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Methodik des wissenschaftlichen Publizierens

Erlernen der Vorgehensweise durch Validierung und Begutachtung aktueller Forschungsergebnisse

Hochschulrektorenkonferenz

Projekt nexus

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INSTITUT FÜR ENERGIESYSTEMTECHNIK
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- Motivation
- Ziele der Lehrveranstaltung
- Aufgabenstellung
- Lehrveranstaltungstyp
- Zeitlicher Ablauf

Wissenschaftliche Publikationen

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8th International Conference on Electrical and Computer Engineering
20-22 December, 2014, Dhaka, Bangladesh

A New Technique to Improve the Linear Generator Designed for Oceanic Wave Energy Conversion

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***Abstract*—In this paper a new technique is proposed to improve the performance of the linear permanent magnet generator (LPMG) which is basically a point absorber. This paper also represents analysis, design and simulation of a LPMG for improvement of oceanic wave energy conversion (WEC). Different output voltage, current and power waveforms of the conventional and proposed LPMG are analyzed, simulated and compared by MATLAB software by constructing mathematical models of WEC, LPMG and output stage. Various parameters like magnitude, wavelength and phase of oceanic wave are observed to make proper simulation by changing different parameters. It is applicable almost all of the point absorbers and offers the great advantage to get relatively more even power distribution which is a major concern for WEC.**

***Index Terms*—Linear generator, point absorber, oceanic wave energy, translator.**

I. Introduction

In recent years WECs are the centre of attention in the renewable energy field because it has the feature of very high energy density. The wave energy resource is substantial, and the total resource around the world is estimated 10 TW in the open sea, which is comparable to the world's total power consumption [1]. Different types of WEC devices have been proposed for development, such as Archimedes Wave Swing (AWS), Oscillating Water Column (OWC), Pelamis structure, Wave Dragon, Mighty Whale etc. ([2]–[4]). Ocean power technology companies own the commercial product based on a point-capture wave power generation system with AWS submerged under the water for power generation [5]. Traditional wave power generation methods have the disadvantages of complex and expensive system structures and are hard to maintain and possess low transformation efficiency ([6], [7]). Hence, the generated electricity from such systems is not cost-effective. The AWS consists of a hollow cylinder and a lid fixed on the sea-bottom filled with air, called floater as shown in Fig.1(a). The floater moves in the vertical direction. When the wave comes, the floater sinks because of increase of the weight of the water above, while the pressure of the air in the cylinder increases and vice-versa. In a power buoy, from the reciprocating motion of the floater moved linearly, the wave energy is extracted that convert the wave energy to electrical energy. A point absorber is a floating structure with components that move relative to each other due to wave action utilizing the rise and fall of the wave height at a single point for energy conversion as shown in Fig.1(b). The measurement of power buoy and accessories are given here as an example and need to be varied according to different situation. The relative up and down bobbing motion caused by passing waves is used to drive electromechanical or hydraulic energy converters to generate power. Internal construction of a conventional LPMG is shown in Fig.1(c).

At present, research studies on direct-drive methods have been carried out by direct capture of wave energy as it is proved to be more efficient compared to the traditional generators ([7]–[10]). The LPMGs are employed to directly transform the low speed mechanical energy into electricity, thus eliminating intermediate mechanical translators, a crank or linkage etc. or converters. Although the LPMGs have relatively large force-to-volume ratio and own high efficiency, the involvement of LPMGs results in complicated winding scheme or sophisticated arrangement and assembly of LPMGs [11].

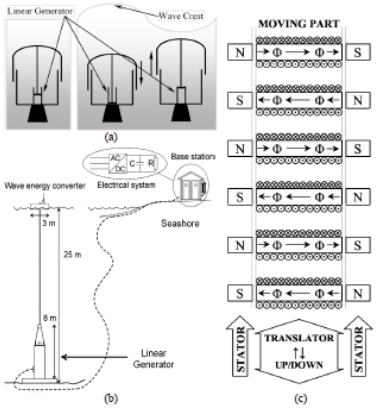

Fig. 1(a) LPMG shown in an AWS configuration, (b) LPMG mounted with power buoy, (c) LPMG internal construction.

In the latest report from the International Energy Agency (IEA), 81 different wave energy projects including linear generator (LG) and WEC were examined and out of them 13 were estimated to have reached the stage of having a full- or near-full-scale prototype at sea [12].

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II. Conventional Linear Generators

Different internal construction of conventional LPMGs are shown in Fig.2(a–c). When a magnet moves in relation to an electromagnetic coil, this changes the magnetic flux passing through the coil, and thus induces the flow of an electric current. Like rotary generators it essentially contains stator and translator which works similar as rotor. The translator and the stator can either have the same vertical length as shown in Fig.1(c) that mean the active surface will vary during cycle of motion or one of them can exceed the other in vertical length as shown in Fig. 2(c). If the surplus in length is equal to the pitch length the active surface will be constant.

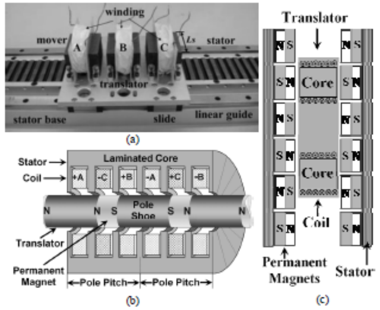

Fig. 2(a) Conventional flux switching LPMG, (b) Conventional tubular LPMG, and (c) Conventional LPMG with longer stator.

However, the longer translator has some advantages on longer stator though both of these give similar output waveforms. A practical output waveform of electrical power is shown in Fig.3 for an example [12].

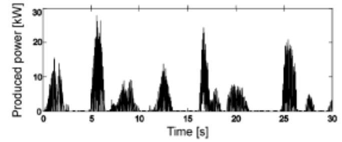

Fig. 3 Electrical power output of a conventional LPMG.

All conventional LPMGs produced discontinuous output power. From Fig.3 it is clear that it gives negligible output power from 2 to 3 seconds approximately in each cycle.

III. Model of WEC and LPMG

The up and down movement produced by an ideal wave can be approximated by a sine function, resulting a cosine-shaped speed variation, with maximum speeds reaching up to 2m/sec, depending on the sea state. The speeds are usually between 0.5m/sec to 1m/sec. The linear generator should be chosen considering these speed values and the working conditions. The induced voltage is found according to Faraday's law of electromagnetic induction as given in (1)

$$E = -N\frac{d\overline{\Phi}}{dt} \qquad (1)$$

Here E is induced voltage in the coil, N is turn number of wire in coil and $\overline{\Phi}$ is average flux passing through coil. As vertical wave displacement is very similar to sinusoidal function, assuming sinusoidal wave the vertical displacement of wave and velocity can be expressed as given in (2) and (3) respectively.

$$y(t) = H_m \sin\left(\frac{2\pi}{T}t \pm \theta_i\right) \qquad (2)$$

$$v(t) = H_m \frac{2\pi}{T}\cos\left(\frac{2\pi}{T}t \pm \theta_i\right) \qquad (3)$$

Here $y(t)$ and $v(t)$ represents position or displacement of wave and velocity respectively. H_m, θ_i and T represents height, phase angle and period of oceanic wave respectively. In this model H_m, θ_i and T can be varied to get wide range of input variable.

The proposed LPMG is consisted of a possible special new translator as shown in Fig.4(a) and a stator with windings. Flux switching method is used for generation of electricity. According to Fig.4(b) when translator moves at a particular time it aligns at position-1 and flux direction is upward through first pole shoe. At position-2 the flux direction is reversed as it is downward through the same pole shoe. All the cases vertical velocity of any type of translator mounted with floater or something like that is very low at the two ends, hence generating negligible amount of electricity as shown in Fig.3 as an example as the output power is proportional to speed or velocity. A new design of pole shoes so far is also implemented which is able to increase rate of change of flux with proper mounting with translator, thus generate more electrical power even with low velocity because although the displacement per unit time is low two consecutive translator tips are closer near both ends compared to the regular distance around the middle position.

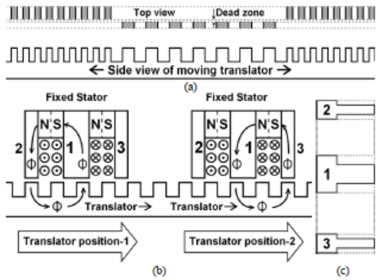

Fig. 4(a) Top view and side view of the proposed translator, (b) Direction change of flux in stator when position is changed, and (c) Bottom view of proposed pole tips of stator.

The Proposed LPMG block diagram of model is shown in Fig.5. Different parameters of wave energy like wave length, height, phase, reaction force, cogging force, friction is considered which can be given as preset value or it can be varied during simulation. Variables can be changed during simulation using function with preset value or can be given in the model by another function named "Random" connected with some other blocks that can produce random height and wavelength of wave energy to produce more realistic outputs.

O. Farrok and M. M. Ali, "A new technique to improve the linear generator designed for oceanic wave energy conversion," *8th International Conference on Electrical and Computer Engineering*, Dhaka, 2014, pp. 714-717.

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- Im Studium sehr wenig Umgang mit **wissenschaftlichen Publikationen**
  - Seminare
  - Abschlussarbeiten
- Belastung des Zeitplans in der Masterarbeit
  - Literaturrecherche
  - Weniger Zeit für andere Arbeiten
- Diese Veranstaltung soll Studierenden bereits im Studium helfen:
  - Wie sind Publikationen aufgebaut?
  - Welche Publikationen sind aussagekräftig?
  - Wo finde ich welche Informationen?
  - Wie finde ich die referenzierten Quellen?
  - etc.

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Ziele der Lehrveranstaltung

- Strukturierte Analyse von englischsprachigen wissenschaftlichen Publikationen erlernen
  - Formale, schriftliche und analytische Fähigkeiten weiterentwickeln
  - Aktive Auseinandersetzung mit **wissenschaftlichen Standards und Methoden** anhand eines gegebenen Beispiels
  - Elektrotechnik: IEEE → genaue Vorgaben an Form & Inhalt

- Simulationsbasierte Validierung der Ergebnisse
  - Kritische Betrachtung der Ergebnisse
  - Umgang mit Simulationssoftware

- Förderung des selbstständigen Arbeitens
  - Effiziente Arbeitsorganisation
  - Anpassbar an individuellen Studienplan

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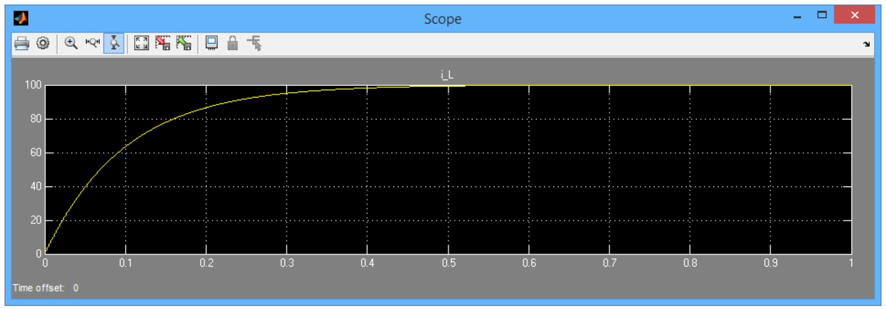
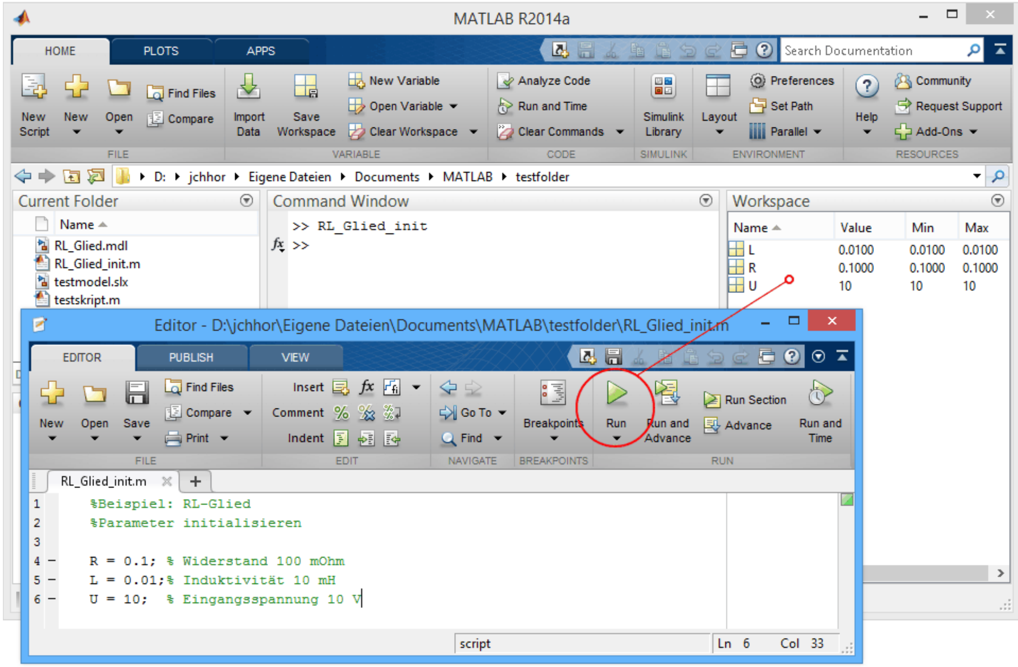
- <u>Aufgabe</u>: Die Validität (Gültigkeit) eines wissenschaftlichen Artikels systematisch zu untersuchen und zu diskutieren.

Stufe 1

- Nachbilden der Simulationsergebnisse
  - Simulationssoftware
  - Parameter aus dem Artikel
- Gegenüberstellung der Ergebnisse
  - Kritische Betrachtung





- Eigenen <u>deutschsprachigen</u> Artikel verfassen:
  - 4–6 DIN A4 Seiten
  - Eigene Ergebnisse wissenschaftlich korrekt darstellen

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Stufe 2

- Drei Gutachten verfassen
  - Studierende erhalten pseudonomisierte Artikel
  - Bewertung der anderen Studierenden
  - Perspektivwechsel

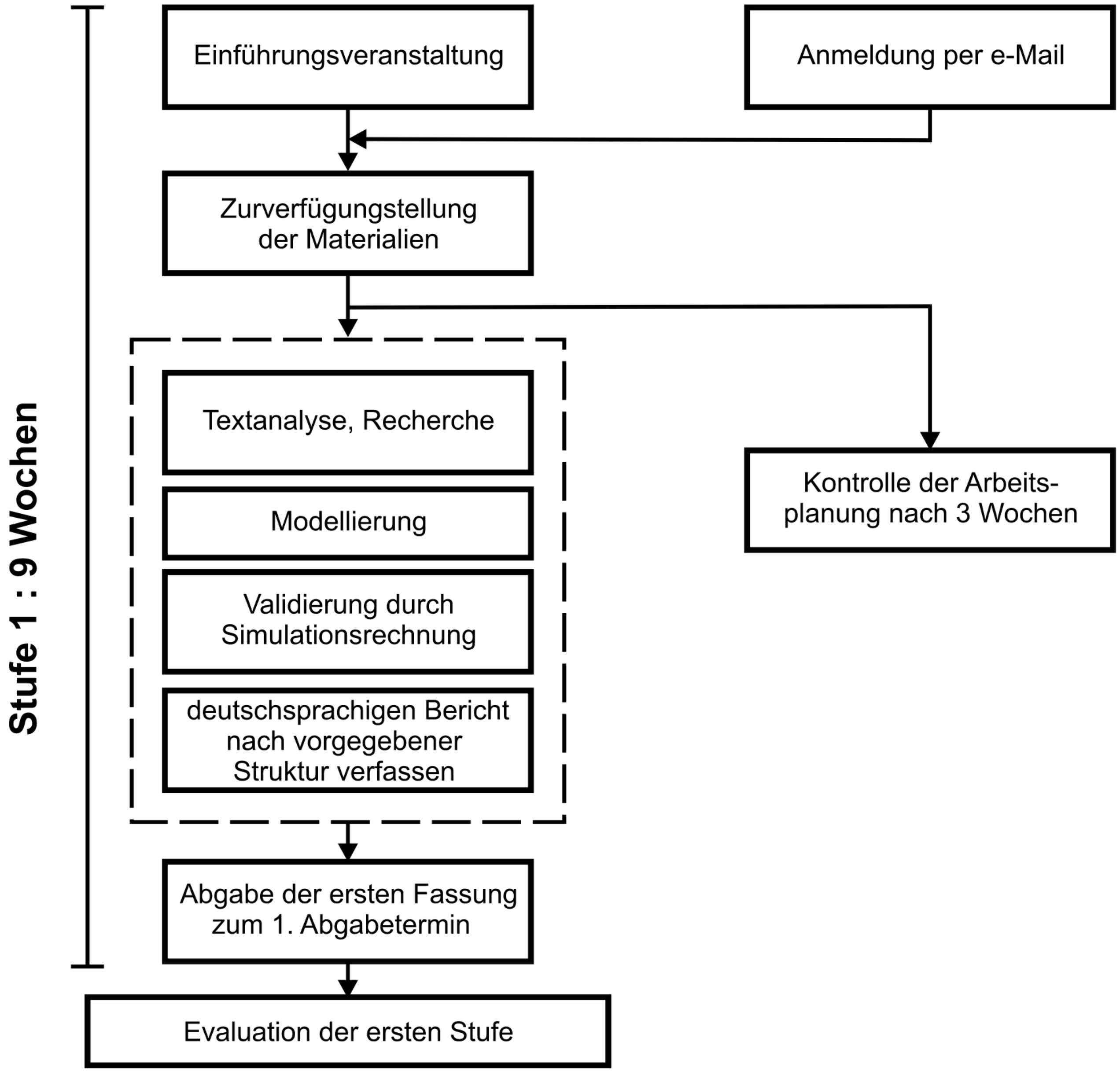
Stufe 3

- Korrektur des eigenen Artikels
  - Basierend auf Gutachten
  - Verbesserung der Qualität

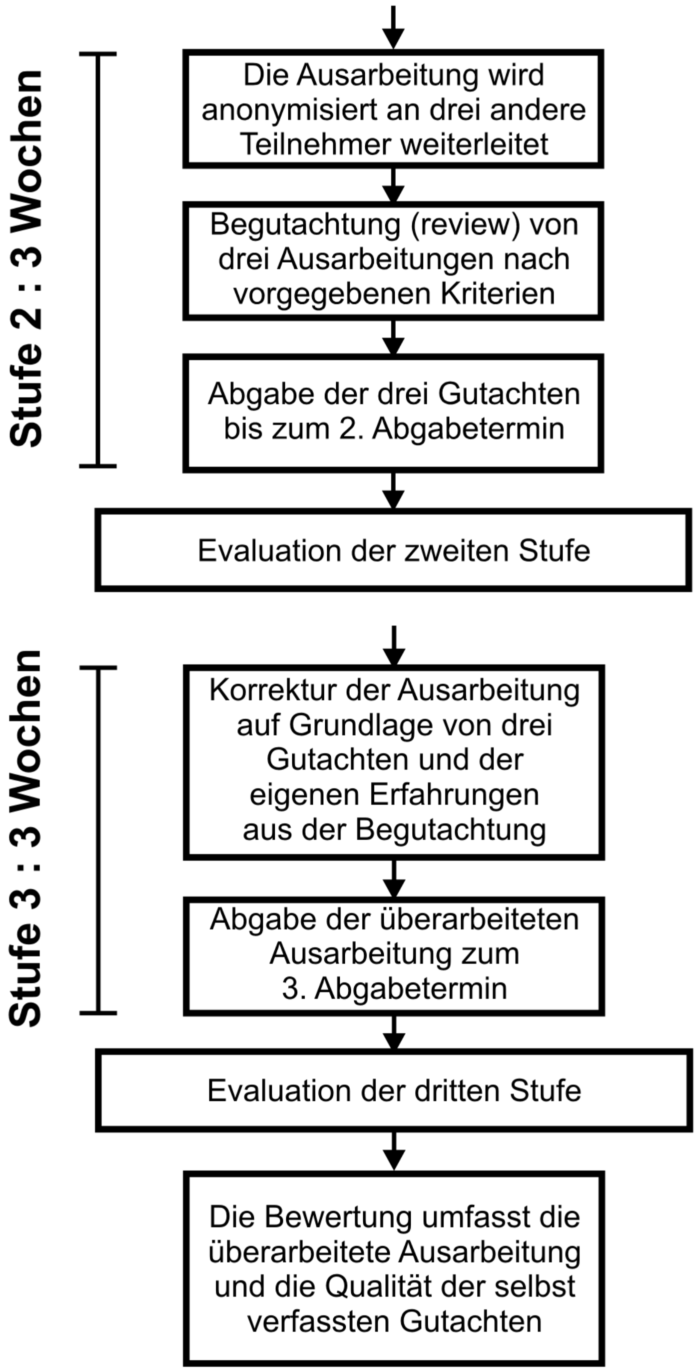
- Projektarbeit
  - Mehrstufige Hausarbeit
  - Feste Abgabetermine
  - Etwa 12 – 15 Wochen
  - 4 Semesterwochenstunden aber freie Zeiteinteilung
  - Workload: 8 – 10 Stunden pro Woche
- Arbeitsmaterial
  - Der Artikel
  - Skriptum zur Lehrveranstaltung
    - Grundlegende Theorie und Arbeitsanweisungen
    - Einführung Simulationssoftware
    - Konventionen: Zitate, Formeln, Abbildungen, Tabellen
  - Simulationssoftware: MATLAB/Simulink (Campuslizenz)
- Bewertung
  - Abzugebende Dokumente
    - Deutschsprachige Ausarbeitung
    - Gutachten & Korrekturen

- Feedback von Studierenden erwünscht
  - Verbesserungsvorschläge & Kritik
  - Zur Weiterentwicklung der Lehrveranstaltung

Ablauf: Stufe 1



Ablauf: Stufe 2 & 3



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Ablauf: Stufe 2 & 3

Stufe 2 : 3 Wochen

- Die Ausarbeitung wird anonymisiert an drei andere Teilnehmer weiterleitet
- Begutachtung (review) von drei Ausarbeitungen nach vorgegebenen Kriterien
- Abgabe der drei Gutachten bis zum 2. Abgabetermin

Evaluation der zweiten Stufe → Feedback

Stufe 3 : 3 Wochen

- Korrektur der Ausarbeitung auf Grundlage von drei Gutachten und der eigenen Erfahrungen aus der Begutachtung
- Abgabe der überarbeiteten Ausarbeitung zum 3. Abgabetermin

Evaluation der dritten Stufe → Feedback

Die Bewertung umfasst die überarbeitete Ausarbeitung und die Qualität der selbst verfassten Gutachten

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Vielen Dank für Ihre Aufmerksamkeit!

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