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NOISE CONTROL FOR A BETTER ENVIRONMENT

## **State wide integrated approach for noise mapping and action planning**

**Stapelfeldt, Hardy<sup>1</sup>**  
Stapelfeldt Ingenieurgesellschaft mbH  
Wilhelm-Brand-Str.7  
D 44141 Dortmund, Germany

**van der Pütten, Norbert<sup>2</sup>**  
Hessian Agency for Nature Conservation, Environment and Geology  
Rheingaustraße 186  
D-65203 Wiesbaden, Germany

### **ABSTRACT**

In an effort to streamline END Noise mapping and action planning activities, the German states of Thuringia and Hessen decided for a new approach to fulfil their obligations. A central data pool has been set up, addressable via GIS web-service by all public agents involved, i.e. ministerial level, state environmental agency, regional authorities and communities.

Based on the implemented ODEN-LIMA web-service

- a continuous update/improvement of model data is supported on large and small scale, i.e. involved communities can provide local knowledge for model refinement.
- Population exposure is documented in different manners, per building, per road segment, per grid cell, per dominant source. The latter is also useful to analyse exposure of areas.
- Combined noise exposure from different source types is supported (VDI 3722)
- regional authorities can develop abatement concepts across community borders
- noise and air-pollution effects of potential urban noise reduction planning can be estimated on community level

The Hessian Agency for Nature Conservation, Environment and Geology (HLNUG) has also used this service to enhance the road net beyond the requirements of END mapping, in order to recognize silent regions.

**Keywords:** Noise Mapping, Action Planning, Software as a Service (SaaS)  
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<sup>1</sup> [hs@stapelfeldt.de](mailto:hs@stapelfeldt.de)

<sup>2</sup> [Norbert.vanderPuetten@hlnug.hessen.de](mailto:Norbert.vanderPuetten@hlnug.hessen.de)

## 1. INTRODUCTION

The web based ODEN system for environmental impact assessment follows the idea of Software as a Service (SaaS). The user is entitled to use environmental simulation software for noise, air pollution and solar radiation aspects without the need for individual licences on the PC he uses to access the system. Additionally the ODEN system offers many users to jointly use a common base data set. The graphic user interface can be invoked by common browsers without further installations on the accessing PC.

The Hessian Agency for Nature Conservation, Environment and Geology (HLNUG) is using ODEN in cooperation with the State of Thuringia. In Thuringia the “Thüringer Landesamts für Umwelt, Bergbau und Naturschutz” (TLUBN) is in charge of the project. Both institutions coordinating state wide activities for mapping, noise action planning as well as air pollution analysis by various participants.

This paper shall provide a brief insight into the activities and during presentation it is intended to give more details on the practical applications and related performance statistics.

## 2. IT BACKGROUND

The ODEN system used by Thuringia and Hessen is hosted by an IT service provider, ensuring high access reliability (DIN/ISO27001 certified) and a powerful internet access (European Backbone).

The communication between Host and client is HTML5 driven which helps to fulfil security requirements. Only for optional 3d viewing JAVA needs to be installed.

An ODEN installation typically consists of 3 components, typically separate virtual machines.

- ODEN web oriented graphic user interface with internet access
- PostGres data base
- Simulator, running environmental simulation software such as LimA for noise and solar aspects and AUSTAL or MISKAM for air pollution aspects.

For simulation a minimum CPU capacity supporting 40 parallel process turned out to be feasible. 18 processes alone are used for MISKAM airflow calculation with a 10 degree resolution in wind direction.

### 3. USER ROLES

Various users with differing roles are participating

- Administrator with IT responsibility, who keeps the system alive but are not in charge of content.
- Administrator with data responsibility i.e. in charge of base data and default parameter setting for calculation requirements. Also deciding what kind of settings are opened up to the “end user”. Login credentials for any users are organised and per end user the access rights are defined. Access rights (view/edit) are handled per individual feature type and individual attribute with a feature type. The data administration is handled by HLNUG and TLUBN respectively.  
Data Administrator is also dealing with state wide calculation activities, such as EU noise maps
- End users are typically found on community level. They provide updated model data information based on their local knowledge and they use ODEN-LimA for regional environmental impact assessment, e.g. during noise action planning.  
On this level users are only entitled to simulation calculation for smaller regions to avoid an overload of the system.
- On Ministerial level (Department of Environment) the system is typically used to have an easy insight (read only) into the status/results of environmental analysis.
- For Hessen an extra level of users has been established for each of the 3 “Regierungspräsidien” (RP), which are in charge of administrative work for larger regions. Already in the past RP’s have been in charge of noise action planning in the regions. This is helpful as some noise planning actions will effect several communities and also the RP’s can offer the necessary technical background and experience for this job. Their work still includes cooperation with the local communities as well as with HLNUG.

#### 4. ORGANIZING TASKS

The typically task solving procedure on end user level is

- User directly extract some regional model data from the base data set, for use in his own scenario.
- Model objects are modified or added/delete for the purpose of comparative investigation into environmental aspects. Improvements to the base data, i.e. bringing model data in line with reality, are marked as such. After finishing work on a scenario, the data administrator is informed, will supervise changes and will finally decide on the update process.  
Modified object gets a termination date and the new variant gets a start of exist date. New objects will only get start of exist and a full delete will result in setting a termination date only.
- The user defines parameters for individual environmental assessments or he selects a prefabricated workflow to run a more complex analysis, e.g. certain ways of exposure assessment.  
His calculation request results in a single processor calculation request which is piled in a specific queue for standard end users.

The data administrator also performs calculation tasks, among others those with cover the total area of Hessen, as e.g. the EU conform noise mapping or the “EU Plus” mapping.

“EU Plus” mapping shall help to identify quiet areas and therefor takes into account the whole Hessen wide road network.

- HLNUG will start a workflow for the total region which then breaks down the total region into tiles and on his own starts calculation per tile in parallel by using many processors. In one go this process calculation noise levels for grid and façade, creates graphics of results and statistics. Grid results are given in ASC and SHAPE. Statistics as CSV table.

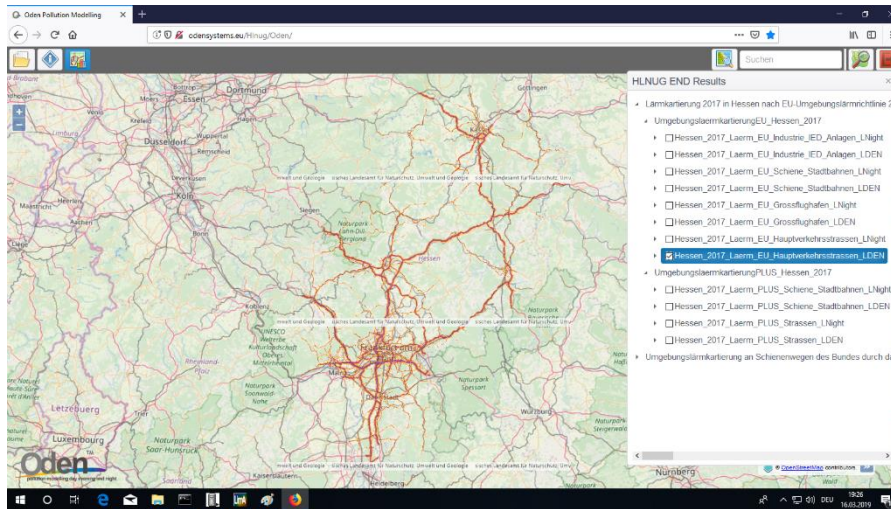


Figure 1 Results of EU Noise mapping for ~ 6000 km of roads

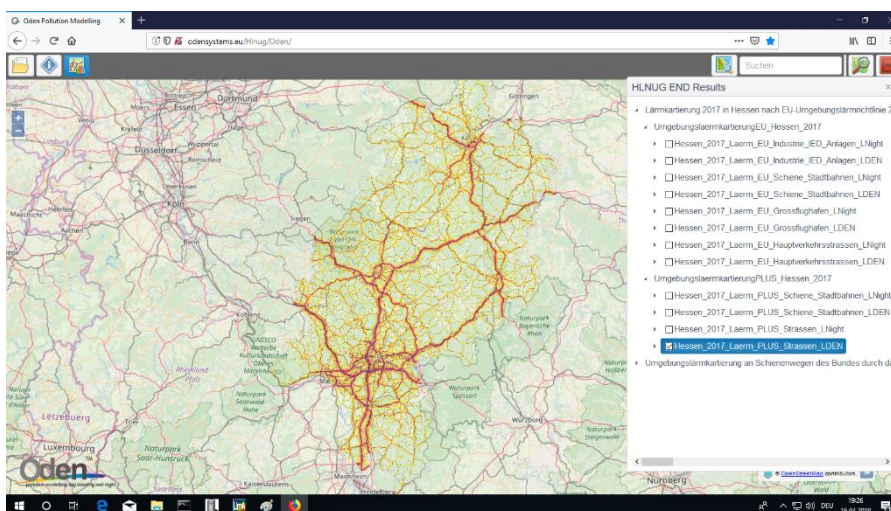


Figure 2 Results of "EU Plus" mapping for about 50000 km of roads

## 5. TOOLS USED IN NOISE ACTION PLANNING

A couple of tools are supplied in ODEN to support noise action planning. Typically methods are following an initial noise calculation for the existing situation or for an anticipated scenario. In line with German regulations national regulations, such as RLS90, have to be used to calculate noise immission values as the EU Interim Methods have no legal relevance in local planning. In principle the methods on offer can be applied for each regulation.

When the user invokes the analysis tool and selects “Noise Exposure” there will be different ways to create statistics or graphics based on the initial noise exposure and input request for the specific parameters, related to the method.

Figure 3 Parameter input for Noise exposure presentation per road segment

### 5.1 LKZ\_ROAD/LKZ\_RAIL Method

Roads or Rail tracks are broken down into constant length segments of  $\leq 100$  m. The façade points are linked to these segments depending on the closest proximity. For each segment a total exposure (LKZ) value is defined by a rule widely used by Hessen authorities in the past.

Inh = number of inhabitants per façade point

Lr = receiver level at façade point

Llimit = Threshold value for Lr, depending on land use category

n = number of relevant façade points

$$LKZ = \sum_{i=1}^n (\text{Inh} * (\text{Lr} - \text{Llimit}))$$

*Equation 1*

For graphic presentation the values are scaled to a length of 100 m in order to achieve same colour coding for shorter road segments: E.g. a 150 m stretch of road will result in 2 75 m segments.

Table 1 Exposure per 100 m road segment (extract from result table)

Straßenname	Länge (m)	ID	Querstr. (Anfang)	Querstr. (Ende)	EW	EW 100 m	LKZ Day /100m	LKZ Ngt /100m
Grafenstraße	115,2	836200	---	Bismarckstraße	4	3,5	4	37,6
Bismarckstraße	50,4	836202	FrankfurterStr	Mathildenplatz	0,8	1,6	3,8	19,5
Bismarckstraße	139,7	836418	---	Grafenstraße	3,5	2,5	6,2	29,2
Bismarckstraße	124,6	836435	Grafenstraße	Mathildenplatz	2,6	2,1	1,3	20,2

Table 1 has a content per column as given in Table 2

Table 2 colum content

1. Road name	2. Length of road
3. Unique Object ID	4. Road name of X or T- road at start
5. Road name of X or T- road at end	6. Number of inhabitants
7. Inhabitants per 100 m	8. LKZ day scaled to 100 m
9. LKZ night scaled to 100 m	

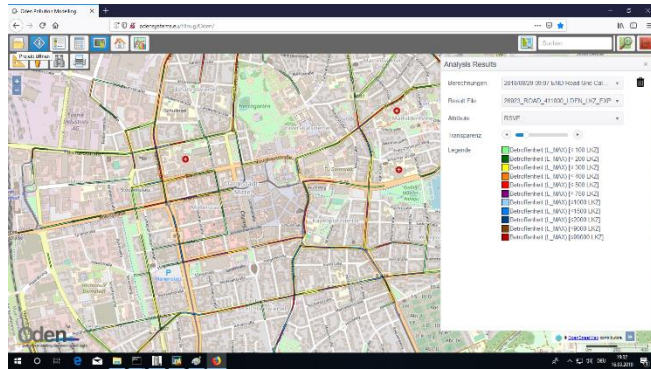


Figure 4 Roads colour coded according to local population exposure

## 5.2 LKZ\_ZONE Method

The user defines separate regions of interest, so called LKZ areas, and for each zone the LKZ value is calculated. For each zone the day and night exposure is given separately. Column Ew gives to total number of significantly exposed people, i.e. above threshold value, and in the 3rd line this value is the sum of worst value of day or night.

Table 3 Exposed inhabitants per region (extract)

LKZ one	Indikator	LKZ	Ew Lr>Schwellwert (dB)						
				1 dB	2 dB	3 dB	4 dB	5 dB	6 dB
Zone_A	ITAG	818	1635	38	39	42	47	50	33
Zone_A	INGT	763	1645	35	39	41	45	55	30
Zone_A	MAX	0	1892	0	0	0	0	0	0

## 5.3 FAS\_MAX Method

The FAS\_MAX method provides a graphic result presentation per residential building for buildings with façade levels above a user define threshold value. Per building max values for day and night are given in a house exposure symbol and the colour of the graphic symbol indicates exceedances.

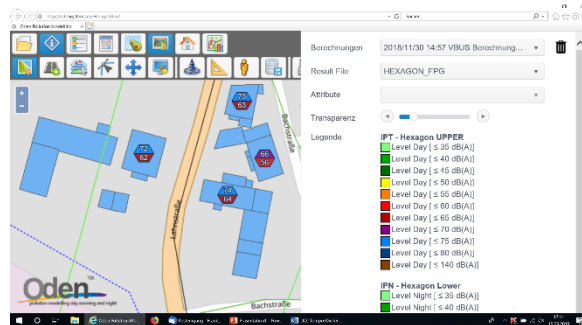


Figure 5 House exposure symbol

## 5.4 LKZ\_NEG method

In the LKZ\_NEG method exposure is defined as number of people exposed to certain noise levels. The specific approach of the NEG method is to focus on the most dominant source. For this sources are grouped as a first step of the method. In ideal planning one will assign roads which are subject to a distinct noise abatement scheme to the same emitter group. As a default approach consecutive roads segments have identical names and similar traffic conditions receive the same group index. To some extent this process takes care of none identical forms of name writing.

Examples of identity are for instance

- German category road code A### or E##/A### where E## is the Euro road code
  - or blanks in category related names, such as B 236 or B236
  - or use of abbreviations, e.g. Thomas-Mann-Straße compared to Thomas-Mann-Str.
- For each group index the number of inhabitants exposed to certain noise level classes are identified, i.e. these people are predominantly exposed to noise from the given NEG group. A table can be used to find the most relevant source group to deal with, either based on maximum exposure or total number of affected or potentially on LKZ criteria.

*Table 4 Number of exposed people per most significant source*

Objekt SLU	Name	NEG	Indikator	>=45	>=50	>=55	>=60	>=65	>=70	>=75	>=80
B7	Holländische Straße	760	LDEN	27	27	25	9	2	1	0	0
B7	Holländische Straße	755	LDEN	12	8	0	0	0	0	0	0
L3386	Niedervellmarer Straße	759	LDEN	14	0	0	0	0	0	0	0
K15	Bunsen Straße	742	LDEN	2	2	2	1	0	0	0	0

## 5.5 UCE\_den Method

This method follows a different annoyance weighting per inhabitant following the formula

$$UCE_{den} = 10 * \log_{10} (\sum (Ew_{Fp} * 10^{L_{denFp}/10}))$$

*Equation 2*

UCEden values are calculated for a grid cell area of user defined 100 x 100 (m) for a larger grid region. Extra to the cell value a second value is produced as average cell value for the ambient region of 5 x 5 cells and both values are scaled to a standard area size of 1 ha (100 m square). The user decides on colour coding per cell value or ambient average value.



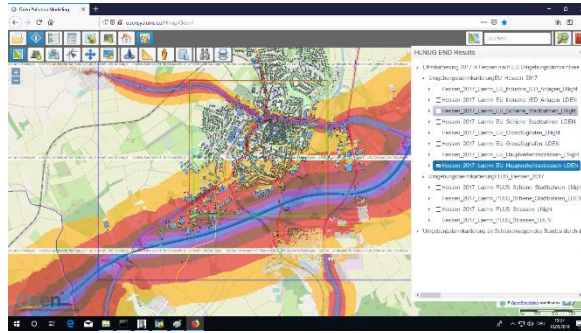


Figure 6 local extract from noise map

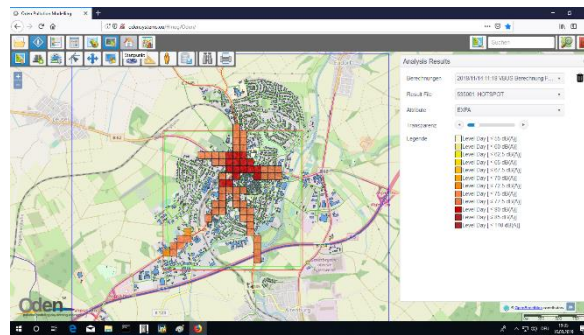


Figure 7 Population exposure using UCEden formula for cells of 100 x 100 (m)

For practical purpose a further workflow has been introduced which simply runs the first 3 methods in one go.

## 6. SUPERPOSITION METHODS

Another analysis aspect is offered to the ODEN user by 2 further workflows. For superposition of results or to present the difference between two calculated scenarios two workflows are offered. As result of this operation a new ASC grid and a new SHAPE of result contours is prepared for download and viewed in ODEN

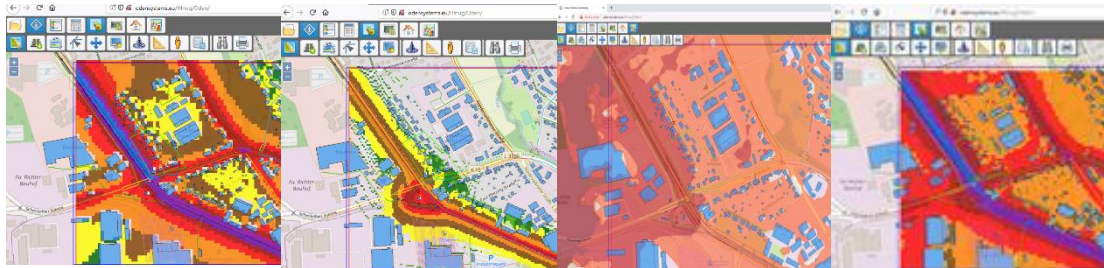
### 6.1 SUM\_ERG Method

This method helps to sum up or create differences of results, energetically or arithmetically.

The need for this comes up when results of different scenarios are compared. The new result set is immediately converted into graphics.

### 6.2 SUM\_VDI Method

Use the German VDI 3722 to superpose noise impact values from different source types such as road and rail, based on weighting criteria which brake down rail and aircraft noise to equivalent road values. The VDI allows support the assessment of noise exposed people as being “disturbed”, “heavily disturbed”, “sleep disturbed” or “heavily sleep disturbed”.



*Figure 8 Result VBUS*

*Result VBUSCH (tram)*

*Result VBUSCH  
(Railway)*

*Energetic sum VDI*

## 7. CONCLUSIONS

- The ODEN-LimA web based environmental simulation system has proven its practicability during the last round of EU noise mapping by TLUBN and HLNUG, the environmental protection agencies for the German states of Thuringia and Hessen.
- Many participants on community or other levels in the administration help to set up a state wide coherent model and use this data for coherent environmental analysis in the field of noise and air pollution control
- Task such as “EU Plus” mapping go beyond the national EU mapping requirements could be handled without letting external contracts.
- The administrative level of Regierungspräsidien (RP) use ODEN to document noise exposure in several alternative approaches and check alternative scenarios in coordination with local communities in a very time efficient manner.