
iii. Missing standardization of IT-interfaces
iv. Expenditure of time

2.4 Governance and policy

i. Complex administration structure (coordination)
ii. Missing integrative planning
iii. Missing political framework conditions
iv. Missing acceptance by public (privacy, data protection)

IV. Methodology

i. Comparison,compari*, compara*
ii. Screening
iii. Index
iv. Morgenstadt
v. EU Smart Cities
vi. Guideline

vii. Ranking
viii. Survey
ix. Mapping

A.2 City profiles and statistics based on literature readout

German Cities		Common features for German Cities
Berlin	• involved stakeholders in developing its 2015 smart city strategy (Senatsverwaltung für Stadtentwicklung und Umwelt, 2015). • is a living Laboratory for smart energy technology development (Blanchet, 2015; Li et al., 2018; Moss & Francesch-Huidobro, 2016) and mobility (Ehrhardt, 2016). • following a change in the political leadership, Berlin shifted from top-down to decentralized approach. • adopts public-private-partnership (PPP) where private entities coordinated the overall and individual projects which have gained a strong influence and power on smart cities projects (Vogelpohl & Klemp, 2018). • in response, Berlin renounced performance indicator to its strategy" (Interview 5, German city).	• Governments of federal states develop smart cities strategies and implement them with consultation and involvement of many stakeholders. • Adopts Public-Private Partnerships approach where cooperation with local consulting and industry stakeholders plays major role. • Stakeholder interests and power dynamics are apparent by changing governance approaches from top-down to decentralized (like Berlin), or from Bottom-up to top-down (like Cologne). • Aim to integrate smart technology solutions into existing cities' infrastructure. • Technology focus is on mobility and energy smart solutions. • Living laboratory to develop smart technologies to market to other cities and countries.
Bremen	• launched its Masterplan Green City in 2019 through stakeholder consultation. • Focus on mobility and with option to cover energy projects (Senator für Umwelt, Bau und Verkehr, 2018). • takes a cautious approach to technology selection and focuses on improving living conditions of inhabitants (Interview 1, German cities).	
Hamburg	• developed its "digital strategy" in coordination with local stakeholders like the Hamburg Port Authority (Reiswich, Köster, & Nitschke, 2016). • tests new technologies in energy (Lorenzen, Duckstein, Vuthi, & Schäfers, 2015; Vuthi et al., 2015), infrastructure (Welzel & Eichhorn, 2016), and mobility (Huang-Lachmann & Lovett, 2016).	
Munich	• launched smart city strategy in 2015 (Stadt München, 2015). • focuses on energy, mobility and citizen inclusion into decision-making (Alawadhi & Scholl, 2016; Scholl & Alawadhi, 2015). • PPP partners include locally based and "familiar" industry players (Interview 7, German city) • adopts an integrative planning (Freudendal-Pedersen, Kesselring, & Servou, 2019; Kesselring, 2016). • implements innovative solutions (Tucci, Santucci, Endres, & Hausladen, 2018).	
Cologne	• developed smart cities concept out of several EU "Lighthouse" projects. • changed from bottom-up to an umbrella strategy to coordinate individual projects (Interview 4, German city). • adopts an integrative approach to smart city development strategy (Kusch, Stadler, & Bhandari, 2016).	

MENA

Arab Cities		Common features for Arab Cities
Abu Dhabi's Masdar City	• is a frontrunner on a global scale (Angelidou, 2017; Huston, Rahimzad, & Parsa, 2015; Shelton, Zook, & Wiig, 2015; Tok, Al Mohammed, & Al Merrekhi, 2014). • adopts PPP approach. • deliver smart cities and sustainable solutions (Lau, 2012; Masdar Company, 2013, 2016; Masdar Institute, 2014): energy (Lee, Braithwaite, Leach, & Rogers, 2016; Reiche, 2010), mobility (Atef Elhamy Kamel, 2013), architecture (Ibrahim, 2016), and sustainability (Madakam & Ramaswamy, 2016; Sodiq et al., 2019). • the aspect of sustainability received controversial reviews (Cugurullo, 2018; Wachsmuth & Angelo, 2018), where the "original aspirations had not been followed up" (Interview 17, MENA cities). • the UAE government integrated the learnings into its "2021" vision and strives to develop smart cities in Dubai or Ras Al Khaima.	• National governments are the main stakeholder who develop smart cities strategies, govern, and participate in implementing projects. • Adopts Public-Private Partnerships approach where cooperation with international consulting and industry plays major role. • National governments, as responsible authorities, runs top-down planning and execution of smart cities projects. to deliver energy, mobility and digital services to the citizens. • Aim to build new smart cities as extensions to existing cities. • Technology focus on efficient and smart building and energy technologies. • Improving socio-economic conditions and living standards of citizens play a major role. In addition, containing population growth and securing housing for population is another motivation for Arab governments.
Kuwait	• "Vision 2035" (The Economist, 2017) responds to economic and population challenges as well as climate and energy concerns (Al-Mutairi, Smallbone, Al-Salem, & Roskilly, 2017; Alotaibi, 2011; A. Gelan, 2018; A. U. Gelan, 2018; Jaffar, Oreszczyn, Raslan, & Summerfield, 2018; Salahuddin, Alam, Ozturk, & Sohag, 2018). • the Public Authority of Housing and Welfare plans, oversees and implements the smart cities projects such as Saad Al-Abdullah project. • following 8 smart city projects are planned and contracted out to public and private sector partners from South Korea.	
Qatar	• Qatar National Vision 2030 orients the country towards sustainable energy and high ecological standard of living for its citizens (Charfeddine et al., 2018). • focuses on building energy efficiency (Ayoub, Musharavati, Pokharel, & Gabbar, 2014; Krarti, Ali, Alaidroos, & Houchati, 2017; Rodriguez-Trejo et al., 2017). • launched several smart city projects (Lusail City, Msheireb Downtown Doha, Energy City). • Msheireb project will consist of more than 100 new buildings concentrated by Leadership in Energy and Environmental Design LEED ratings (Msheireb official website, 2018). • the ecological downtown of Doha is expected to use 30% less energy than regular buildings, focusing on the efficient use of energy in smart grids and the deployment of renewable energies (Abdmouleh, Gastli, & Ben-Brahim, 2018; Al-Marri, Al-Habaibeh, & Watkins, 2018).	

	Area [km²]	Population	GDP per capita [m USD]	Temperature [daily mean min/max] - harmonized WMO data	Public transport modes
Berlin	891,68	3748148	80757,25	Min: 5,67°C Max: 13,36°C	Metro, tram, bus, taxi
Bremen	326,18	569352	86499,06	Min: 5,2°C Max: 13,2°C	Tram, bus, taxi
Cologne	404,89	1085767	93794,21	Min: 5,51°C Max: 14,47°C	Metro, tram, bus, taxi
Hamburg	755,09	1841179	105063,41	Min: 5,24°C Max: 12,74°C	Metro, tram, bus, taxi
Munich	310,7	1471508	113893,51	Min: 4,17°C Max: 12,98°C	Metro, tram, bus, taxi
Cairo	3085	9500000	2412,73*	Min: 15,77°C Max: 27,73°C	Metro, bus taxi
Dubai/RAK	4114	3173000	44516,22*	Min: 21,32°C Max: 33°C	Metro, ferry, bus, taxi
Kuwait City	200	4100000	29040*	Min: 19,88°C Max: 34,34°C	Bus, taxi
Masdar/Abu Dhabi	6 (972)	40000 (1200000)	100000*	Min: 20,23°C Max: 33,68°C	Bus, taxi
Doha	132	796947	66600*	Min: 21,58°C Max: 32,7°C	Bus, taxi

Source: WMO; National offices for statistics; IEA Energy and transport balances

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Expert Opinion Survey

- Your personal information will be fully anonymized and protected according to EU data protection rules.
- We will contact you just in case of follow up questions and for sharing the research results.

Your Country	
City	
Name	
Organization/ Your function	
E-mail	
Follow-up (yes, no)	

1. Presentation of project

a. Could you briefly describe the smart city project you intend to implement?

Aspects:

- Coverage (city/town quarter/sector)
- Size (km2, inhabitants)
- Timeline/roll-out plan
- Investment needed
- Financing (public, private, PPP)
- Focus (private dwellings, Business, mixed)
- National Project/International cooperation/Cooperation with company

b. Let me ask you about the motivation for taking up the project. On a 6-point scale from 1 (not important at all) to 6 (very important), how would you rate the following motives:

	1	2	3	4	5	6
Climate change adaptation						
Better living conditions for citizens						
Energy independence						
Energy savings						
Sustainability/Sparing of fossil resources						
Modernize the city/infrastructure (fit for the future)						
Living laboratory to test new technologies						
Economic concerns (green growth)						
Mobility concerns						

2 Planning

a. Who are your partners to implement the smart city project?

b. Do you plan to build from scratch or re-organize an existing town (quarter)?

c. (Follow up) Please rate the role of these stakeholders from 1 (not important at all) to 6 (very important)

	1	2	3	4	5	6
National government						
Regional government						
City government						
City Administration						
Business associations						
NGOs						
Citizens						
University/research institutions						
SMEs/start-up/spin-offs						
External partners						
Other (specify)						

d. How do you ensure the coordination/consultation between these partners? Do you consult citizens?

3. Implementation

a. How important are the following energy and transport components in the smart city strategy (Please rate from 1 (not important at all) to 6 (very important)).

	1	2	3	4	5	6
Renewable energies for central use (which RES?)						
Distributed renewables						
Heating and cooling networks						
Building energy efficiency (private)						

Building energy efficiency (office and public buildings)						
Efficient appliances						
Prosumer						
Demand side management						
Smart meters & consumption feedback						
Smart grids/smart infrastructure						
ICT-based solutions (IoT/wireless)						
Public transport (which?)						
Cycling/walking						
E-vehicles						
Traffic management						
Other (specify)						

b. Do you plan to develop business models to sell/export the model solutions which you have implemented?

c. Please rate the following drivers for the implementation of the project from 1 (not important at all to 6 (very important)

	1	2	3	4	5	6
Economics						
Cost effectiveness						
Competitiveness						
New business models						
Increase attractiveness for investors						
Economic advantages by improved infrastructure						
Enable ICT-entrepreneurship						
Deploy ICT/IoT						
Environment & energy						
Lower energy consumption						
Reduce CO2 emissions						
Resource efficiency						
Deploy RES and save fossil fuels						
Governance and policy						
Political support for project						

Improvement of services for citizens						
Allow participation for citizens						
Society						
Population growth						
Traffic problems						
Increase living conditions						
Build up knowledge society						

d. Please rate the following barriers against the implementation of the project from 1 (not important at all to 6 (very important)

	1	2	3	4	5	6
Qualifications						
Lack of qualified workforce						
Lack of technical expertise						
Economics						
Lack of economic expertise						
Investors hesitate to provide finance (risk investment)						
Economic feasibility of project is not guaranteed (negative cost/benefits)						
Value added is not clear						
Management and organization						
Principal-agent problem with external construction partner						
Specialists focus too strongly						
Missing standardization of IT-interfaces						
Expenditure of time						
Governance and policy						
Complex administration structure (coordination)						
Missing integrative planning						
Missing political framework conditions						
Missing acceptance by public (privacy, data protection)						

4. Governance: How do you intend to run the future city (public, PPP, private government arrangement?)

5. Impact: Do you have evaluations/studies on the impact of the project, which you could share with me?

Thank you for your cooperation and support

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Arab-German Young Academy of Sciences and Humanities (AGYA)

A.4 Survey data for descriptive statistics

	Renewables			Energy efficiency			Demand management		Smart meter/grids		
City	Central	Decentral	Heating & Cooling	Buildings private	Buildings public	Appliances	Prosumer	DSM	Smart meter	Smart grid	ICT solutions
1	2,0	6,0	6,0	3,0	6,0	6,0	5,0	6,0	4,0	6,0	6,0
1	6,0	6,0	3,0	5,0	6,0	3,0	6,0	6,0	5,0	6,0	6,0
1	6,0	6,0	6,0	5,0	5,0	4,0	6,0	6,0	5,0	6,0	6,0
2	6,0	6,0	6,0	6,0	5,0	6,0	4,0	5,0	5,0	6,0	6,0
2	5,0	5,0	4,0	2,0	2,0	3,0	4,0	2,0	4,0	6,0	6,0
3	4,0	6,0	6,0	5,0	6,0	4,0	5,0	6,0	4,0	6,0	6,0
3	6,0	6,0	6,0	6,0	6,0	5,0	4,0	4,0	5,0	5,0	6,0
4	4,0	5,0	6,0	3,0	6,0	4,0	1,0	3,0	1,0	1,0	1,0
4	5,0	6,0	6,0	6,0	5,0	6,0	1,0	4,0	3,0	3,0	3,0
5	6,0	6,0	6,0	6,0	4,0	1,0	6,0	3,0	6,0	6,0	6,0
5	6,0	6,0	6,0	6,0	5,0	6,0	4,0	5,0	5,0	6,0	6,0
5	6,0	6,0	6,0	6,0	5,0	6,0	4,0	5,0	5,0	6,0	6,0
6	6,0	6,0	6,0	6,0	5,0	3,0	1,0	1,0	5,0	5,0	5,0
6	5,0	5,0	4,0	5,0	4,0	4,0	4,0	5,0	6,0	6,0	6,0
7	6,0	3,0	6,0	6,0	6,0	5,0	3,0	3,0	3,0	4,0	4,0
7	6,0	6,0	6,0	6,0	6,0	5,0	5,0	5,0	6,0	6,0	6,0
11	4,0	6,0	2,0	4,0	5,0	6,0	3,0	2,0	6,0	5,0	2,0
11	4,0	4,0	4,0	4,0	6,0	6,0	4,0	5,0	5,0	4,0	6,0
8	4,0	4,0	4,0	4,0	4,0	4,0	4,0	4,0	4,0	4,0	3,0
8	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0
12	6,0	6,0	6,0	6,0	6,0	4,0	4,0	4,0	4,0	5,0	6,0
12	2,0	2,0	6,0	6,0	5,0	6,0	4,0	5,0	6,0	6,0	6,0

	Mobility				Motivation to engage in smart city activies		Role of stakeholders				
City	Public transport	Cycling/walking	E-Vehicles	Traffic management	Motive resource & energy saving	Motive energy & environment	Stakeholder national government	Stakeholder local government	Stakeholder NGO-private	Stakeholder business	Stakeholder external-universities
1	6,0	5,0	5,0	6,0	4,0	5,0	3,0	6,0	4,0	5,0	5,5
1	5,0	6,0	6,0	6,0	4,0	5,5	3,0	6,0	3,5	5,5	5,5
1	6,0	6,0	6,0	5,0	5,0	5,0	3,0	6,0	4,5	5,0	5,0
2	6,0	6,0	6,0	6,0	2,5	5,0	5,0	6,0	5,0	4,5	6,0
2	5,0	2,0	6,0	5,0	5,0	4,5	4,0	5,0	3,5	2,5	4,0
3	6,0	5,0	5,0	6,0	5,0	5,5	4,0	6,0	4,5	5,0	5,5
3	6,0	6,0	6,0	6,0	5,5	5,5	5,0	6,0	5,0	4,5	5,0
4	1,0	1,0	1,0	1,0	6,0	4,5	1,0	6,0	1,0	1,0	6,0
4	3,0	3,0	3,0	3,0	6,0	6,0	1,0	6,0	3,5	3,0	6,0
5	6,0	6,0	6,0	5,0	5,5	5,5	1,0	6,0	3,5	3,5	6,0
5	6,0	6,0	6,0	6,0	6,0	6,0	5,0	6,0	4,5	4,5	6,0
5	6,0	6,0	6,0	6,0	6,0	6,0	3,0	6,0	5,5	4,5	6,0
6	1,0	1,0	1,0	1,0	5,0	5,5	6,0	5,0	2,5	2,0	3,0
6	4,0	4,0	3,0	6,0	5,0	5,0	6,0	6,0	5,0	2,5	3,5
7	6,0	5,0	6,0	3,0	1,0	2,5	5,0	2,0	4,0	2,5	2,0
7	5,0	5,0	6,0	6,0	6,0	5,5	6,0	3,0	5,0	4,5	5,5
11	1,0	1,0	4,0	1,0	4,5	3,5	6,0	6,0	1,5	1,0	3,5
11	3,0	3,0	4,0	5,0	5,0	6,0	5,0	5,0	4,0	4,0	5,0
8	3,0	3,0	3,0	3,0	4,0	3,0	6,0	5,0	4,0	5,0	4,0
8	3,0	3,0	3,0	3,0	3,0	4,5	6,0	6,0	4,5	3,0	3,0
12					5,5	3,0	6,0	6,0	6,0	5,5	5,0
12	6,0	6,0	4,0	5,0	5,0	5,0	6,0	6,0	2,0	2,5	3,5

	Evaluation of technology options					Drivers and barriers for/against smart city development							
City	Renewable Energy	Energy Efficiency	Prosumer /Demand side management	Smart grids/smart meters	Mobility	Driver Economics	Driver Environment/energy	Driver governance	Driver society	Barrier qualifications	Barriers economics	Barrier management	Barrier governance
1	6,0	6,0	5,5	6,0	5,5	5,0	6,0	6,0	6,0	3,0	2,0	3,5	5,0
1	6,0	5,0	6,0	6,0	6,0	6,0	6,0	4,0	6,0	1,5	1,0	1,0	3,5
1	6,0	5,0	6,0	6,0	6,0	6,0	6,0	5,0	5,5	3,0	3,0	5,0	5,0
2	6,0	6,0	4,5	6,0	6,0	5,0	6,0	5,0	6,0	3,5	4,0	3,5	5,5
2	5,0	2,0	3,0	6,0	5,0	5,0	4,5	3,0	3,0	5,0	2,0	3,0	3,5
3	6,0	5,0	5,5	6,0	5,5	5,0	6,0	6,0	6,0	3,0	2,0	3,5	5,0
3	6,0	6,0	4,0	5,0	6,0	6,0	6,0	6,0	5,0	1,5	2,5	3,5	4,0
4	5,0	4,0	2,0	1,0	1,0	6,0	6,0	6,0	3,5	1,0	1,0	1,0	5,0
4	6,0	6,0	2,5	3,0	3,0	6,0	6,0	5,0	5,0	2,5	3,0	2,5	4,0
5	6,0	4,0	4,5	6,0	6,0	5,0	6,0	6,0	6,0				
5	6,0	6,0	4,5	6,0	6,0	5,0	6,0	5,0	5,5	3,5	3,5	2,5	4,0
5	6,0	6,0	4,5	6,0	6,0	5,0	6,0	6,0	6,0	3,0	2,5	3,0	2,5
6	6,0	5,0	1,0	5,0	1,0	5,0	6,0	6,0	6,0	4,0	3,0	3,0	2,0
6	5,0	4,0	4,5	6,0	4,0	6,0	6,0	6,0	6,0	6,0	3,0	5,5	5,0
7	6,0	6,0	3,0	4,0	5,5	2,0	2,0	3,0	4,5	2,0	2,0	2,5	4,0
7	6,0	6,0	5,0	6,0	5,5	4,0	4,0	6,0	6,0	4,0	5,0	5,0	6,0
11	4,0	5,0	2,5	5,0	1,0	5,0	6,0	3,0	4,0	1,0	1,5	1,5	2,5
11	4,0	6,0	4,5	5,0	3,5	5,0	6,0	5,0	5,0	2,0	2,5	2,5	3,0
8	4,0	4,0	4,0	4,0	3,0	6,0	4,0	5,0	5,0	6,0	6,0	4,5	5,0
8	3,0	3,0	3,0	3,0	3,0	3,0	3,0	6,0	6,0	3,0	2,0	3,0	3,0
12	6,0	6,0	4,0	5,0		5,0	6,0	5,0	5,0	5,0	4,5	4,0	5,0
12	2,0	6,0	4,5	6,0	5,5	5,0	4,5	5,0	6,0	4,5	2,0	3,0	1,5