Techno-Economic Evaluation of Radio Innovation Antenna

as a solution for very low ARPU AMEA areas

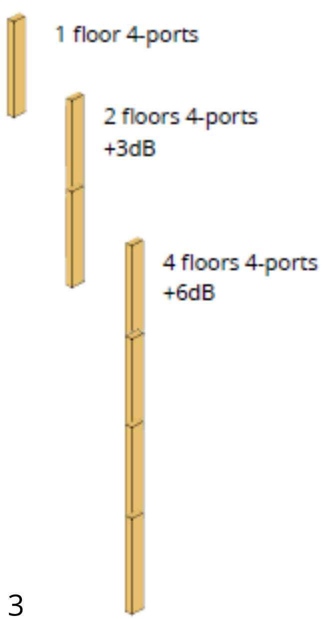
Content

Radio Innovation antenna system

Each panel, 2.5m x 0.3m contains an antenna working in a frequency band

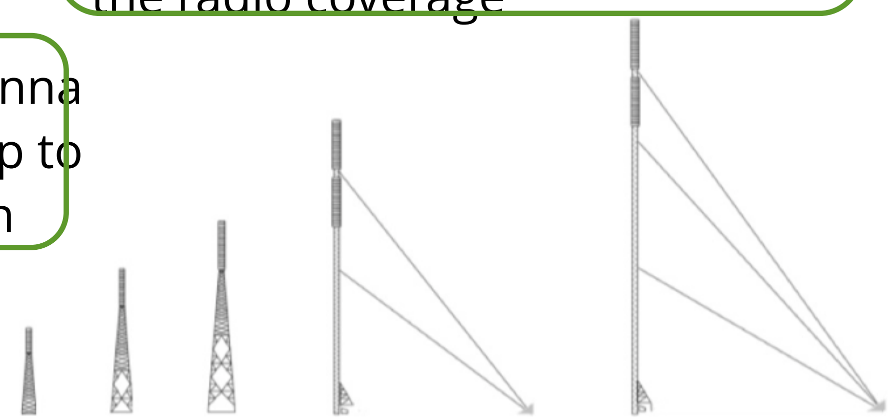
3 frequency bands
790-960 MHz
1710-2170 MHz
2300-2700 MHz

36 antenna panels in cylinder form,
with max 18 sectors.
The tower can be shared by several MNO



Up to 8 floors of antenna panels can be piled up to increase antenna gain

Antenna panel is wind resistant, it can be installed at mast of several hundred meters height to enlarge the radio coverage



Advantages of RI antenna as a solution for very long range radio site

1. A single RI antenna has bigger gain than traditional antenna, e.g. 20dBi at 800MHz band, compared to 16.5 dBi for traditional antenna at this band

2. The antenna can be piled vertically to increase the antenna system gain
   - 1 floor to 2 floors, + 3dB
   - 2 floors to 4 floors, +3dB
   - 4 floors to 8 floors, +3dB

3. The antenna system can be installed at very tall mast

Content

- **Radio Innovation antenna**
- **Evaluation method, radio site configurations & cost model**
- **Results & analysis**

Method for calculation of radio site coverage in LTE

- The **LTE** radio coverage with/without Radio Innovation antenna is calculated by
  - Link budget tool, LTE edition
    - Inputs
      - Antenna gain
      - Transmit power
      - Frequency band and its width
      - Site technical characteristics: MIMO order, reception diversity
      - Antenna height
      - Target cell throughput for DL and UL
    - Outputs
      - Max allowed path loss in dB
  - Long distance propagation model
    - The propagation model in Link budget tool is not appropriate for very long distance
    - A modified Hata long distance propagation model has been used in our study
      - Input
        - Max allowed path loss in dB
        - Antenna height
        - Frequency band
      - Output
        - Site radius, i. e. the maximal distance to satisfy the max. allowed path loss
  - 3GPP radio interface physical channels link budget data
    - The maximal path loss for each type of control and data channels have been deduced
    - The comparison with the max allowed path loss calculated by target throughputs permit to identify which channel is the most limiting factor for radio coverage

Method for calculation of radio site coverage in LTE

- The minimum among the 4 following numbers is considered as the radio site radius:
  1. The site radius calculated by target downlink throughput
  2. The site radius calculated by target uplink throughput
  3. The site radius calculated by minimum downlink control channel level
  4. The site radius calculated by minimum uplink control channel level

Radio site configurations considered in the study

- 21 radio site configurations are assessed to find the best trade-off between site cost and its coverage

- Site configuration variables
  - *With or without Radio innovation antenna*
  - *Number of Radio Innovation antenna floors: 1, 2, 4 floors*
  - *Tower/mast height: antennas installed at 60m, 75m, 108m*
  - *Sector number per site: 3, 6 sectors*
  - *MIMO configurations: MIMO 2x2, MIMO 4x2*
  - *Transmit power per sector: 80w, 160w*

- The combination of these site variables gives 21 radio site configurations which have been assessed and compared

Cost model

- Cost items included in the study
  - Tower/mast CAPEX
    - including all related costs, from 68k€ to 178k€
  - eNodeB
    - Buyin/Ericsson commercial contract prices, including hardware, embedded software and I&C, from 20k€ to 32k€
    - A local discount is possible after local negotiation
  - Antenna
    - average traditional antenna price
    - 4000$ per antenna panel for Radio Innovation antenna system
  - Antenna installation
    - based on a French commercial proposal
  - Energy equipment
    - solar energy equipment including backup battery, from 25,8k€ to 35k€
  - Site rent (assumption)
  - Site maintenance
  - eNodeB maintenance
  - Antenna maintenance
- Cost items **not** included in current edition
  - Backhaul CAPEX and OPEX

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Conditions of link budget calculation

- 2 sets of targeted throughputs
  - DL = 2 Mbps, UL = 512 kbps
  - DL = 1 Mbps, UL = 216 kbps
  - **All results in following slides are relative to DL = 1 Mbps, UL = 216 kbps**
  - **The results relative to DL = 2 Mbps, UL = 512 kbps are presented in Annex**

- The penetration type is outdoor, device type is desk

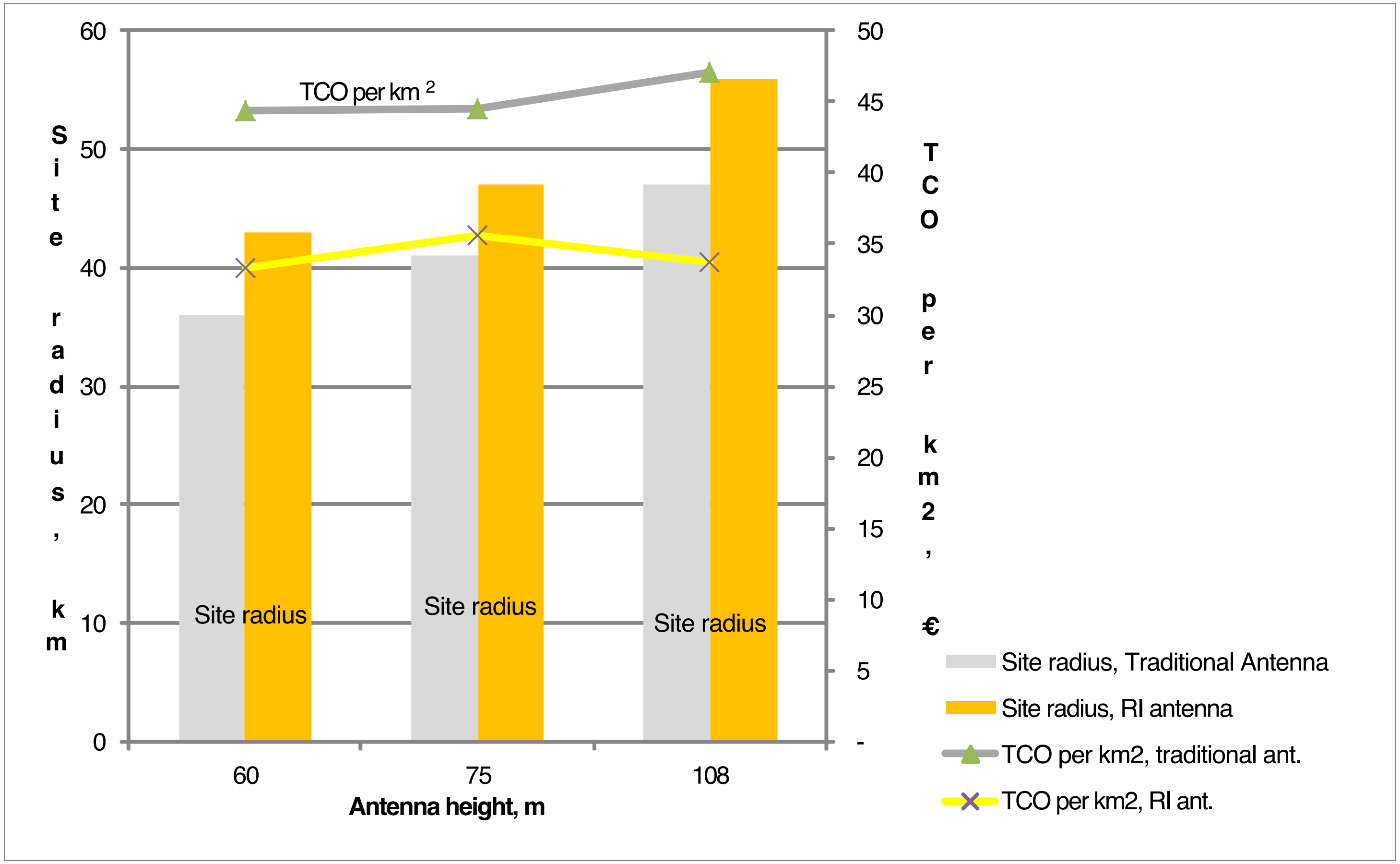
- LTE FDD at 800MHz band, 10MHz band width

- The neighboring cell load is set to 20%

- The user terminal is Cat4
  - output power = 22 dBm
  - antenna gain = 0 dB

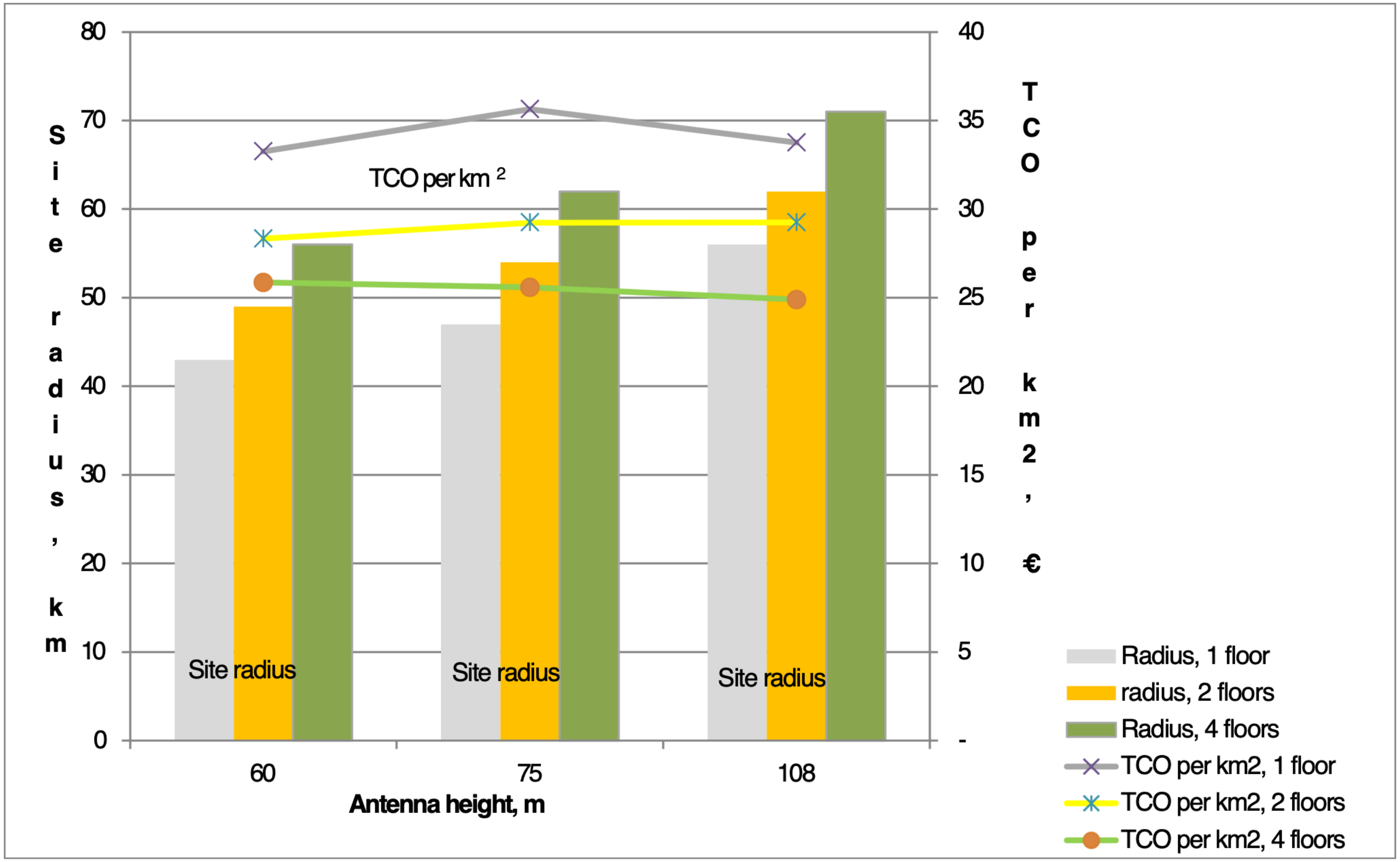
- Feed loss = 0.5dB, Shadowing margin = 3.6 dB

With or without Radio Innovation antenna (1 floor antenna configuration)



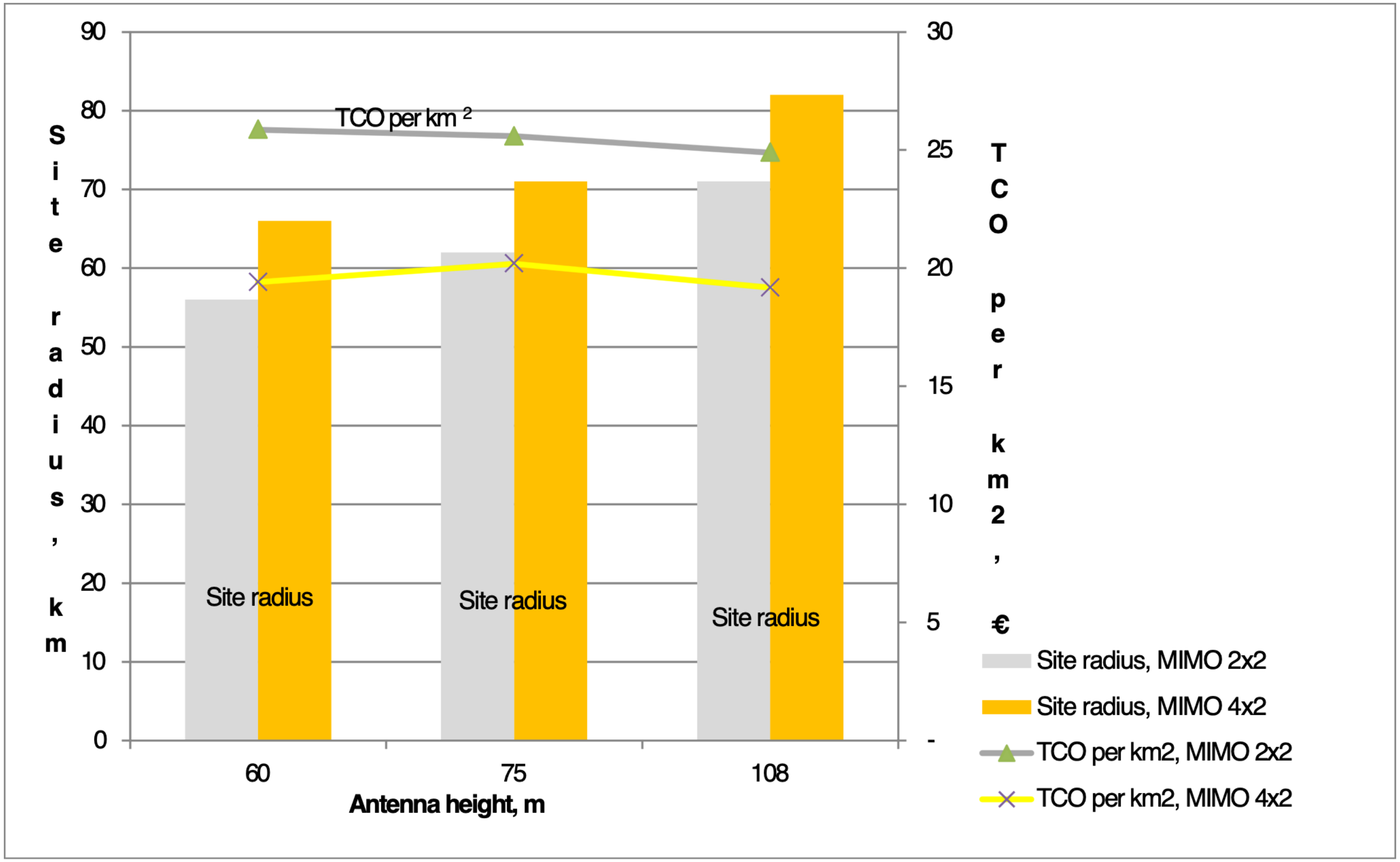
- With the same number of antennas (same number of floors), The Radio Innovation antenna system extends the coverage and lower the TCO per km^2
- This advantage is only due to its higher unit antenna gain, 20dBi compared to 16.5dBi for traditional antenna
- With 1 floor of antenna, increasing antenna height allows to extend the coverage but there is no significant change of TCO per km^2, because higher costs for taller masts

Influence of number of Radio Innovation antenna floors



- Every time the number of antenna floors is doubled, the gain of Radio Innovation antenna system is thus doubled (+3dB)
- A antenna system with more antenna floor extends the coverage and lower TCO per km^2
- No significant change of TCO per km^2 among different antenna heights is observed
- The same phenomena could also occur if the traditional antennas were piled up vertically

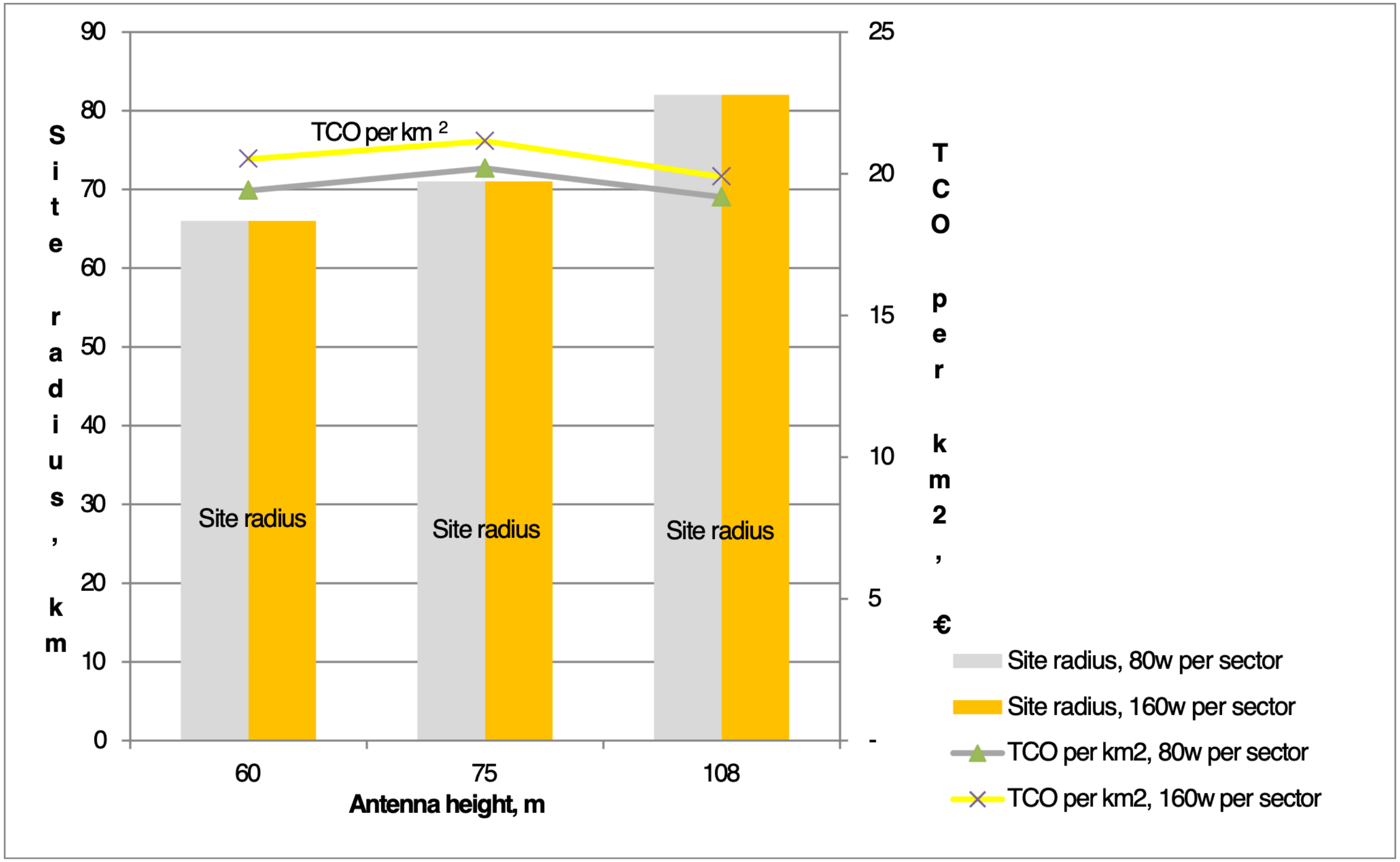
From MIMO 2x2 to MIMO 4x2



- The bigger radius when MIMO 4x2 is installed instead of MIMO 2x2 results from the uplink diversity gain (+3dB in the case of MIMO 4x2 compared to MIMO 2x2)

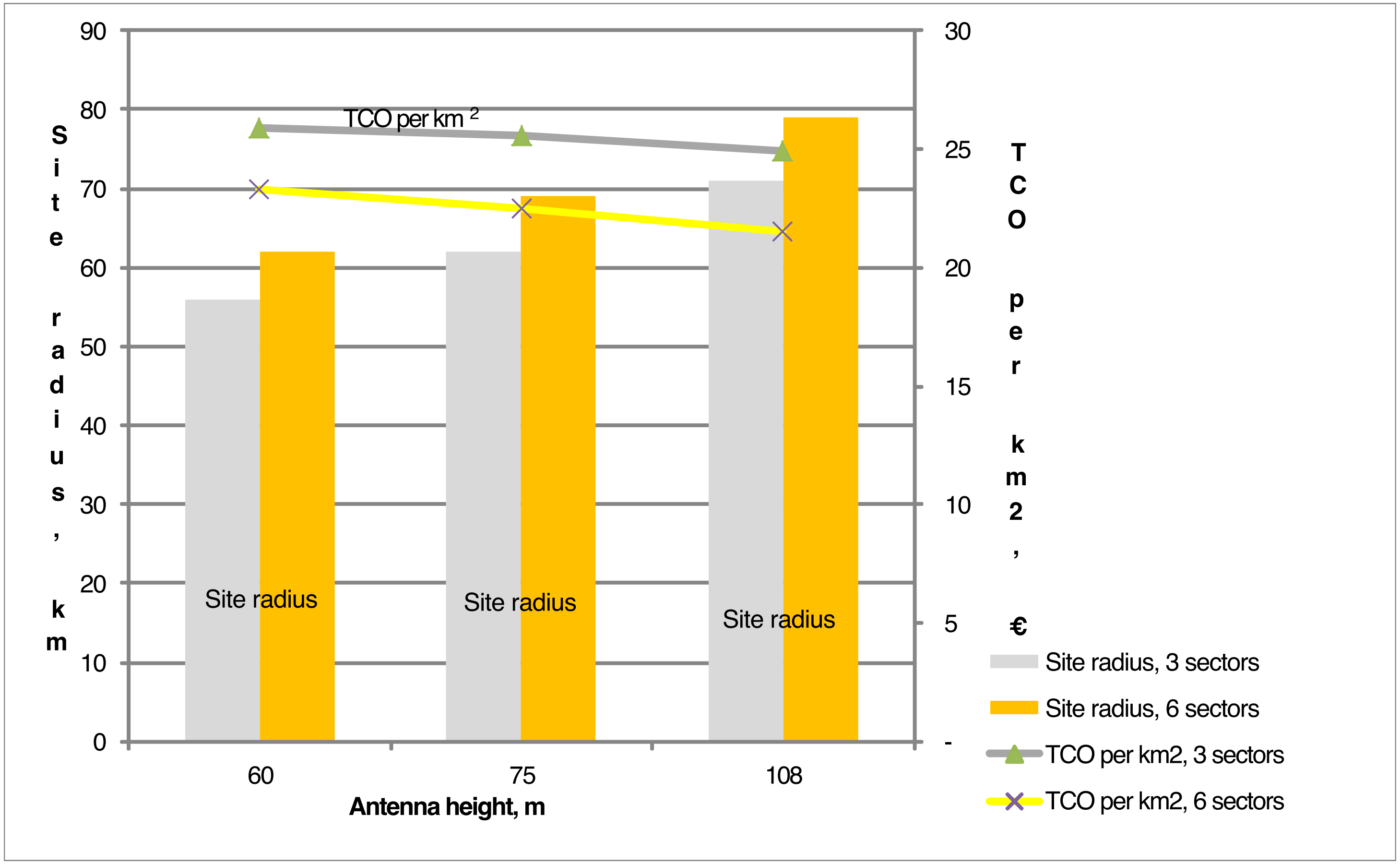
- The higher antenna gain brought by MIMO 4x2 in downlink has no impact on site radiu since the uplink is the limiting direction, but it increases the downlink capacity

When the base station transmit power is doubled from 80w to 160w per sector



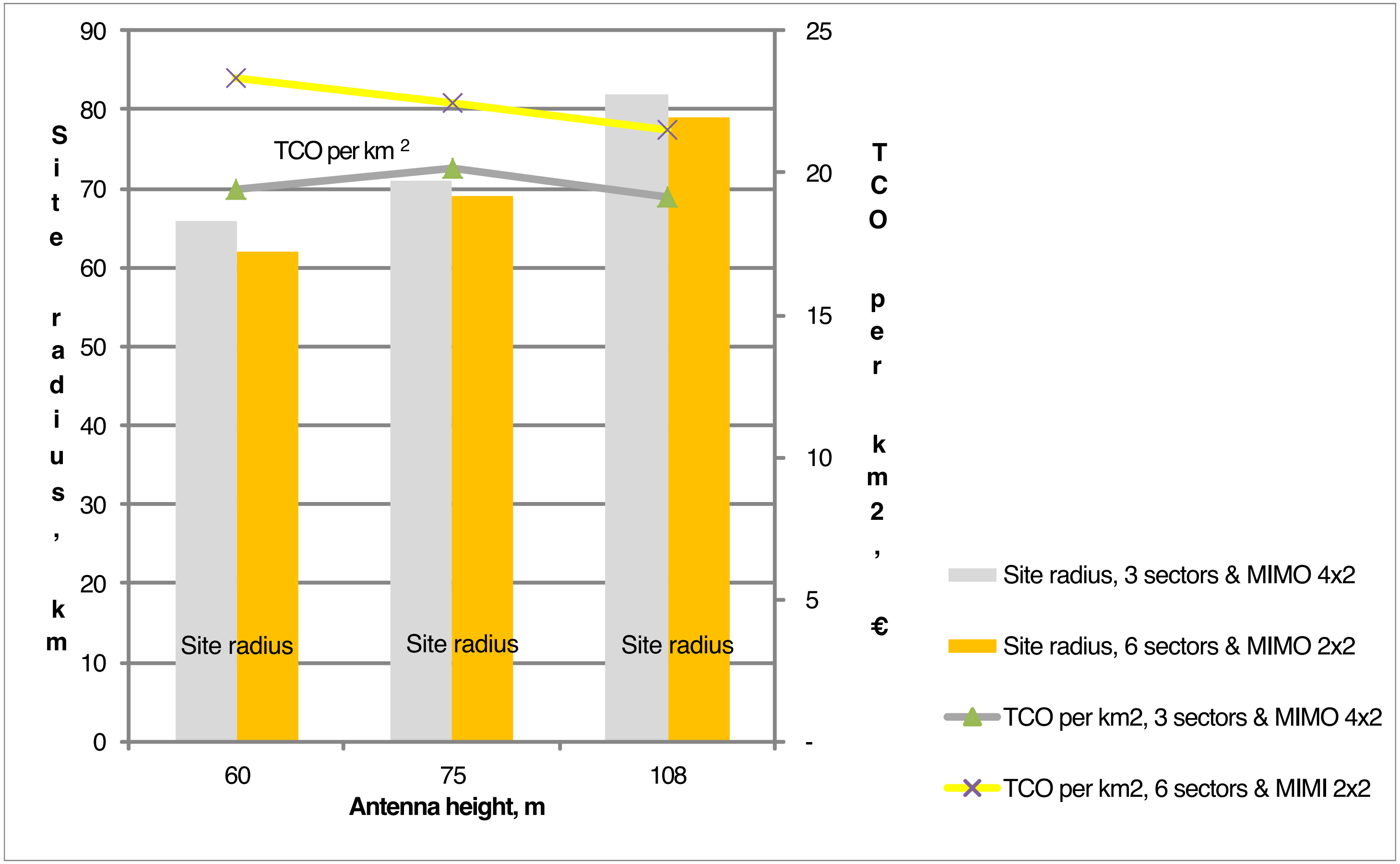
- No benefit observed when the Base station output power pass from 80w to 160w per sector
- The site radiu remains the same while the TCO per km2 is slightly more higher for 160w case

From 3 sectors to 6 sectors site



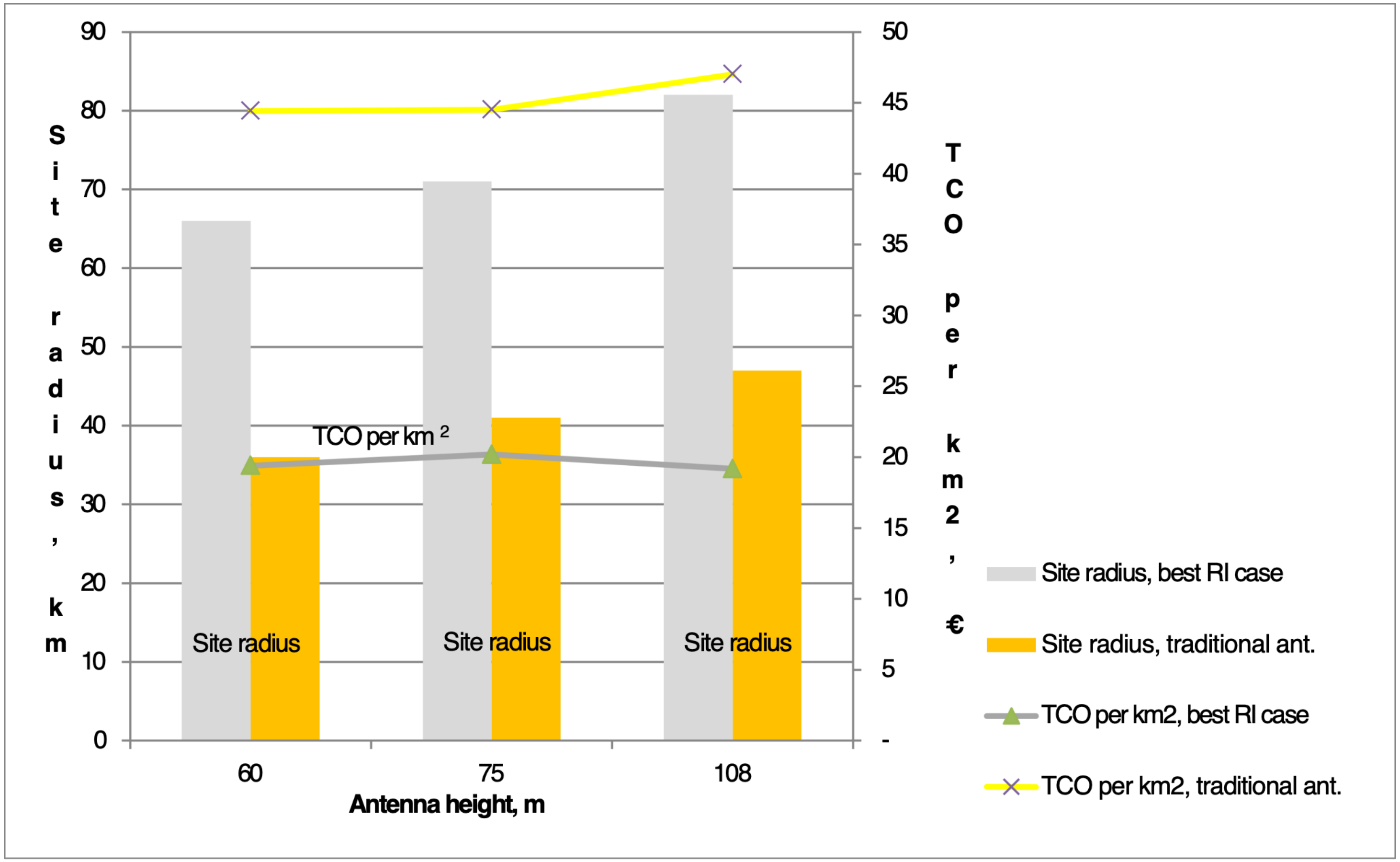
- The sectorization extends the site radius and reduces the TCO per km^2
- When the number of sectors is doubled, the total capacity of a site is also doubled

Higher order MIMO or more sectors ?



- Compared to upgrade a 3 sector to 6 sector site, the upgrade from MIMO 2x2 to MIMO 4x2 is more efficient to extend the radio coverage thanks to higher order uplink diversity, and MIMO 4x2 is also a more cost efficient solution than 6 sectorization
- Sectorization is a more appropriate solution for increasing the traffic capacity of a site

Comparison between the best case of Radio Innovation in scope and traditional antenna



- The important improvements can be noted when a comparison is made between traditional antennas and the most favorable configuration of Radio Innovation antenna system
  - Traditional antenna: MIMO 2x2, one single antenna per sector (1 floor)
  - Radio Innovation antenna system: MIMO 4x2, 4 vertical piled antennas per sector (4 floors)
  - **Traditional antenna: the smallest site radius is 36 km, the highest TCO/km² is 47€**
  - **Radio Innovation antenna system : the highest site radius is 82 km, the lowest TCO/km² is 19€**

Traffic capacity requirements of extreme long range mobile network

- Traffic model of extreme long range network in low density area
  - 2 users/km^2
  - 1 GBytes/month/subscriber as traffic volume (the consumption per subscriber varies very much from one AMEA country to another)

- Average throughput at Busy Hour per site
  - Average throughput at BH per subscribers: 8,42 kbps
  - Dimensioning Throughputs - Average throughput at Busy Hour per site:
    - **28 Mbps** (traditional ant. at 60m, MIMO 2x2)
    - **221 Mbps** (RI ant. at 108m, MIMO 2x2)
    - **273 Mbps** (RI ant. at 108m, MIMO 2x2, 6 sectors)
  - With a typical spectrum efficiency value of 1,7 bit/Hz, the traffic capacity of a tri sector site is **17 Mbps** on 10MHz bandwidth per cell basis, i.e. **51Mbps** for a 3 sector site, **102Mbps** for a 6 sector site

- **The area is covered by a under dimensioned network (without enough traffic capacity for 1 GBytes/subscriber traffic) if a network with estimated site radius is rolled out**

- Options
  - More spectrum if available
  - More sectors per base station
  - 5G spectrum efficiency will be a bit higher

Requirements for backhaul network of extreme long range mobile network

- High throughputs per site
- Very large inter-site distance (ISD)
  - traditional antenna at 60m, MIMO 2x2: 62km
  - 4 floors of RI antenna at 60m, MIMO 2x2: 97km
  - 4 floors of RI antenna at 60m, MIMO 4x2: 114km
  - 4 floors of RI antenna at 60m, MIMO 2x2, 6 sector: 107km
- The maximum span of one traditional microwave link is 50km
  - **If more than 1 hop is needed between 2 sites, a long range solution has no more economic benefit**
- The span of a sub-6 microwave hop could reach 100km or more according to vendors, but its throughputs are only several Mbps
- The optic fiber's price is prohibitive
- The feasibility of satellite backhaul, especially its cost, should be studied

General comments

- For all studied configuration the **uplink** is the limiting direction
- The site radius are given by target throughput rather than minimum common channels' levels
- From 60m to 108m **antenna height**, even taller mast/ tower can enlarge the radio coverage, the TCO per unit coverage surface nearly stay the same for all site configuration studied
- According to the announced performances by Radio Innovation, its antenna system can result in **important improvement** both of **site radius** and of **TCO per unit coverage surface**

General comments

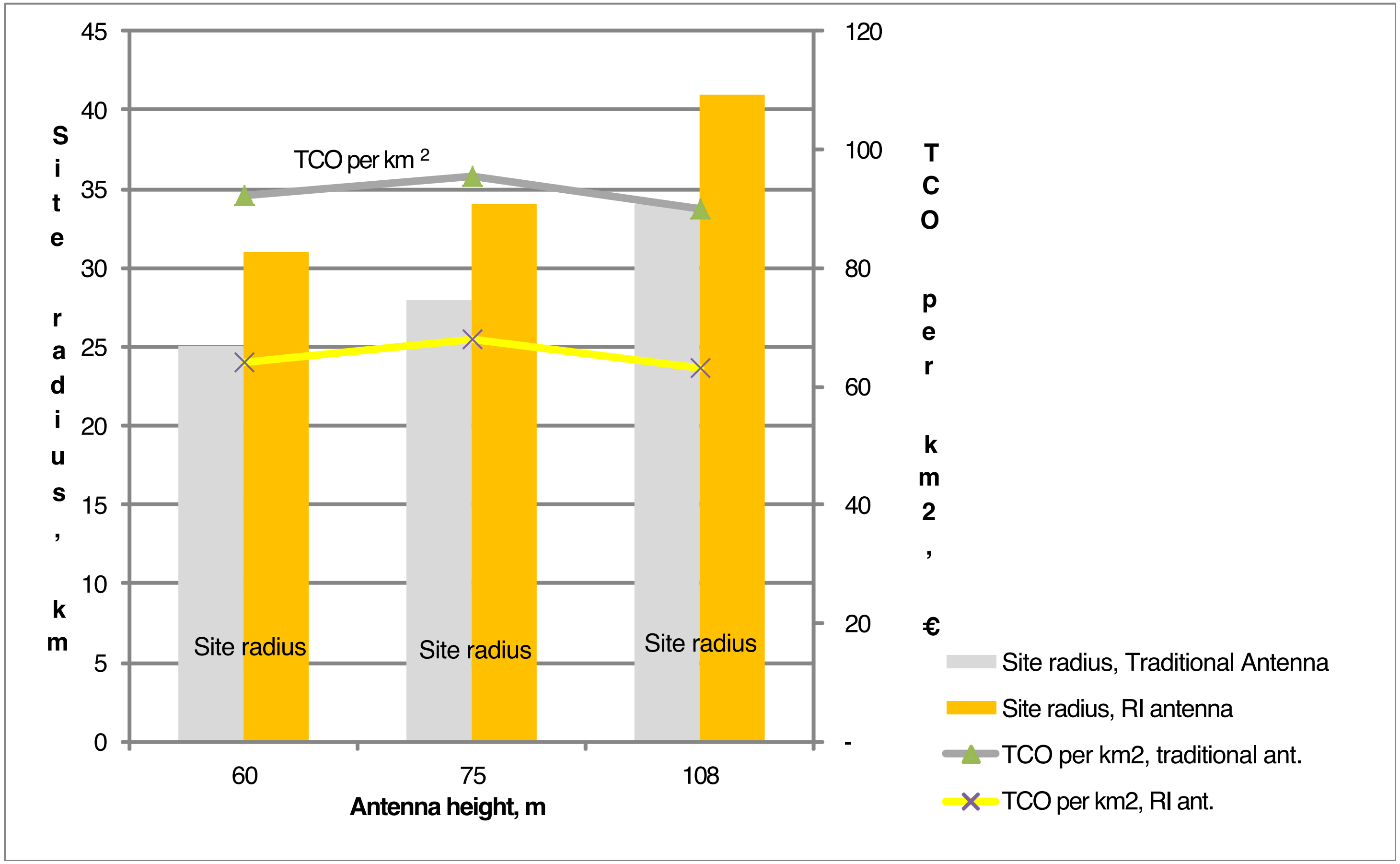
- Nevertheless the improvements brought by Radio Innovation antenna system are due to
  - Its higher unit antenna gain
  - Its vertical diversity, i.e. several vertically piled floors of antennas
- Even the far remote areas are covered with such kind of very long range cells, the very long range network performances are poor: low throughputs and limited traffic volume per subscriber
- The appropriate backhaul solution needs to be identified for very big site radius and high throughput, the total cost efficiency (radio + backhaul) must be evaluated

Thank you

Annex 1

Results & analysis related to targeted throughputs of 2Mbps at DL and 512kbps at UL

With or without Radio Innovation antenna (1 floor antenna configuration)



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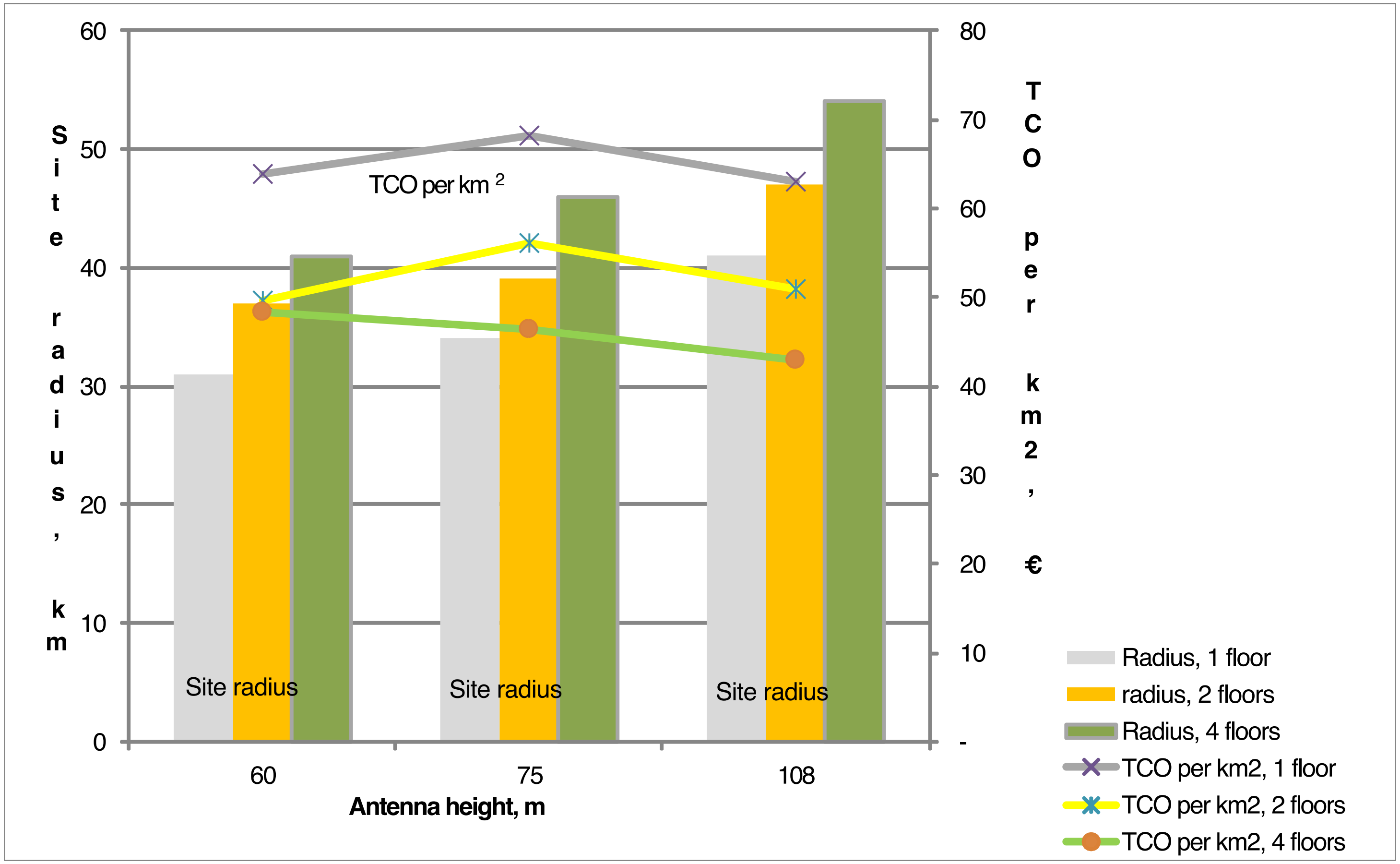

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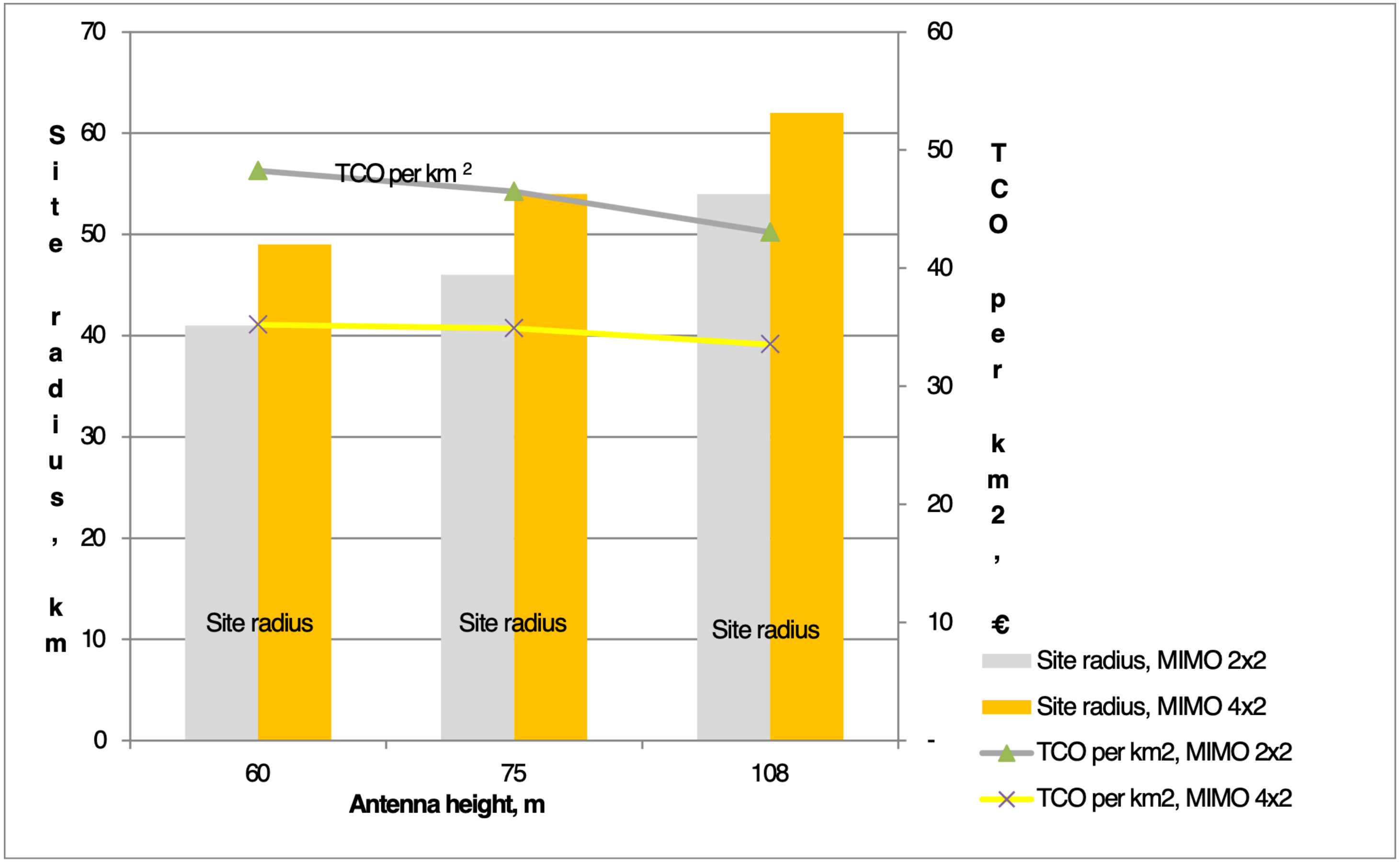

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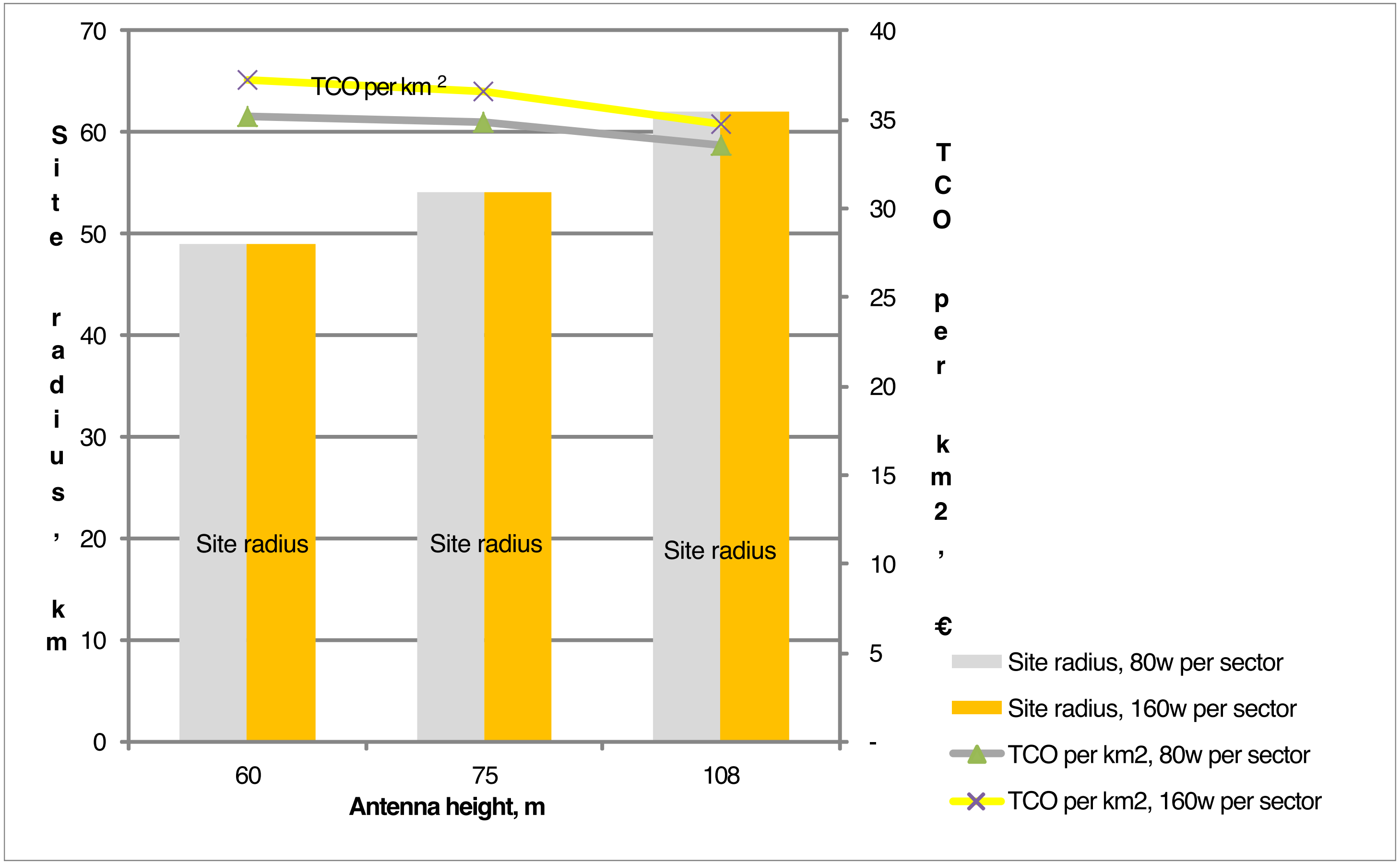

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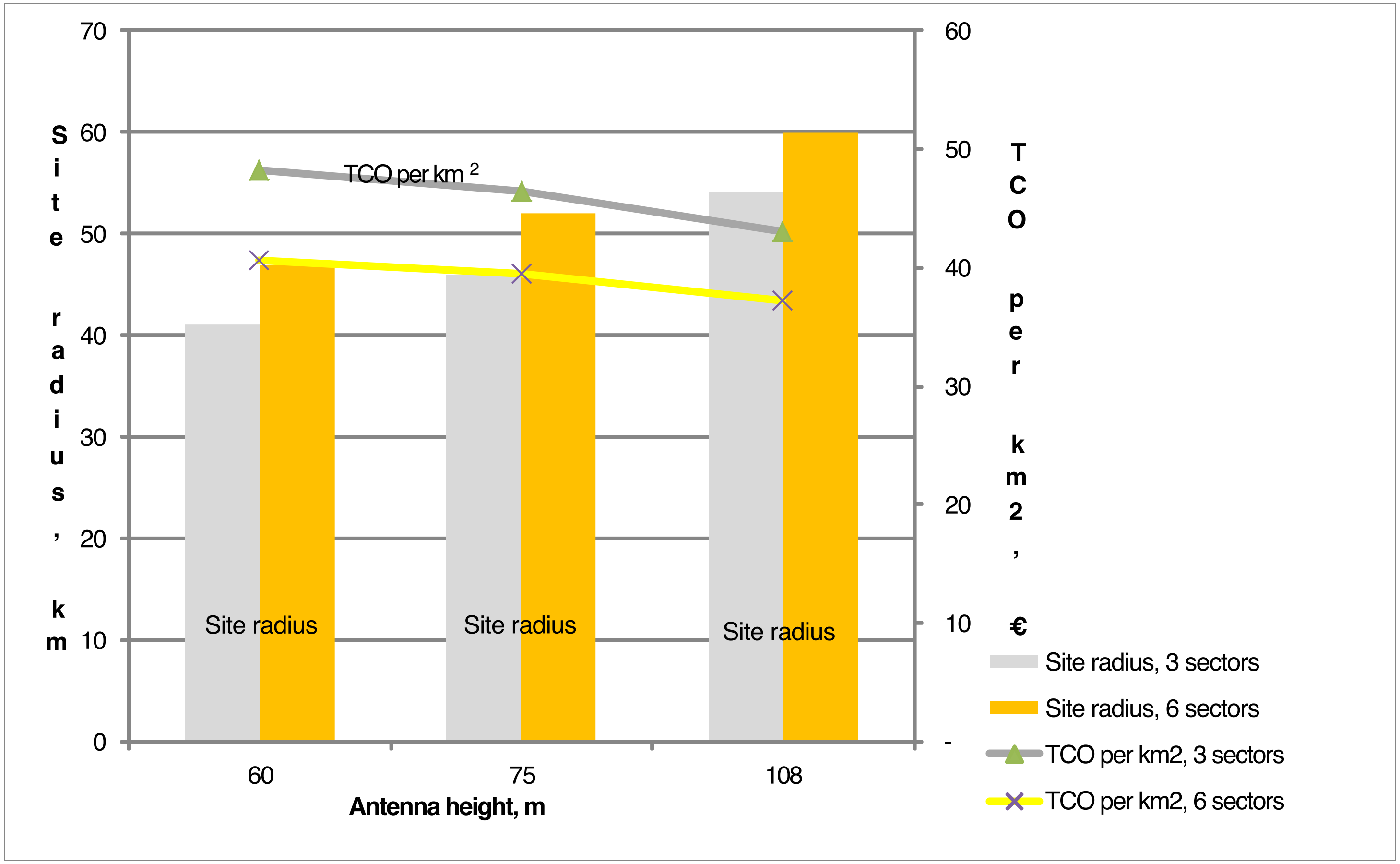


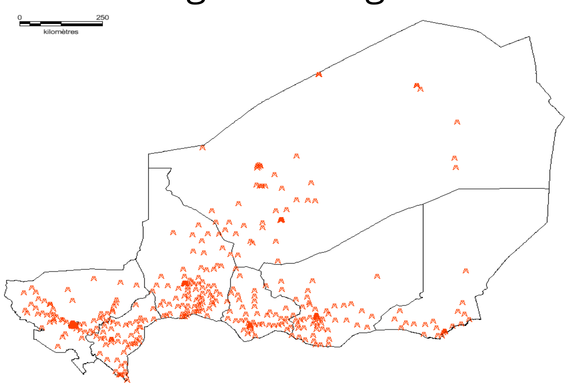
- The sectorization extends the site radius and reduces the TCO per km^2

Annex 2

Possible gains from Ultra long range coverage

Problem statement and possible gains from Ultra-Long-Range-Coverage

Niger existing BTS



Radius cell (km)	Number of cells to be deployed	Number of inhabitants covered	Number of villages covered
20	119	1.884.230	4443
30	74	2.034.988	5092
45	45	2.139.909	5370
60	33	2.266.273	5817
75	21	2.237.530	5910

7337 villages (>= 300 inhabitants)
not yet connected = 2746820 inhabitants