

# FINAL PROJECT REPORT

## NOISE ANNOYANCE IN THE INNER CITY COPENHAGEN

SPECIAL COURSE

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## 1. Introduction

Noise pollution is a big issue in urban areas in cities since it affects negatively to the human development, urban environment, and human lifestyle. Urban soundscapes are an issue for urban planners and designers, having an important role for indoor and outdoor architectural ambiances. Therefore, currently it is a public concerned that the correlation between noise reduction and acoustic comfort will be high. Mitigating sound levels does not necessarily lead to a better acoustic comfort. Currently, local authorities around the world are actively making noise maps of their cities.

Audition is a psychophysics ability to perceive sound and vibrations, people can perceive the world through their ears. Consequently, the evaluation of sound effects is mainly based on subjective parameters rather than objective issues because considerable differences in noise tolerance can be found within a group of people. Urban planning and designing are focused in people acoustic sensibility, the so called noise sensibility.

Noise level produced by the environment affect directly to the acoustic comfort inside buildings, so knowing users' perception of sounds is vital in a noise assessment project. Therefore, people's reactions and perception of noise is assessed in this report.

### 1.1. Environmental Noise

Noise is the result and outcome of modernity, and environmental noise sources emanating from outdoor and indoor. Environmental noise is also called community noise, which is the noise emitted from all sources except noise at the industrial workplace (WHO, 1999).

There are many types of environmental noise sources that affect the community. Currently, noise comes from industry and transportation sources and from leisure and residential areas. Since there can be different kind of sources it is implicit that the same Leq do not cause the same response or effect in the community.

#### Transportation noise

Transport noise, is the undesired sound caused by road, rail, and air traffic. Noise of road vehicles is mainly caused by the engine and frictional contact of the tires in the pavement and by aerodynamics. Railway noise depends mainly of the speed of the train, engine, wagons, rails and their foundations, and the roughness of wheels and rails. Aircraft noise depends on takeoffs, landings, and flying.

#### Domestic and social-leisure noise

Domestic noise is caused by neighbors' activities, radio, televisions, human and animal sources, household appliances, laundry machines, air conditioning systems, vacuum cleaner, heat pumps, voices, music. Social and leisure sources such us, entertainment devices, private and public parties, outdoor and indoor concerts, bars, restaurants, portable music players, sports, fireworks, discotheques, festivals, and leisure activities.

#### Construction and building services noise

Construction and building noise is generated by cranes, cement mixers, welding, hammering, boring and other work processes. In general, it is any source related with the process of building and manufacturing.

Street services such as garbage disposal and street cleaning can also cause considerable disturbance (WHO, 1999).

### Industrial noise

This noise is caused by machinery of all kinds and it is responsible for annoying noise indoors and outdoors. Rotating, reciprocating machines and air moving equipment generate sounds containing tonal components and wide frequency range (WHO, 1999). The most common sources are fans, steam pressure relief valves, stamping, riveting, road breaking, etc.

## 1.2. Effects of Noise

Noise is part of a cause-effect sequence, in other words, noise is the external agent that after certain exposure can cause harm in humans exposed to noise. The perception of noise is strongly dependent of the context its exposure. People are affected in different ways by the same sound (Korfali et al., 2002). For instance, the sound in a concert is pleasant music to the audience but noise to the neighbors. For the audience the exposure would not be annoying but most probable contributing to hearing loss; for the neighbors, hearing loss would be improbable, but annoyance would certainly occur (Passchier-Vermeer and Passchier, 2000). Figure 1 shows a conceptual model to address the health and quality life effects of noise exposure.

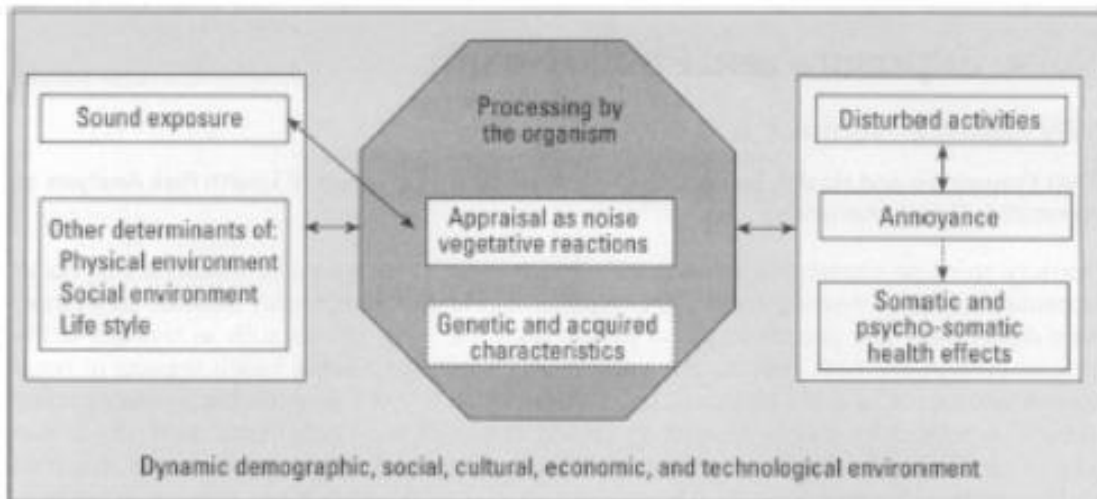


Figure 1. Conceptual model of the interaction of sound with the organism and the occurrence of effects on health and quality of life. (taken from *Passchier-Vermeer and Passchier, 2000*)

Sound can be generated by a vibrating body, for instance, by the corpus of a stringed musical instrument, the membrane of a loudspeaker or by some part of a machine in operation (Kuttruff, 2007). These sound sources generate mechanical vibrations or oscillations that propagate throughout a medium and these physical motions evoke physiological responses in human's auditory system. Figure 2, shows that every sound event produce a sound pressure measured in Pascals and commonly represented by a logarithm scale, the so called Sound Pressure Level expressed in decibel (dB).

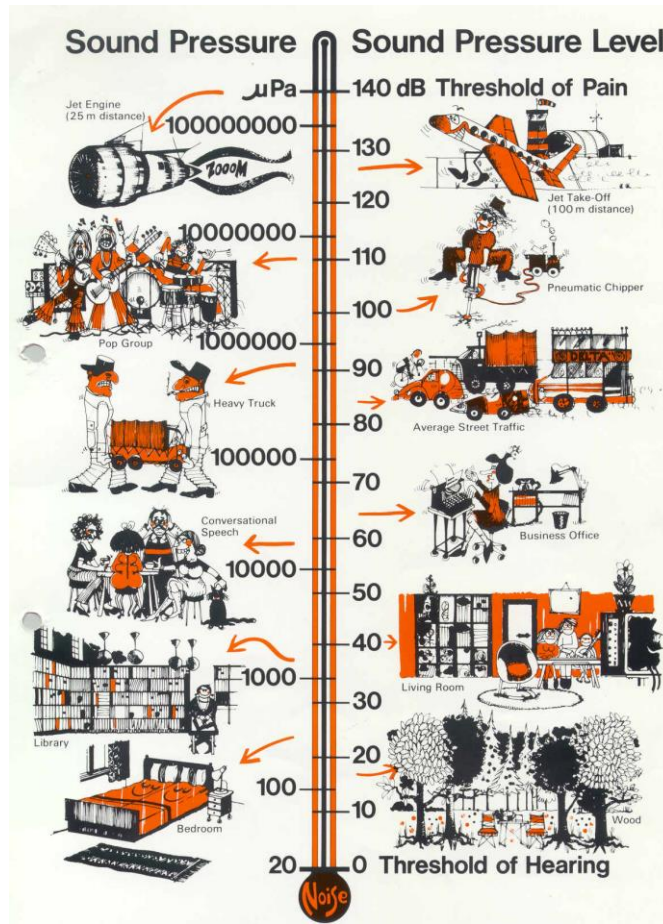


Figure 2. Sound pressure events expressed in dB (taken from <http://personal.cityu.edu.hk/~bsapplec/Fire/SPL01.jpg>)

Figure 3, sound exposure is related to the spectral sensitivity directly related with the human hearing organ, the so called A-weighted sound pressure level (L) is expressed in dB(A). Note that curve A looks like the “reversed” equal loudness curve.

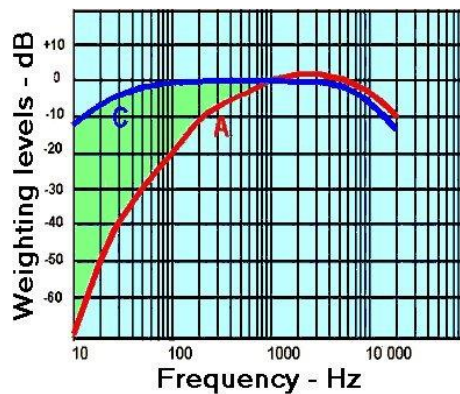


Figure 3 Weighting level curves: A and C-weightings across the frequency ([http://navalmarinearchive.com/research/ims/weighting\\_a\\_c.jpg](http://navalmarinearchive.com/research/ims/weighting_a_c.jpg))

In addition, a person can be exposed to different sounds and noises for a certain period of time. Noise exposure is a measure of equivalent noise “dose” over time, known as Equivalent Sound level expressed in dB(A).

$$L_{Aeq,T} = 10 \log \left[ \frac{1}{T} \int_T 10^{L(t)/10} dt \right],$$

For some environmental health assessment purposes the day-evening-night level ( $L_{den}$ ) is the noise indicator across EU for annoyance. For the Danish Environmental Protection Agency the day ( $L_{day}$ ) is considered from 07:00 to 18:00 without penalty, the evening  $L_{evening}$  is from 18:00 to 22:00 with +5dB penalty, and for the  $L_{night}$  from 22:00 to 07:00 is the maximum penalty of +10dB. These adjustment of 10 or 5 dB(A) is to take into account that during the night and evening noise is more annoying than day-time noise, therefore people are more sensitive to noise (Passchier-Vermeer and Passchier, 2000).

For short noise events and noise peaks is the Sound Exposure Level (SEL). There is also the Day-night ( $L_{dn}$ ) that is the same as the  $L_{den}$  but considering the evening as part of the day ( $L_{day}$  over 16 hours).

Depending of the amount of noise exposure it can harm and cause health effects, when increasing noise levels the effects in physical and psychological health can occur. A person exposed to 80dB(A) for more than eight hours can be caused hearing impairment. Also, psychologically, sound is a sensory perception. Thus, from the perspective of a listener noise is a class of sounds that are considered as unwanted (Berglund et al., 1995).

### 1.3. Assessment of Health Effects

Different types of noises and sound levels can generate different attitudes, responses and effects in human beings. Negative reactions towards increasing noises are directly proportional to the sound level difference between background noise (ambient noise) and a particular noise. Indeed, researchers have found that being exposed constantly to noise with a specific sound level causes physiological and psychological issues. Noise is also a perceptual phenomenon that can cause the same physical and mental issues in people.

Table 1 shows the WHO (World Health Organization) guideline values, which are organized according to specific environments and set at the level of the lowest adverse health effect (the critical health effect).

Table 1. Guideline values for community noise in specific environments (from WHO).

Specific environment	Critical health effect(s)	L <sub>Aeq</sub> [dB]	Time base [hours]	L <sub>Amax, fast</sub> [dB]
Outdoor living area	Serious annoyance, daytime and evening	55	16	-
	Moderate annoyance, daytime and evening	50	16	-
Dwelling, indoors	Speech intelligibility and moderate annoyance, daytime and evening	35	16	-
Inside bedrooms	Sleep disturbance, night-time	30	8	45
Outside bedrooms	Sleep disturbance, window open (outdoor values)	45	8	60
School class rooms and pre-schools, indoors	Speech intelligibility, disturbance of information extraction, message communication	35	during class	-
Pre-school Bedrooms, indoors	Sleep disturbance	30	sleeping-time	45
School, playground outdoor	Annoyance (external source)	55	during play	-
Hospital, ward rooms, indoors	Sleep disturbance, night-time	30	8	40
	Sleep disturbance, daytime and evenings	30	16	-
Hospitals, treatment rooms, indoors	Interference with rest and recovery	#1		
Industrial, commercial, shopping and traffic areas, indoors and Outdoors	Hearing impairment	70	24	110
Ceremonies, festivals and entertainment events	Hearing impairment (patrons:<5 times/year)	100	4	110
Public addresses, indoors and outdoors	Hearing impairment	85	1	110
Music through headphones/ Earphones	Hearing impairment (free-field value)	85 #4	1	110
Impulse sounds from toys, fireworks and firearms	Hearing impairment (adults)	-	-	140 #2
	Hearing impairment (children)	-	-	120 #2
Outdoors in parkland and conservation areas	Disruption of tranquillity	#3		

#1: as low as possible;

#2: peak sound pressure (not L<sub>Amax, fast</sub>), measured 100 mm from the ear;

#3: existing quiet outdoor areas should be preserved and the ratio of intruding noise to natural background sound should be kept low;

#4: under headphones, adapted to free-field values

Summarizing, annoyance is an emotional state connected to feelings of discomfort, disturbance, depression, anger, and helplessness. It can be measured by means of a standardized questionnaire.

## 2. Problem Formulation

### 2.1. Studied Area

The project will assess noise in the inner city of Copenhagen (Indre By), being more specific Downtown Copenhagen also known as Københavns K (see figure 4), and aiming to obtain noise nuisance characteristics for this geographical area. Indre By covers an area of 4.65 km<sup>2</sup>, has a population of 26223 and a population density of 5638 per km<sup>2</sup> (taken from Wikipedia).

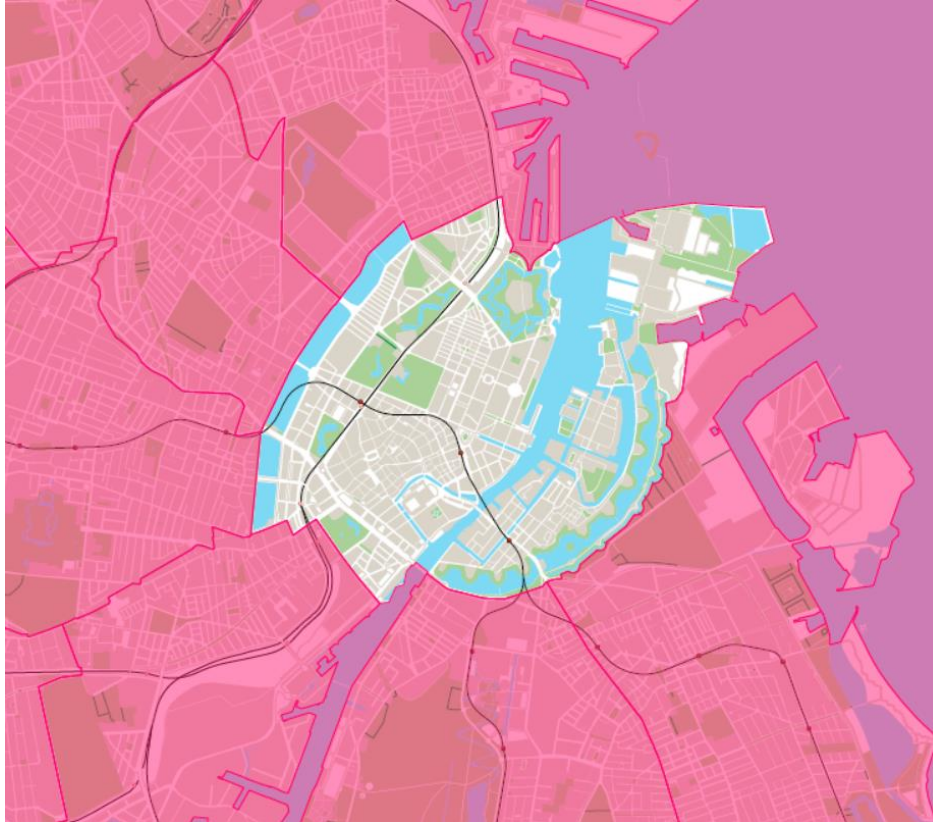


Figure 4. Assessment area: Københavns K. (taken from *Plads guide Indre By*)

Nowadays, Københavns K district is the historic, geographic and political core of Copenhagen; which its boundaries are:

- *East:* Inner Harbour (Inderhavnen) and Copenhagen Harbour (Københavns Havn) that separate it from Christianshavn district.
- *North:* Indre Østerbro.
- *West:* Indre Nørrebro and Frederiksberg municipality which are separated from the Indre By along the so-called “lakes” (Skt. Jørgens Lake, Peblinge Lake, and Sortedams Lake).
- *South:* Vestamager that is separated from Københavns K by the South Harbour (Sydhavnen), and at the southwest is Vesterbro.

Due to the relevance of the studied area, there are a lot of activities during the day and night. There are a lot of human and transportation traffic because of the economic, political, cultural, social, and leisure activities. In addition, there are a considerable number of dwellings where people are potentially affected by the noise emitted from the different activities going on all day and night long.

## 2.2. Danish Legislation: Noise Limits

There are three main entities that manage the noise regulation in Denmark, and the three of them are authorities. These are the Danish Environmental Protection Agency (EPA), Municipality, Advising Board. Also, the guide lines that determine the noise limits are done by the EPA will be used to find the noise



limits according to the land use of each noise zone. Table 2 shows a summary of the different noise sources taking into account by the EPA. It is interesting to see that the EPA does not mention any type of domestic and social-leisure noise sources.

Table 2.Noise limits guideline summary in Denmark (from eng.mst.dk/topics/noise/recommended-noise-limits/noise-zones).

Noise Zone	Metrics (Units)	Land Use	
		Dwelling	Commercial
Aircraft	Equivalent level (Leq_den)	55	60
High-speed ferry	Equivalent level (Leq_den)	55	60
	Maximum level (LAFmax)	70	75
Industrial	mixed dwellings & commercial	55	
	Lday multi-storey dwellings	50	
	low rise dwellings	45	
Motorsport track	Lday	53	-
Railway	Equivalent level (Leq_den)	64	69
	Maximum level (LAFmax)	85	85
	Equiv. acceleration level (Law dBKB)	75	75
Road Traffic	Equivalent level (Leq_den)	58	58
Low frequency, infrasound and vibrations	Lday	25	30
	Infrasound Level(G-wighted level)	75	75

### 2.3. The Motivation

There are several people complaining about the annoying noise levels, and the lack of authorities' control and noise management. Also, the context that Indre By is the oldest area of Copenhagen means that the sound insulation quality is not appropriate according to the current social, technological and economic development of this area.

The inner city has a complex environmental acoustics context due to tourism, transportation, nightlife, neighbors, leisure places, complex architecture, outdoor events, etc. basically these are the general cases of community noise sources that are affecting people living in this area. Community noise is the result and outcome of modernity, and sources emanate from both outdoor and indoor events. Indeed, major contribution to community noise is traffic noise (aircraft, road traffic, rail-roads). However, depending on the context of the receiver the main annoyance can be caused by these other community sources that can affect in the same way, and thus causing the same affections.

For instance, non-traffic sources are not well evaluated, and there are very few investigations about the annoyance created by community noise sources in comparison with the number of publications, normative, guide lines, and regulations for noise due to transportation. Community noise can be complex due to the fact that noise sources are not well defined, and the circumstances to consider a place as affected by community noise.

## 2.4. The Thesis

- Are people living in Indre By annoyed, disturbed or irritated by noise when they are at home?

It is important to know and realized if people are annoyed by the current noise levels in the inner city

- What are the sources that annoy the most and at what time are people annoyed by these sources?

It is relevant for noise management, urban planning and the health of the community.

## 2.5. Objectives

The main goal is to study noise annoyance in Indre By and which noise sources disturbing, annoying and bothering to people.

The specific objective is to investigate the annoyance level of people and which sources people consider the most annoying.

## 3. Methodology and Strategy

Interviewing subjects, i.e. people living in the inner city, throughout a survey in order to identify the general reaction of people towards noise sources and to determine which types of sounds they find annoying or even nerve-wrecking and when/how they are annoyed.

In order to tackle the foregoing method, subjective measurements are going to be carrying out by mean of a survey of noise assessment based on the ISO/TS 15666.

*Subjective measurements:* people's perception of noise

- Questionnaire survey
- Interviews

It is preferable for gathering relevant and comparable data in subjective measurements is that people are not biased, meaning that people can established by themselves the noise sources. Consequently, questionnaire/survey is initially developed in English and then translated into Danish by native speakers. Thus, two surveys were presented to the subjects to obtain data.

In the survey for the evaluation of the noise annoyance a five linear scale might be use:

1. Not annoying at all
2. Slightly annoying
3. Moderately annoying
4. Very annoying
5. Extremely annoying

Also, subjects are going to be asked to mention, describe ant identify the types of sound that disturbed them.

### 3.1. Noise annoyance questionnaire

The questions stated by this project are focused on doing assessment of noise annoyance by means of social and socio-acoustic survey based on ISO/TS 15666. The survey was done in order to determine if people living in Indre By are annoyed by their home soundscape. It was developed in order to have a survey that were easy to understand, that subjects get focused on replying relievable data, and that it does not take too much time answering since long surveys are commonly avoid by subjects. The idea was to get the most quantity of surveys replied, therefore more data. See appendix to find the surveys template used, in English and Danish.

The survey asked for personal information about the subjects, and there were two main questions. Details and explanation of each part of the survey:

- Personal Information: The address was important to ask in order to determine that the replies correspond to the studied area. Phone number and E-mail were optional questions.
- Question 1 and 2: The two main closed-ended questions were done based on Fields et al., 2001, both are direct 5-point scale verbal questions based. In other words, the questions were a 5-point scale verbal questions and that can be related with the numerical scale to make comparisons.

*“Thinking about the last 12 months or so, when you are here inside your home, how much does noise bother, disturb or annoy you? Tick one answer.”*

Figure 5. Template for question 1 and 2 of questionnaire.

Figure 5 shows the question stated in the survey used in question 1 and 2. It is important that the questions used can gather unbiased information, so the wording of the questions was taking into account. First, to get a general evaluation for the respondent’s dwelling environment, it was asked about noise for the “*last 12 months or so*”, and it was specified in the questions to evaluate the noise annoyance “*here inside...home*” in order to define the boundary of the receiver. Second, in the same way the words “*your/you*” are used to get the respondent’s own reaction towards noise. The questions were written in present tense to encourage a habitual general response. Finally, since the main issue to know is about noise annoyance the words used were “*bother, disturb and annoy*” to address the general impression of a negative reaction. Note that length of words varies with the language.

- Type of answer: Figure 6 is the type of options for each question, so the respondent has to define his/her annoyance level by picking a word that describes it. Based on Fields et al 2001. the best words in English are ‘not at all’ which means that the subject has a 0% of annoyance, ‘slightly’, ‘moderately’, ‘very’, and 100 % annoyed when ‘extremely’ is selected. Note that the type of answer used in the surveys was just a verbal scale.

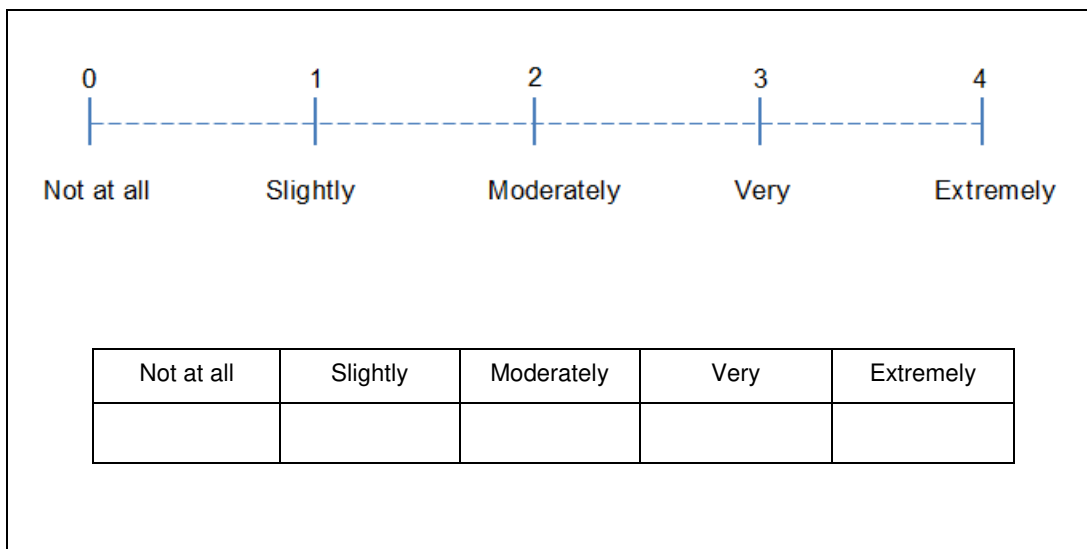


Figure 6. Verbal and numerical scale for grading noise annoyance.

Talking about noise annoyance is talking about nuisance, disturbance, and unpleasantness, so different scales have been developed to measuring annoyance reactions. Figure 6 shows an international standardized nuisance scale having equidistant scale-units, achieved by defined verbal labels marking the different steps of the scale, will be presented to each subject during the 24 hours of the whole day (i.e. day- and night-time annoyance).

- Question 2: It was the same as question 1, meaning that respondents have to rate their annoyance score based on a 5-points verbal question. The difference, as figure 7 shows, is that in question 2 it was asked to mention or name the most annoying sources. The purpose for this is to get information of the main and common noise sources that are bothering people in Indre By, and to avoid questions that could bias the respondents. This is the reason why it was not presented a list with the most annoying sources.

*“If you now think about the last 12 months here, which are the most annoying noise sources you can hear inside your home and how much do they bother, disturb or annoy you? Also, indicate with a cross if it is during the day (7:00 to 18:00), evening (18:00 to 22:00), or at night (22:00 to 7:00).”*

Figure 7. Template for question 2 of questionnaire.

It was asked to mentioned three noise sources, one of it was mandatory. The purpose was to somehow force the respondents to mention the most relevant noise sources for in their

environment. It was also asked when these sources mostly annoy people in order to be able to characterize the type of annoyance.

### 3.2. Procedure

Survey was design to be comparable with earlier surveys, and to be friendly and easy to understand, so it can be assure that each respondent is given useful data. The first version was done in English and later was translated to Danish by a native speaker. The two questions keep a certain degree of uniformity since both are direct questions, with the particularity that the second question is also asking for extra information about the source, not just the annoyance level, something related with the time exposure and type of source. This information will be useful to describe the sources. Also, both questions have the same response scale for statistical analysis proposal. The questionnaire was presented as an online survey keeping the all the characteristics mentioned above, and to avoid dependence of administration mode (telephone, face-to-face, paper, etc). Having online surveys help with the process of the distribution, and gathering of data. The online survey was done to be clear, easy to understand, not time consuming for respondents, and according to ISO/TS 15666. It was not necessary to give instructions to the interviewers neither to have interviewers, having an online questionnaire avoid intermediaries.

After having the survey uploaded for more than 2 months, it was possible to obtain 95 replies. First of all, they were filter; for instance, the replies that were from out of Indre By were discriminated. Second, the filtered answers were classified following the theory and based on the context of the studied area therefore they were classified as a function of annoyance, the source type and time. As figure 8 shows, the noise sources were classified according to section 1.1 but to follow the inner city context they were also divided in smaller groups and also Industrial source was presented with construction sources since it is expected that there is not industrial areas within Indre By.



Figure 8. Classification of noise sources.

Third, the results are going to be classified as figure 9 which is based on the Technical report No. 11/2010 of the European Environment Agency in order to show the results in an easy way to understand and to analyze them.

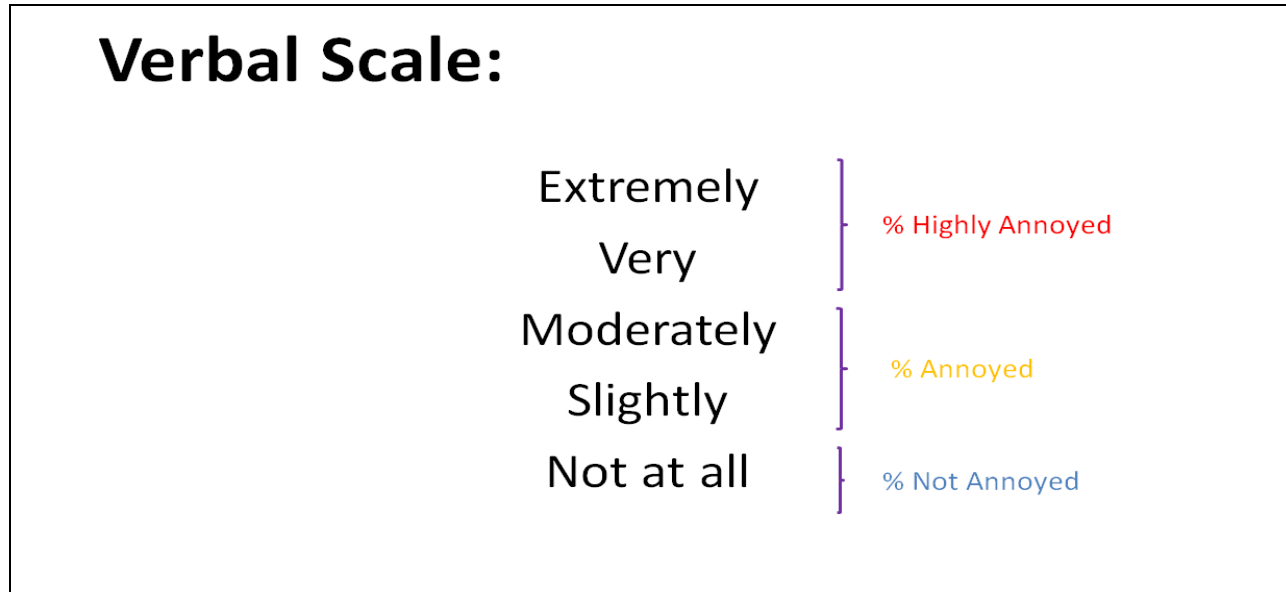


Figure 9. Criteria to define annoyance perceptual levels.

The criteria used to define the %Highly Annoyed (%HA), %Annoyed (%A), and %Not Annoyed is based on the percentage of responses exceeding a certain cut-off point on the verbal scale. Following convention, the first cut-off is between moderately and very that define the results within %HA or %A. In the same way, the cut-off between slightly and not at all determine the result between %A and %NA. Finally, it was possible to plot the results and to analyze them.

#### 4. Results

After obtaining 88 useful replies to the online survey the data were gathered, filtered, classified and plotted. Of the 95 replies, 7 of them were not valid since they were out of the studied area. The data were gather mostly in summer and late spring.

First, from the first question in the survey, which assess the general feeling towards noise at home without regarding the noise source. Figure 10 shows how people feel about noise when they are at home. The percentage of people highly annoyed (%HA) is more than the half of subjects' replies, in other words, the 56% of people have highly levels of nuisance towards noise. Also, the percentage of people annoyed (%A) is 43%. In the other hand, there is a 4.5% of people not annoyed (%NA).

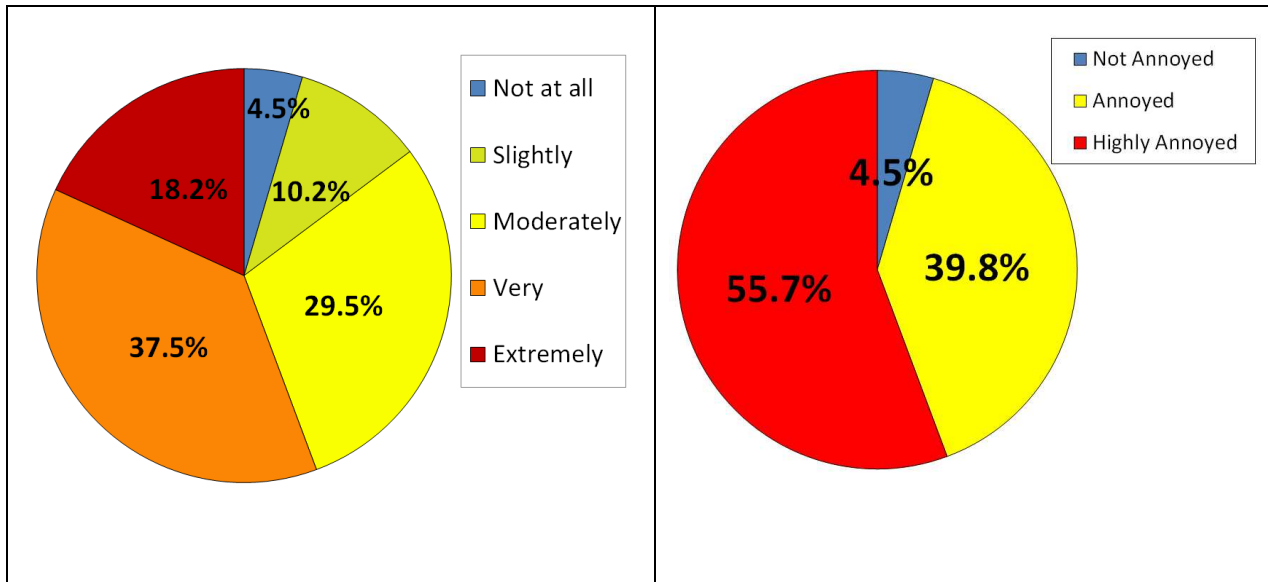


Figure 10. Noise annoyance percentage levels from question 1.

Second, for the question about specifying noise sources, the ones defined by each subject were categorized based on section 1.1 as Domestic & Social-leisure, transportation, and construction & industrial noise sources. In general, for question 2 there were a 5.3% of people that left this question in blank or partially filled. From the

The main purpose of this is to be able to synthesize information, and to compare and analyze it better due to that each respondent was able to write down the source that they consider relevant. Figure 11 shows more details about the characteristics of noise annoyance sources that are bothering people in Indre By.

Figure 11a shows that 38.3% people are highly annoyed, that 54.5% of annoyed people, and for not annoyed there is a 1.9% of people. For the %HA there is 2.28% for construction and industrial, 9.1% for transportation, and 26.9% for domestic and social-leisure noise sources. Showing that the last one is the most annoying, where people feel more bother by 10.61% at night time (22h00 to 07h00) when normally people rest, which suggest a high sleep disturbance. For the %A there is 2.65% for construction and industrial, 15.53% for transportation, and 36.36% for domestic and social-leisure noise sources. Showing that the last one is the most annoying, where people feel more disturbed by 20.83% at this time of day when normally people is relaxing after working, studying or their normal journey. The %NA is very small in comparison with the rest, which means that almost no one is annoyed.

It is also important to be aware that transportation noise is the second noise source most annoying below domestic and social-leisure noise sources. However, it is interesting that even that the most relevant annoyance is caused by the community, Danish noise guidelines do not consider community noise sources, and there is no established noise limits for type of sources.

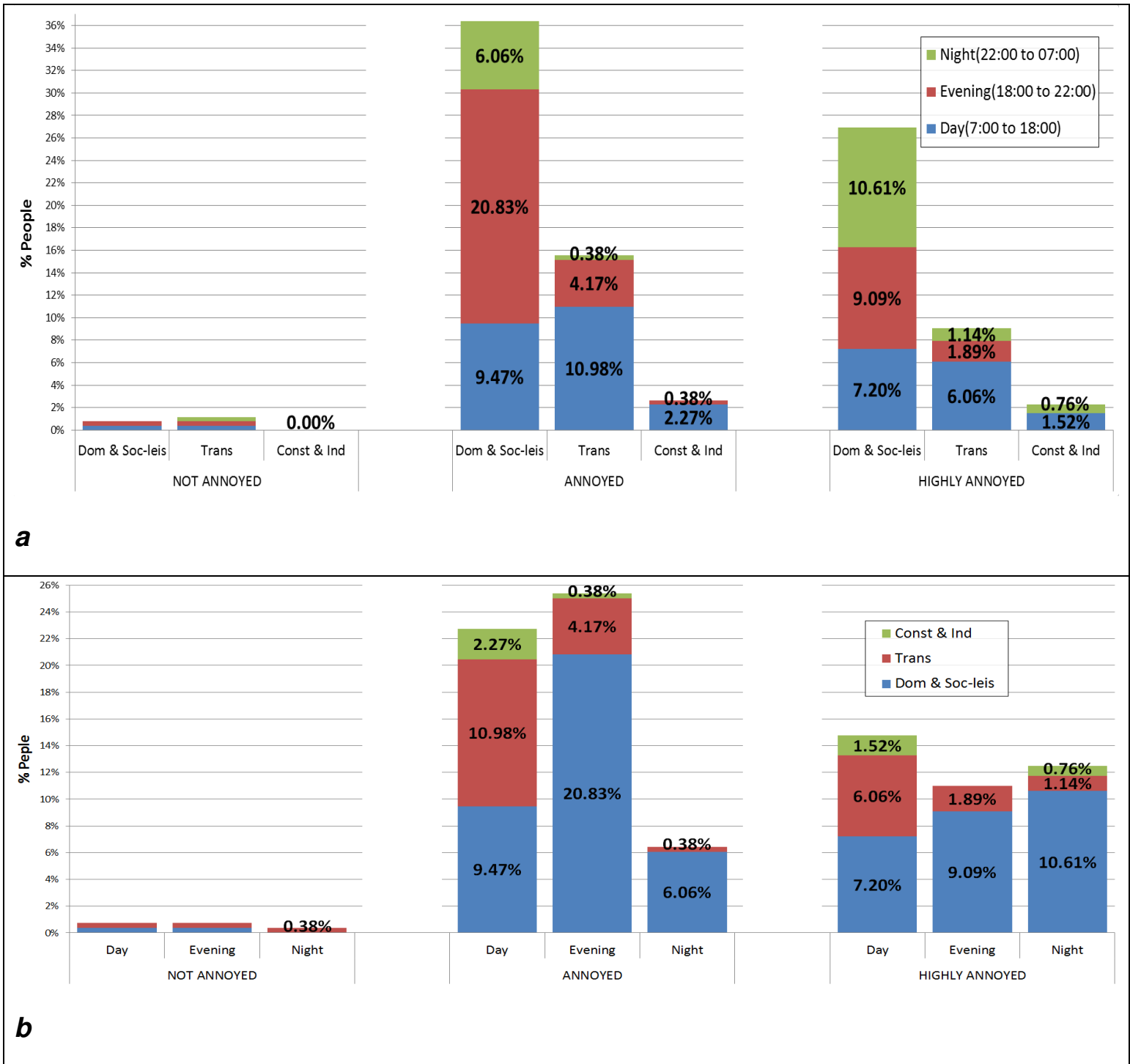


Figure 11. Noise annoyance percentage levels from question 2. a) as function of noise source, and b) as function of time of the day.

Figure 11b deal with the same data than the foregoing, the difference is that it is plotted as function of the day time unlike that figure 11a. Figure 11b shows that for %HA there is 12.51% at night (22h00 to 07h00), 11% in the evening (18h00 to 22h00), and 14.8% in the day (07h00 to 18h00). Obviously, this shows that during the day people feel the most annoyed, within people feel more bother by 7.2% caused by domestic



and social-leisure noise sources. For the %A there is 6.44% of people annoyed at night (22h00 to 07h00), 25.4% in the evening (18h00 to 22h00), and 22.72% in the day (07h00 to 18h00). Showing that people feel the most disturbed during evening, where people feel more bother by 20.83% caused by domestic and social-leisure noise sources. In general, it is also important to be aware that a relevant number of people feel annoyed by domestic and social-leisure sources.

Finally, since it is interesting to be more specific about the different noise sources, so figure 12, 13 and 14 show the different sources that were mentioned by the subjects according to section 1.1. For figure 12 the noise sources are classified in two types: Domestic and Social-leisure noise sources. For the first type there is 5% for %HA and 13.26% for %A, the highest concentration of people here is in the day (2.27%) and the evening (9.47%) respectively. For the second one it is 22% for %HA and 23.11% for %A, here the highest concentration is in the night (9.09%) and in the evening (11.36%) respectively. This figure demonstrates that social-leisure activities are the biggest contributors to annoyance in Indre By. Thus, domestic sources are the second most annoying. Social and leisure activities are related with nightlife in the inner city; meanwhile domestic is related with noise sources from the dwelling environment. However, there is a considerable concentration in the evening which can also be considered part of the nightlife when social-leisure comes.

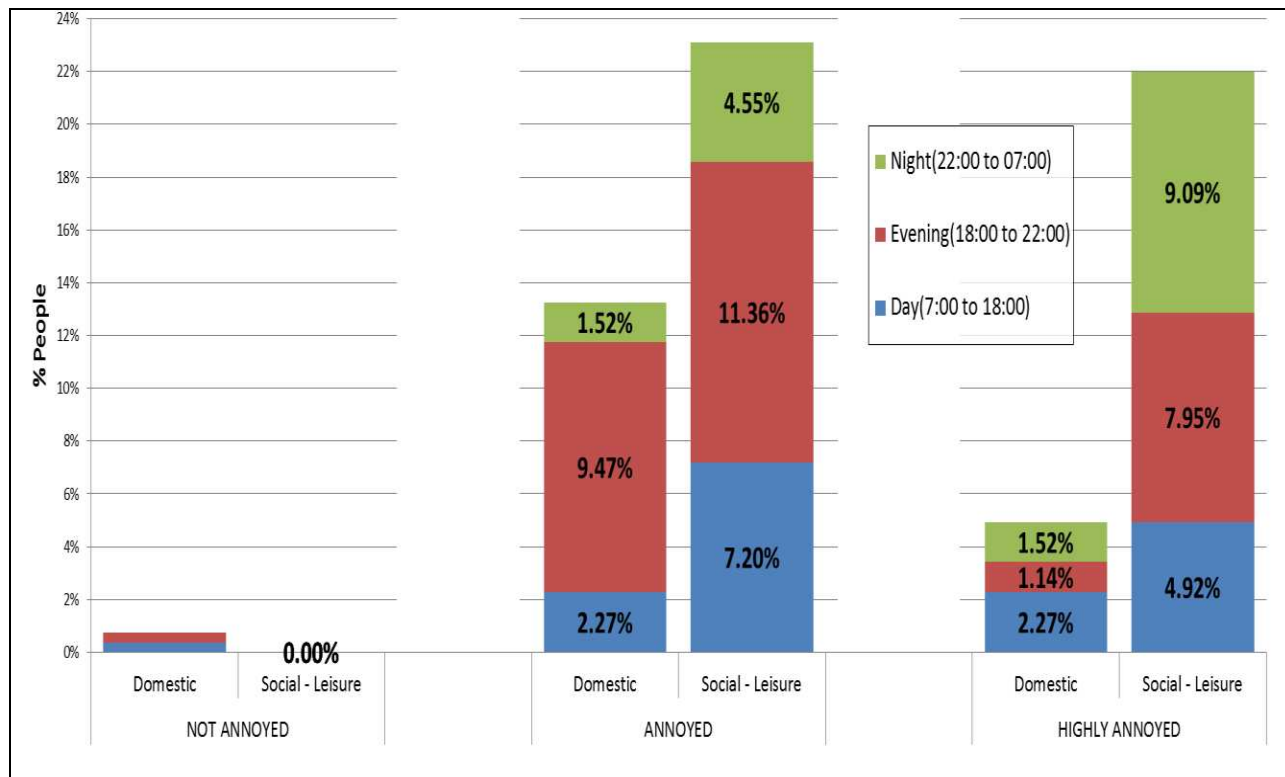


Figure 12. Noise annoyance percentage levels from question 2. Only data from *Domestic* and *Social-leisure* noise sources.

In the same way as before, so figure 13 the noise sources are classified in: road, rail and air transportation noise sources. It is obvious that people is almost just annoyed by road sources, obtaining 6.82% for %HA, 15.15% for %A, and 1.14% for %NA. Rail transportation noise has a slightly influence in

annoyance in comparison with road noise due to this depends on the proximity to the source. Subjects mainly affected for this kind might be close to a station or to a railway, but it is known that in the inner city most of the rail transportation stations are underground. In addition, air transportation annoyance is almost null according to the obtained data.

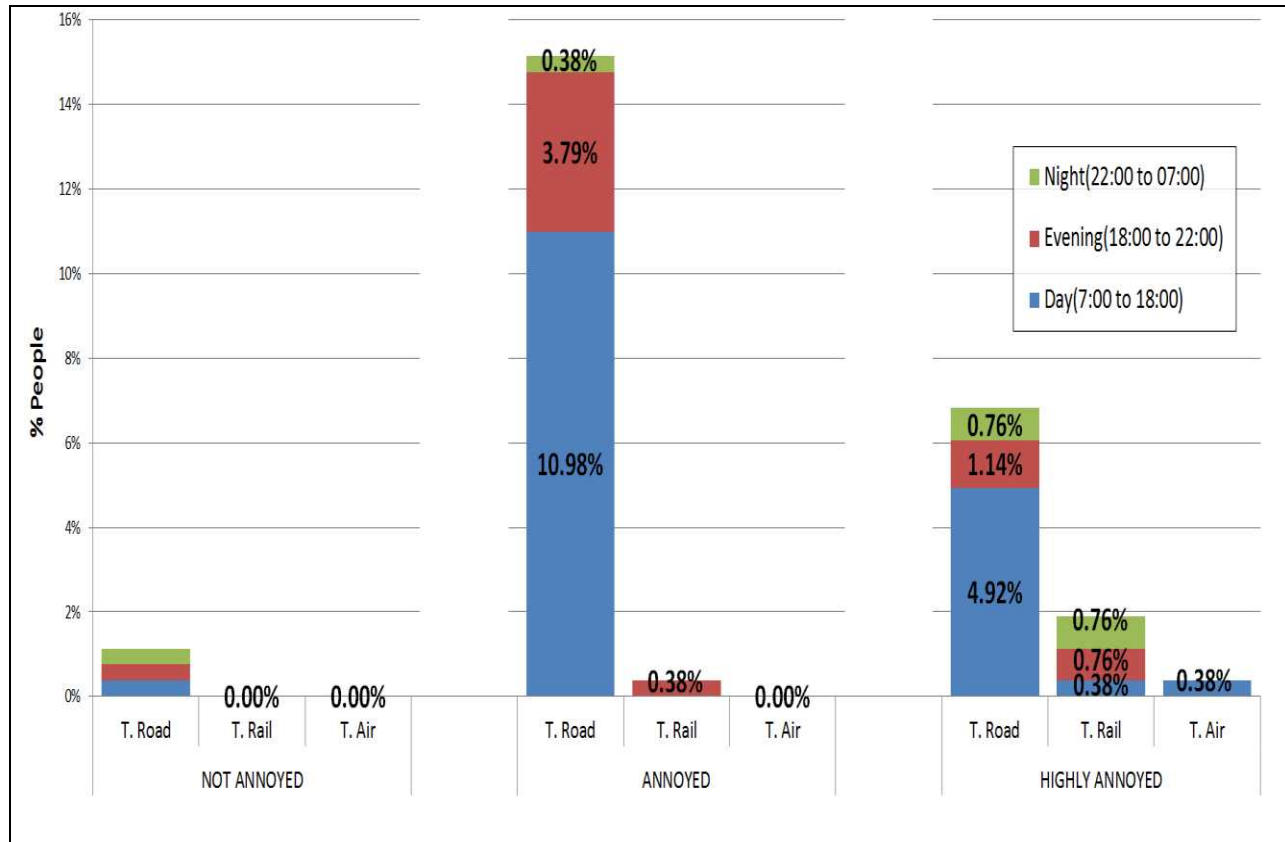


Figure 13. Noise annoyance percentage levels from question 2. Only data from *Road, Rail and Air Transportation* noise dsources.

Figure 14 shows the noise coming from construction and industry sources. A particularity is that people in the inner city is completely not at all annoyed by industry sources, and looking at the noise map of Denmark (<http://mst.dk/74697>) done by Danish Environmental Protection Agency, it shows that there is any industry noise in Indre By. In contrast, people are only annoyed by construction and building services sources. It is evident that Copenhagen is a city that is being constantly repaired and given maintenance to their buildings and streets, therefore people is consequently bothered by this type of activities. However, there is just a 2.3% of %HA, 2.65% of %A. Fortunately, this is just happening mostly in the day time where most of people are not at home.

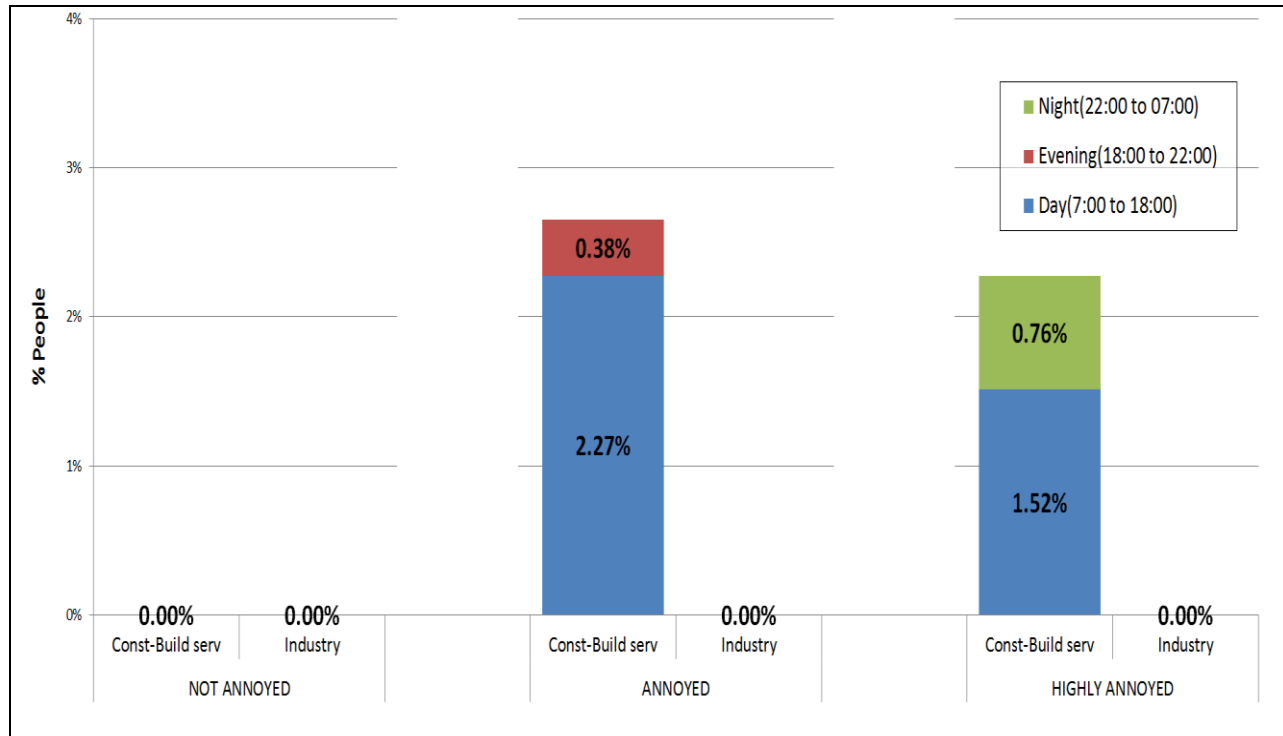


Figure 14. Noise annoyance percentage levels from question 2. Only data from *Construction-Building services* and *Industry* noise sources.

Analyzing the last three figures one can say that constructions and industrial sources are the least felt as annoying by people living in Indre By. However, the most relevant noise source is community, social & leisure noise. People are being mostly annoyed in the day time by transport noise and at night by community sources, especially by the night life.

## 5. Discussion and Conclusions

In general, people are annoyed and highly annoyed which can be interpreted as a not good acoustic comfort at home at least for sleeping, relaxing or being concentrate. However, to determine if noise is affecting and what kind of health effects it will cause is to do objective measurements and obtain exposure-response relationships and thresholds for health endpoints. In addition, domestic and social-leisure is the most problematic noise source according to people's perception. Since mostly the questionnaire was carry out during summer, the respondents reply that they are feel more annoyed when they have to open their windows. The possible reason for this is the cultural and life style differences (W. Yang and J. Kang, 2005)

The inner city has a complex environmental acoustics context. Transportation noise, including road traffic, rail traffic and air traffic, is the main source of environmental noise pollution contribution to community noise is traffic (WHO, 1999). However, according to the results, perceptually, domestic and social-leisure is the main annoying source. Indeed, it depends on the context of the receiver, and the main sources can be the other community sources that can affect in the same way, causing therefore the same affections.

It seems that social-leisure and domestic sources are not well evaluated, and there are very few investigations about the annoyance created by community noise sources; for instance, in comparison with the number of publications, normative, guide lines, and regulations for noise due to transportation. Domestic and social-leisure can be complex due to the fact that noise sources are not well known. There is sufficient evidence about the annoyance of transport, and construction and industry environmental noise, but there is not enough evidence about nuisance from domestic and social-leisure sources.

Measuring or characterizing domestic and social-leisure noise can be challenging since it is difficult to define a clear or a unique source. From the data obtained throughout the survey one of the most common sources mentioned are bars/pubs/restaurants, amplified music, outdoors public events such as, marathons, concerts, music festivals and parades, and nightlife. In addition, talking about the reasons why these are the most mentioned sources, it is possible that the respondents are people that are really affected by noise, people that mostly stay at home, or perhaps most of people are at home in the early morning or at night, and therefore they are mostly annoyed by the nightlife. Also, very common noise sources mentioned for domestic noise are noise coming from neighbors house activities, which suggest that dwellings have not a good sound insulation that is logic since the architecture of the inner city is antique.

Since the complexity of these sources authorities and community has to participate more in figure out how to decrease environmental noise. The best way to decrease noise annoyance and prevent it is to have better normative, to invest better and more noise consciousness socialization campaigns, to increase noise emission controls and permits, invest in better noise insulation for buildings, and make frequently measurements and noise maps. First, It is important to change the status of the guidelines of the EPA into a normative, so noise limits must be respect. Also, in is important to mention specifically domestic and social-leisure noise sources and define their noise exposure limits; this can help increasing noise consciousness in community. Secondly, community noise consciousness occurs when people is aware that the sound pressure levels produce by them can affect negatively to people, this can be achieve by making campaigns to make people learn about the negative effects of noise in people's health and daily life. Third, to give permits to bars/pubs, concerts managers. The municipality might ask for permits, so the sound levels emitted by amplified equipment can be control. Also, it would be a very good idea to have banners indicating to be aware of noise and the negative effects of it. Fourth, have noise measurements stations that constantly are measuring all day long in order to obtain data about the sound pressure levels and to get noise maps that will help in the urban design and redesign of the city and to develop better plans to improve people's life style. Fifth, having better sound insulation in buildings will help a lot to attenuate noise. However, to get a good isolation for buildings it will represent a great investment of money so perhaps this is not the cheapest option since a relevant quantity of buildings in Indre By.

## 6. References

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## APPENDIX



### UNDERSØGELSE OM STØJGENER (INDRE BY)

Adresse: \_\_\_\_\_.

Må vi kontakte dig senere med henvisning til støjgener? Hvis ja, bedes du oplyse din e-mail og / eller telefonnummer.

Telefonnummer: \_\_\_\_\_.

E-mail: \_\_\_\_\_.

Du bedes svare på følgende spørgsmål:

1.

Tænk de sidste 12 måneder eller deromkring, når du er her hjemme, hvor meget betyder støj generer, forstyrrer eller generer dig? Sæt et kryds.

Overhovedet ikke	En anelse	Moderat	Meget	Særdeles meget

2.

Hvis du nu tænker over de sidste 12 måneder: hvilke er de mest irriterende støjkilder, som du kan høre inde i dit hjem, og hvor meget irriterer, forstyrrer eller generer de dig? Angiv med et kryds, hvornår i løbet af dagen det er: morgenen(7:00 til 19:00), aftenen(19:00 til 23:00) eller natten(23:00 til 07:00).

a) Støjkilde: \_\_\_\_\_.

I løbet af (a) *Morgenen* \_\_\_\_\_, (c) *Aftenen* \_\_\_\_\_, eller (b) *Natten* \_\_\_\_\_.

Overhovedet ikke	En anelse	Moderat	Meget	Særdeles meget

b) Støjkilde: \_\_\_\_\_.

I løbet af (a) *Morgenen* \_\_\_\_\_, (c) *Aftenen* \_\_\_\_\_, eller (b) *Natten* \_\_\_\_\_.

Overhovedet ikke	En anelse	Moderat	Meget	Særdeles meget

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c) Støjkilde: \_\_\_\_\_.

I løbet af (a) *Morgenen* \_\_\_\_\_, (c) *Aftenen* \_\_\_\_\_, eller (b) *Natten* \_\_\_\_\_.

Overhovedet ikke	En anelse	Moderat	Meget	Særdeles meget



MILJØPUNKT



**NOISE ANNOYANCE SURVEY (Indre By)**

**Address:** \_\_\_\_\_.

**Can we contact you later about noise issues?** If yes, please provide your e-mail and/or phone number.

**Phone number:** \_\_\_\_\_.

**E-mail:** \_\_\_\_\_.

Please answer to the following questions:

1.

*Thinking about the last 12 months or so, when you are here inside your home, how much does noise bother, disturb or annoy you? Tick one answer.*

Not at all	Slightly	Moderately	Very	Extremely

2.

*If you now think about the last 12 months here, which are the most annoying noise sources you can hear inside your home and how much do they bother, disturb or annoy you? Also, indicate with a cross if it is during the day (7:00 to 19:00), evening (19:00 to 23:00), or at night (22:00 to 7:00).*

a) *Noise source:* \_\_\_\_\_.

During (a) the *Day* \_\_\_\_\_, (b) the *Evening* \_\_\_\_\_ or (c) the *Night* \_\_\_\_\_.

Not at all	Slightly	Moderately	Very	Extremely

b) *Noise source:* \_\_\_\_\_.

During (a) the *Day* \_\_\_\_\_, (b) the *Evening* \_\_\_\_\_ or (c) the *Night* \_\_\_\_\_.

Not at all	Slightly	Moderately	Very	Extremely

c) *Noise source:* \_\_\_\_\_.

During (a) the *Day*\_\_\_\_\_, (b) the *Evening*\_\_\_\_\_ or (c) the *Night*\_\_\_\_\_.

Not at all	Slightly	Moderately	Very	Extremely